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ABSTRACT

Described are 4501 projects in progress during 1968 under the general headings: Nature of Water; Water Cycle; Water Supply Augmentation and Conservation; Water Quality Management and Control; Water Quality Management and Protection; Water Resources Planning; Resource Data; Engineering Works; and Manpower, Grants and Facilities. Each description outlines the objectives of the project and the procedures being used. The name of the principal investigator and the address of the institution are given, and supporting agencies are identified. There is a subject index, a principal investigator index, a contractor index, and a supporting agency index. (EB)

ED038315

VOLUME 4

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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Water Resources Research Catalog

March 3, 1849

U.S. DEPARTMENT OF THE INTERIOR
Office of Water Resources Research
Water Resources Scientific Information Center
Washington D.C. December 1968

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INTRODUCTION

This Volume 4 of the *Water Resources Research Catalog* is published pursuant to the Water Research Act of 1964 (78 Stat. 329 as amended by 80 Stat. 129), whose purposes (as stated in the preamble) are: "In order to assist in assuring the Nation at all times of a supply of water sufficient in quantity and quality to meet the requirements of its expanding population, it is the purpose of the Congress, by this Act, to stimulate, sponsor, provide for, and supplement present programs for the conduct of research, investigations, experiments, and the training of scientists in the field of water and resources which affect water."

The Catalog series, initiated in February, 1965, with Volume 1, Part 1, presents annually summary descriptions of current research on water resources problems. Such information is needed by the Office of Water Resources Research as one of the tools for administration of the program of research support in accordance with the statutory requirement to avoid undesirable duplication of effort. The Catalog also makes readily available to all who are engaged in water-related research, or otherwise concerned with water resources problems, information on what is being done, by whom, and where. Three years of experience demonstrates that availability of this information is valuable to research program administrators, research scientists and engineers, and the users of research results.

Continuing enlargement of research activities, responsive to the magnitude and urgency of water resources problems, makes all the more necessary availability of information on current activities. Volume 4 of the Catalog is one means of providing that.

Appreciation for continuing effective cooperation and support of the Catalog project is expressed to Dr. Bernard B. Berger, Chairman, and to each of the individuals who constitute the membership of the Committee on Water Resources Research of the Federal Council for Science and Technology. They are responsible for the timely provision of informative summaries of 3,824 federally-supported research projects. Appreciation also is expressed to the personnel of the universities, research institutions, state agencies, industrial enterprises, and others who have voluntarily contributed the descriptive summaries of 677 research projects that are wholly supported from non-Federal sources. As in the case of Volume 3, publication of this volume is possible only because of the outstanding cooperation, the special efforts, and the highly skilled performance of the Science Information Exchange in completing its assigned task.

Volume 4 includes description of 4,501 active research projects in comparison with 4,193 in Volume 3 for 1967. This increase generally reflects the expanding interest in water resources research that has taken place and the accompanying research activity. The Catalog lists 5,749 investigators, 781 performing organizations of which 194 are Federal and 587 non-Federal, and 320 supporting organizations of which 31 are Federal and 289 non-Federal.

Roland R Renne

Roland R. Renne
Director
Office of Water Resources Research

EDITOR'S NOTE

Volume 4 of the *Water Resources Research Catalog* has been prepared at the request of the Office of Water Resources Research, Department of the Interior, by the Science Information Exchange of the Smithsonian Institution as part of its continuing responsibilities as the national cataloging center for current water resources research. It provides information on 4,501 ongoing water resources research projects, supported by both Federal and non-Federal funds, which were collected by the Science Information Exchange through a special solicitation of Federal and non-Federal sources. About 101 additional potential non-Federal sources of water research were queried over those contacted for Volume 3. Also, the director of each of the 51 state water research institutes was requested to submit records for new non-Federal projects.

Included in Volume 4 are reports of research being carried on in the 50 states, the District of Columbia, and Puerto Rico as well as research in about 25 foreign countries. The total of 4,501 summaries in Volume 4 represents an increase of 308 over the number that were listed in Volume 3. However, this should not be construed only as an absolute increase in the amount of research being done, but rather as a combination of increased water research effort plus more complete coverage of existing research not previously registered at the Exchange. At the same time, a more rigorous screening out of inappropriate projects was accomplished by the contributing agencies.

The research listed has been forwarded for inclusion by the supporting agencies. Frequently, several agencies contributed substantially to a single research project, or to various aspects of a single project, and several summaries were received describing essentially the same research. If these similar descriptions could be accurately identified as comprising the same research, there would still remain the problem of deciding which summary best described the research. Thus only projects with identical summaries have been removed. The various supporting sources are identified in every case.

The projects included herein were reviewed, updated, and designated as water resources research by the original source of the material: Federal and state agencies, private industry, academic institutions, private foundations, and individual scientists. The contributors also assigned each summary to one of the nine major water resources research categories established by the Committee on Water Resources Research of the Federal Council for Science and Technology (February 1966). The categories define the nine chapters of the Catalog in which the summaries appear. In addition to the summaries of the 4,501 projects, the Catalog contains the following indexes: Subject Index, Investigator Index, Contractor Index, Supporting Agency Index, and an Index of Chapter Definitions. The information which appears in the summaries and indexes was taken directly from the project records as received by the Exchange.

The Subject Index is based on a hierarchy developed by the Science Information Exchange. The index terms are arranged in hierarchies indicating relationships between broader and narrower subject terms. Related terms are thus grouped together under broader terms. The hierarchical term is followed by the project title, a list of about five keywords, and the chapter number of the project. All index terms were selected to emphasize the water aspects of the project.

The indexing is as specific as the language of the project summary, however, as it is hierarchical in nature, a project which deals with "riparian rights" will be indexed to that specific term under a hierarchy consisting of the term "water rights" and the still broader term "legal aspects of water." Thus, one must turn to the high level term "legal aspects of water" to find projects dealing with riparian rights, but he will also find all other legal studies grouped together in the same section. To further aid in locating subject areas, the first high level hierarchical term to appear on a left-hand Subject Index page is also printed in the upper left-hand Corner of that page, and the last high level term to appear on the right-hand page will also appear in the upper right-hand corner of that page in dictionary fashion.

The Supporting Agency Index consists of a single alphabetic listing of both Federal and non-Federal sources of support. In view of the large number of state agencies and departments, they are displayed as a combined group under each state. All investigators cited on the source document are included in the Investigator Index. An asterisk is used to designate the individual specified as principal investigator. However, in some instances it is apparent that the "principal investigator" denoted on the source document is, in fact, a program manager who is not working at the contractor location given in the project summary. The Contractor Index is an alphabetic listing of the performing organization and its location.

All of the indexes in the Catalog were generated by means of a computer, necessitating a limitation of the number of characters available for index terms and caption. Thus, in some instances, abbreviations had to be used.

We hope that the users of this Catalog will advise the Science Information Exchange of any errors of omission or commission that have been made. Also, critiques of this Volume are encouraged so that future editions might best reflect the information therein in a format and with indexes which are most convenient and acceptable to the user.

Monroe E. Freeman, Director
Science Information Exchange

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DESCRIPTION OF RESEARCH TASKS

1. NATURE OF WATER

Properties of Water; Aqueous Solutions.

1.0001, THE EFFECT OF SURFACTANTS ON THE AQUEOUS SOLUBILITY OF OXYGEN AND HYDROGEN SULFIDE
R.H. DINIUS, Auburn University, Water Resources Research Inst., *Auburn, Alabama* 36830

The solubility of oxygen and hydrogen sulfide as effected by surfactants in aqueous systems is being determined. Cationic and anionic surfactants with alkyl groups representing optimum surface activity, wetting ability and the combination of the two propoerties are being utilized in this investigation. Wet chemical methods are used to determine oxygen and hydrogen sulfide concentrations. The maximum surfactant concentrations used in this investigation correspond to the critical miscelle formation concentration.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Auburn University

1.0002, DIFFUSION OF OXYGEN AND HYDROGEN SULFIDE IN WATER AS EFFECTED BY DISSOLVED SURFACTANTS
R.H. DINIUS, Auburn University, Water Resources Research Inst., *Auburn, Alabama* 36830

The proposed research is to determine and measure the effect of surfactants upon the diffusion coefficients of oxygen and hydrogen sulfide in aqueous solutions of surfactants. A secondary objective is to determine the effect of surfactants on the structure of the near infrared absorption spectra of water. A comparison of the effects of surfactants on both sets of measurements will be made in terms of the molecular size, spatial conformation and charge distribution of the surfactant molecule.

Diffusion coefficients are being measured in terms of concentration change as a function of time across a diaphragm diffusion cell. Oxygen concentrations will be determined with qalvanic type cells and H2S concentrations will be determined via the gas chromatograph.

NIR spectra will be measured in the 0.8 to 1.5 micron range as a function of surfactant concentration.

As a result of initial work with the galvanic type oxygen determination cell an effort is being made to improve its long term stability and like time. The possible effects of the absorption of foreign species on the membrane of the cell upon cell sensitive to oxygen is being determined.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Auburn University

1.0003, DIFFUSIVITY OF OXYGEN AND SULFIDE SPECIES IN AQUEOUS SOLUTIONS
R.H. DINIUS, Auburn University, Graduate School, *Auburn, Alabama* 36830

The Proposed research has three objectives: 1. Continuation of oxygen diffusivity investigations to determine the effect of solutes (e.g. surfactants and some simpler electrolytes such as phosphates and carbonates) found in waste discharges. 2. Extend the diffusivity studies to sulfide ions in the solution system used above. 3. Continue development work on a continuous, nondestructive method for measuring hydrogen sulfide concentrations.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Auburn University

1.0004, PATHWAYS OF TRACE ELEMENTS IN ARCTIC LAKE ECOSYSTEMS
R.J. BARSDATE, Univ. of Alaska, Inst. of Marine Sciences, *College, Alaska* 99735 (AT(04-3)310-4)

This research is a study of the behavior and abundance of trace metals in high latitude lakes. It includes the quantitative determination of Co, Cu, Fe, Mn, and Zn in water, sediments and bio materials by atomic absorption and electrochemical techniques. To assess the role of dissolved organic substances, separations of organic components are being made by gel filtration and solvent extraction, the isolated fractions being tested for complexation ability. Tracer techniques, dialysis, and chromatography will be employed to establish the abundance and strength of complexes in lakes. To determine the effects of complexation by sulfides and organic substances and of the competition between these two systems, several lakes with differing concentrations of dissolved organics and sulfides are being examined.

In addition to the treatment of trace metals, in progress are a general chemical description and classification of high latitude lakes and studies of lake ice and complexation of the major cations.

Observations of the geochemistry of ice include the partition of dissolved substances during freezing, the effects of ice cover on terrestrial run-off and atmospheric fall-out, and the spatial distribution of impurities in ice.

Substantial fractionation of the major cations has been observed during the precipitation of the salts of organic acids. Since similar precipitation occurs in some lakes, this mechanism may influence the natural distribution of Na, K, Cs, Mg, Ca, and Sr. The relative stability and solubility of complexes of these cations with organic acids will be determined by equilibrium dialysis and tracer techniques. Analysis of lake waters will be made to confirm the mechanism and assess its importance.

SUPPORTED BY U.S. Atomic Energy Commission

1.0005, ORGANIC COMPOUNDS IN ALASKA PERMAFROST GROUNDWATER
N.J. BIRKHOLZ, Univ. of Alaska, Inst. of Water Resources Res., *College, Alaska* 99735

Detection and identification of trace organic compounds in well waters associated with the interior Alaska permafrost regime are being studied using gas and thin layer chromatogrpahy and spectra. Surface waters and soil samples are being similarly investigated to the extent that they can clarify the origin of organics at deeper levels. Changes in trace organics will be studied during development of a well.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

1.0006, THE KINETICS OF MICROBIOLOGICAL MODIFICATION OF ORGANIC SUBSTANCES OCCURRING IN NATURAL WATERS
D.K. BUTTON, Univ. of Alaska, Inst. of Marine Sciences, *College, Alaska* 99735

1. NATURE OF WATER

We have found large changes in the efficiency of the substrate transport systems of microorganisms with changing external conditions. We propose to examine this phenomenon carefully and to use it as an avenue to study the transport systems of microorganisms which effect the concentration of dilute substrates in a natural environment. We further propose to investigate the kinetics of degradation of the rather stable high molecular weight dissolved organic fraction one can concentrate from most lake and sea water. This will be done using continuous culture techniques.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Alaska

1.0007, NUCLEAR TECHNIQUES IN SOILS HYDROLOGY, SNOW GAGING, AND RELATED APPLICATIONS

J.L. SMITH, U.S. Dept. of Agriculture, Pac. Sw. For. & Rg. Expt. Sta., *Berkeley, California* (AT(49-11)-2773)

Previous work has been in the field of soils hydrology, construction and use of a snow density gage, water use by plants, and hexadecanol tracing in the application concerned with reducing evaporation. Current studies are concerned with the following:

Effect of Aspect and Cover Upon Snow Accumulation, Metamorphosis, and Melt: The objective of this study is to determine the mathematical relation that exists between the snow condition as determined by the snow gage at the Central Sierra Snow Laboratory and that existing at various locations away from the Laboratory (radius of 5 miles). Hopefully, it will be demonstrated that the centrally located snow gage can be used to determine snow condition at any other point within its area of influence.

Soil Collection and Analysis - This work will continue since the conformation is essential to furnish data on soil hydrologic properties to the water tracing by isotopes study.

Study of Soil Water Movement Under Saturated and Nonsaturated Soil Moisture Conditions This is a joint effort with Hazelton Nuclear Science Corporation (see contract AT(04-3)-676. Attempts will be made to measure the movement rate and amounts of water in the soils studied, determine the path and rate of soil water movement in its journey down slope from hilltop to stream, determine water use of vegetation growing on a hillside by using double tracers.

Determination of Water Movement in Plants by Nuclear and Heat Pulse Techniques This study is concerned with water movement in various vegetation indigenous to Sierra Nevada. Areas of concern are the determination of the relation between velocity of water movement in the stems and environmental driving factors such as solar radiation, soil moisture availability, and temperature.

In all instances, isotopes will be a prime tool used in the studies.

SUPPORTED BY U.S. Atomic Energy Commission

1.0008, FILTRATION OF AQUEOUS EFFLUENTS CARRYING EMULSIFIED OILS

S.L. GOREN, Univ. of California, Graduate School, *Berkeley, California* 94720

A number of aqueous wastes carry micron and submicron droplets of emulsified oils which may affect the quality of the water into which these wastes are discharged. A promising method of separating such emulsions cheaply and thoroughly is to promote coalescence of the dispersed phase by passing the stream through a fibrous mat.

We are studying the coalescence of aqueous emulsions by fibrous media with the aim of elucidating the mechanisms involved and establishing the effectiveness of coalescence as a function of such variables as drop size, fiber size, mat geometry, fluid and surface properties, flow rate, etc. Emulsions well characterized as to drop size are passed through mats made from uniform diameter fibers, and the extent of coalescence is determined from measurements of turbidity and/or drop size distributions made with a Coulter counter before and after the mats. Pressure drop is also measured.

In addition to the purification of aqueous wastes containing emulsified oils, some of the results may be of importance in the filtration of solid wastes and in the improvement of water quality by percolation through soils.

SUPPORTED BY University of California

1.0009, DETERMINATION OF OXYGEN IN SEA WATER

S. LYNN, Univ. of California, School of Engineering, *Berkeley, California* 94720

Dissolved oxygen can be determined quantitatively by measuring the limiting current drawn by a rotating disk electrode. In sea water certain organic and/or inorganic materials may interfere. The proposed project would aim to a) determine the most suitable electrode material, geometry, and cell configuration; b) determine the range of oxygen concentrations in artificial sea water which can be determined by this method; c) determine which common constituents of sea water interfere with the method and whether this interference can be prevented; and, d) develop the design and circuitry for a device for the continuous monitoring of oxygen in sea water.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0010, STUDY OF A SPECIFIC INFLUENCE OF IONIC SPECIES ON STRUCTURING IN WATER

J. GREYSON, North Amer. Rockwell Corp., *Canoga Park, California*

The proposed work entails an investigation of the free energy and entropy of transfer of ionic salts between heavy and normal water. The salts to be studied will include carbonates, sulfates, phosphates, alkaline earth cations, tetraalkylammonium halides and a large anion such as tetraphenyl boride. The purpose of the investigation is to obtain insight into the influence of dissolved ions on the structure of water. The investigation will be carried out by measuring the heat of solution of the selected electrolytes in heavy and normal water and the electromotive force of electrochemical cells, the configuration of which will represent the process of transfer of the electrolytes between heavy and normal water. Cell configurations will include half cells of heavy and normal water solutions separated by ion exchange membranes. The resulting data will be used to obtained the transfer entropy values which can then be related to the structure influence of the electrolytes.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0011, A STUDY OF PRESCALING DEPOSITION

H.L. RECHT, North Amer. Rockwell Corp., *Canoga Park, California*

A continuation of the laboratory investigation of the phenomenon of scale formation on heat transfer surfaces in saline water conversion will be carried out by exploring the energetics and mechanism involved in prescale deposition preceeding actual scale formation utilizing radioactive tracer techniques. Specifically, the following will be carried out:

1) Investigate the energetics and mechanism of the surface influenced processes that precede the appearance of bulk scale on heat transfer surfaces.

2) Measure equilibrium and kinetic parameters of the sorption of calcium sulfate from an aqueous solution onto metals such as copper, copper-nickel alloys, platinum, copper and nickel oxides, and any other materials that appear appropriate.

3) From the measurements values obtained estimate heat of sorption, activation energy for sorption, and entropy of sorption for the various surfaces.

4) Correlate the measured and calculated properties on the basis of bulk scale formation tendencies of the materials.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0012, AQUATIC TRANSPORT OF NUCLEAR DEBRIS

A.R. TAMPLIN, Univ. of California, Lawrence Radiation Laboratory, *Livermore, California* 94551 (W-7405-ENG-48)

Aside from the physical transport by ocean, ground, and surface water systems, our review of this problem indicated that the major determinants of the ultimate fate of radionuclides within these media are the ion-binding and ion-exchange properties of soils and bottom sediments, and the interactions that occur when fresh water containing soluble radioisotopes merges with salt water. The ion-binding and exchange properties of soil and bottom sediments determine the rate at which fallout material will be leached and moved about by surface water. The fresh-salt water reactions will determine whether or not a soluble radioisotope between fresh water will be precipitated at and, hence, concentrated in the area of interface between fresh and salt water. Both factors considered together determine whether or not a marine 'hot spot' could develop subsequent to the construction of a sea-level canal by nuclear explosives. In this case, it is imperative to develop the ability to predict the rate at which radionuclides are leached from fall-back, throw-out, and base-surge material of the canal site by rainfall and, in addition, the ability to predict whether or not these leached radionuclides will be concentrated as a marine 'hot spot' where this fresh water flows into the ocean.

At the present time, a concerted analytical effort is being applied to this area to bring together and analyze the data contained in existing literature. It is felt that the state-of-the-art as reflected by this literature is adequate to develop a practical predictive capability. If this is not the case, experimental programs will be initiated to obtain the necessary additional information.

SUPPORTED BY U.S. Atomic Energy Commission

1.0013, TRACE ELEMENT STUDY OF SOIL-PLANT-WATER SYSTEMS

G.R. BRADFORD, Univ. of California, Agricultural Experiment Sta., *Riverside, California* 92502

Objectives: 1) Establish the concentration of certain trace elements (Fe, Mo, Mn, Ba, Cu, Zn, Ni, Co, Cr, Si, Pb, Ti, Al, V, B, Sr, Be, Ag, Ge, Ga, Bi, Tl, La, Sn, Cd, As, Au, Sb, and Se) in surface and ground waters of California, 2) Relate trace-element concentrations to the past history of the water, including geologic and use factors, 3) Determine how trace-element concentrations are modified upon the passage of water through soils, 4) Establish the effects of water composition and water-soil interactions on crop plants.

Description of work proposed: Water samples and background data will be supplied through a cooperative arrangement with the California State Department of Water Resources. The above objectives will be accomplished by improved analytical techniques using direct reading emission spectrographic and atomic absorption instrumentation. Samples will be pretreated with chelating compounds and solvent extraction techniques used to separate and concentrate trace elements. Twenty-four large lysimeters installed at the Citrus Research Center will be used to study the water-soil interaction on crop plants and modifications of trace element concentration upon the passage of water through soils.

SUPPORTED BY U.S. Dept. of Agriculture
California State Government

1.0014, PROPERTIES OF SEA WATER AND ITS CONCENTRATES AT TEMPERATURES UP TO 400 DEGREES FAHRENHEIT

L.A. BROMLEY, Univ. of California, Graduate School, *San Diego - La Jolla, California* 92038

These data are important for desalination processes and for increasing the fundamental understanding of the physico-chemical behavior of sea water. Under OSW Research Grant 14-01-0001-363, heat capacities at constant pressure of one atmosphere have been determined from 2-80 degrees C for sea water solutions ranging from 1.1 - 11.7% salinity. These are approximately 1/3 to 3 1/2 times the natural concentration of sea water. Also, a high pressure calorimeter has been designed and partially built to extend these measurements to 200 degrees C under the present Research Grant. Heats of concentration, vapor pressures, and viscosities will also be studied.

Heats of concentration will be measured as heats of dilution. The atmospheric pressure heat capacity calorimeter has been modified for this new use. For high temperature measurements, the high pressure calorimeter will be altered as required.

The method we are most seriously considering for vapor pressures is the direct measurement of boiling point elevations using an original modification of conventional ebulliometers. These values, cross-checked by those calculated from heats of concentration and heat capacities, should resolve existing differences among present values reported by various investigators. Also, enthalpies will be determined from heat capacities and vapor pressures.

Available data on the viscosities of sea water cover only a narrow range of temperature and concentration. It is our present plan to use capillary viscometers at both atmospheric and elevated pressures. Conventional pressure viscometers will have to be modified to satisfy the specific requirements for sea water.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0015, DETERMINATION OF THE PHOSPHATE CONTENT OF NATURAL WATERS, AT THE NUTRIENT LEVEL, BY SOLVENT EXTRACTION

G.C. CAVE, Mcgill University, Graduate School, *Montreal - Quebec, Canada*

(a) The Proposed Research: To study solvent extraction as a technique for the quantitative concentration of trace amounts of phosphate from natural waters. Phosphate in the resulting concentrate may then be determined by novel or conventional methods.

(a) The objectives, briefly: To develop a rapid quantitative method for phosphate in natural waters, preferably a method capable of automation.

(c) Relation to Health Field: To provide Public Health Engineers with a reliable rapid method for large-scale surveys of lake and river water for phosphate at the nutrient level.

SUPPORTED BY Canadian Government

1.0016, THEORY OF LIQUIDS

D. HENDERSON, Univ. of Waterloo, Graduate School, *Waterloo - Ontario, Canada*

The successful perturbation theory of liquids developed by Barker and Henderson will be applied to liquids in which the intermolecular potential has a soft-core and, in particular, to the 6:12 potential. This should yield a theory which will give good results for the thermodynamic properties of simple liquids. In addition, better approximations to the second-order term will be sought and this approach will be applied to develop a theory of solutions of molecules of different sizes. The possibility of applying this approach to the calculation of the radial distribution function will be investigated.

Also, improvements to the Percus-Yevick, hyper-netted chain and Born-Green-Yvon theories will be sought by direct calculation of the correction terms to the basic approximations of these theories.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0017, CHANGES IN THE PHYSICAL AND BIOLOGICAL CHARACTERISTICS OF GROUND WATER RESERVOIRS AND ADJACENT SURFACE WATERS

S.M. MORRISON, Colorado State University, Natural Resources Center, *Fort Collins, Colorado* 80521

The mechanism of removal of bacteria from suspension in waste water flowing through soil materials is under investigation. There are four component studies required: (1) measurement of the electrophoretic mobilities of the bacteria in various electrolyte solutions at different pH; (2) measurement of the electrical potential generated in porous media during flow through the porous material by various electrolyte solutions at various pH; (3) measurement of the removal of bacteria, tagged with a radioactive tracer, from a bacterial suspension passing through a column of porous material; and (4) determination of the distribution in the porous column of the bacteria removed during flow through the column.

A computer program modeling the movement of contaminants in ground water aquifers is being developed. This model will incorporate the effects of natural recharge on the quality of ground water as well as the effects of contamination sources such as brine pits, irrigation and feed lots.

Substantial progress has been made in delineating boundary conditions for ground water flow in the alluvial plains of the Lower Cache la Poudre River Basin. In particular, sub-alluvial bedrock topography has been established for approximately 900 square miles in Larimer and Weld Counties, Colorado.

Anisotrophy of flow in the unconsolidated sediments is being analyzed through geophysical techniques. This analysis should lead to improved understanding of patterns of dispersion of contaminants in subsurface waters.

A series of experiments have been carried out in attempts to clarify the knowledge on survival and movement of microbial particles through soil.

The survival of organisms in soil with known organic additives are to be studied. Also the microbial factor which seems to control survival of enteric in soil is to be studied.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Colorado State University

1.0018, ION-SOLVENT INTERACTION

R.M. FUOSS, Yale University, Graduate School, *New Haven, Connecticut* 06520

This research will be directed towards a deeper understanding of the several kinds of short range interionic and ion-solvent interactions that govern observed behavior of aqueous saline solutions. Short range interionic effects are superimposed on the electrostatic forces which cause primary ion associations to pairs. Short range anion-cation effects include dipole (and quadrupole) forces for ions with aspherical charge distribution, polarization forces, and steric factors. Ion solvent effects include charge-dipole electrostatic interaction, hydrogen bonding, polarization (and dielectric saturation), electrostriction, and complex ion formation. From conductance data, the limiting conductance, association constant and contact distance can be calculated by theoretical analysis. Dependence of these parameters on structure and properties of ions and solvent molecules is the information sought. Typical systems to be investigated include the following: (1) lithium, sodium and potassium chlorides in water- dioxane mixtures over a concentration range ten times higher than has previously been covered (made possible by quite recent advances in the theory of conductance); (2) conductance of these salts in mixtures of water with dimethylsulfoxide, acetonitrile and urea; (3), conductance of magnesium, manganese, copper and nickel sulfates in water-dioxane mixtures (and possibly in other mixtures); (4), conductance of potassium and silver nitrates in dioxane-water mixtures; (5), conductance of selected 1-1 and 2-2 salts at 35 degrees and 50 degrees; (6), conductance of alkali and quaternary sulfonates and carboxylates to study non-coulombic association.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0019, THE DETERMINATION OF THE ENGINEERING THERMO-PHYSICAL PROPERTIES OF SOLUTIONS CONTAINING DISSOLVED SOLIDS

D.A. FISHER, Univ. of Connecticut, School of Engineering, *Storrs, Connecticut* 06268

The raw feed to conversion equipment used in the production of fresh water consists of a solution containing dissolved solids such as brackish water, sea water, the effluent of sewage plants, and other waste waters. Process analysis and the engineering development of conversion equipment is frequently hampered by a lack of knowledge of such properties as specific heat capacity, enthalpy, viscosity, and thermal conductivity of the raw feed and of the concentrated solution as it progresses through the process. It is proposed to experimentally determine these properties to engineering accuracy.

The first phase of the work will be to design and build a calorimeter for the determination of specific heat capacity in the temperature range 40 - 400 degrees Fah. and to prove its accuracy using distilled water.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Connecticut

1.0020, ION - ION AND ION - MOLECULE INTERACTIONS IN AQUEOUS SALT SOLUTIONS

W.L. MASTERTON, Univ. of Connecticut, Graduate School, *Storrs, Connecticut* 06268

The objective of the proposed research is to evaluate the relative importance of electrostatic forces, Van der Waals forces and solvent -structure effects in determining the extent of: (1) Association between oppositely charged ions (ion pairing) in aqueous salt solutions. (2) Interactions between solute molecules and ions in water solution.

The electrolytes used in this study will be stable coordination compounds derived from cobalt (III). It is believed that thermodynamic data for solutions of these 'model compounds' can be more readily interpreted than that for so-called 'simple' salts derived from alkaline earth or transition metals (e.g., Ca(NO3)2, CoCl2), where the exact nature of the cationic species is unknown. The molecular compounds studied will include aromatic hydrocarbons and their halogen derivatives. Here, we shall examine the effect of size and polarity of the non-electrolyte molecule upon its interaction with ions in solution.

The experimental work will involve the measurement of: (1) Activity and osmotic coefficients of coordination compounds in aqueous solution. (2) Conductivities of these compounds in water and mixed solvents. (3) Solubilities of non-electrolytes in water solutions of coordination compounds.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Connecticut

1.0021, SCATTERING MEASUREMENTS ON ALKALI - WATER SYSTEMS

T.I. MORAN, Univ. of Connecticut, Graduate School, *Storrs, Connecticut* 06268

The proposed experiment will study the interactions between alkali atoms and water molecules by atomic scattering techniques. These techniques are well established and yield important information on the intermolecular forces involved. Experiments of this type are performed by directing a velocity selected alkali atomic beam through water vapor and measuring the intensity of the scattered alkali beam. At the present time the atomic beam laboratory has an apparatus capable of making such measurements and is studying alkali-halogen interactions (preliminary results have been presented at a recent meeting of the American Physical Society.) The water molecule is of special interest for scattering studies since it has a permanent electric dipole moment (unlike the halogen molecules) which may enable it to be oriented relative to an incident alkali atom. Reactive scattering can also occur with a typical channel being Na plus H20 yields NaOH plus H. The experiments will yield information on the interaction of a single alkali atom with a single H20 molecule (an unusual feature of this type of experiment).

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Connecticut

1.0022, SCATTERING MEASUREMENTS ON ALKALI - WATER SYSTEMS

T.I. MORAN, Univ. of Connecticut, Graduate School, *Storrs, Connecticut* 06268

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SUPPORTED BY University of Connecticut

1.0023, AIR OXIDATION OF ORGANIC COMPOUNDS IN AQUEOUS SYSTEMS

D.W. SUNDSTROM, Univ. of Connecticut, School of Engineering, *Storrs, Connecticut* 06268

Organic compounds can be oxidized chemically in an aqueous system by heating under pressure in the presence of air. When applied to the disposal of aqueous wastes, the technique is referred to as wet oxidation. Under the usual operating conditions, the organic wastes are not completely destroyed during oxidation. The method is of particular interest since the wastes are removed by chemical rather than by biological action.

The purpose of the project is to determine the reaction kinetics of several organic compounds during wet oxidation. The rate and extent of oxidation of several organic compounds will be examined over a range of temperatures, pressures and concentrations. Since simultaneous mass transfer and chemical reaction occur during wet oxidation, the relative magnitudes of these rate processes will be established. Initial experiments will emphasize the destruction of an insoluble organic compound in a flow reactor. The results of this study should provide a better understanding of the wet oxidation process.

SUPPORTED BY University of Connecticut

1.0024, AN ANALYSIS OF PHOSPHORUS AND NITROGEN COMPOUNDS IN TIDAL MARSHLAND DRAINAGE - LABORATORY PROCEDURES

F.C. DAIBER, State Board of Game & Fish, *Dover, Delaware*

Objective: An evaluation of the effects of various types of marshland management on the diurnal and seasonal concentrations of phosphorus and nitrogen in tidal marshes.

Procedures: The water samples collected in the field will be processed in the following manner: 1. Inorganic phosphorus - Reimold, R. J., 1965. An evaluation of inorganic phosphate concentrations of Canary Creek Marsh. This procedure requires that inorganic phosphorus determination be made immediately after sample collection to avoid errors due to sample storage. The determination, a spectrophotometric technique, requires electrical power. 2. Total phosphorus - Water samples for total phosphorus concentrations are processed upon return to the Bayside Laboratory. The sample is oxidized in an ordinary autoclave according to the technique of Menzel, D. and Corwin, N. 1965. This procedure converts all phosphorus to the inorganic form which can then be measured by the technique of Reimold as cited above. 3. Organic phosphorus concentration is determined by the difference between the initially measured inorganic form and the subsequent total phosphorus determination. 4. Nitrate nitrogen - Wood, E.D., F. A. J. Armstrong, and F. A. Richards. 1967. This technique offers extreme accuracy and is easily used in the field. In this new method nitrate is converted to nitrite and then measured as in number 5. 5. Nitrite nitrogen - Strickland, J.D.H., and T. R. Parsons. 1960. A manual of sea water analysis. Fish Res. Bd. Can. 125:71-74. 6. Ammonia nitrogen - Roskam, R., and D. de Langen. 1964. A simple colorimetric method for the determination of ammonia in sea water. Anal. Chim. Acta 30: 56-59. 7. Salinity will be measured by the conductance method using an induction salinometer

The results will be processed for computer evaluation of the various suspected relationships between the phosphorus and nitrogen concentrations and related physical parameters measured. The I.B.M. computer program STUFF (Sixteen Twenty Universal Function Fitter) will be used to determine significant relationships between organic phosphorus, inorganic phosphorus, total phosphorus, nitrate, nitrite, ammonia, salinity, water temperature, air temperature, tide state, time, lunar phase, day of year and weather. Other statistical and graphical techniques may also be employed to interpret the data.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Delaware State Government

1.0025, BIOCHEMICAL EFFECTS OF MICROORGANISMS UPON THE SALT MARSH ENVIRONMENT - LABORATORY PROCEDURES

F.C. DAIBER, State Board of Game & Fish, *Dover, Delaware*

Objective: To enumerate and identify the microorganisms indigenous to various salt marsh environments, and to relate the known metabolic processes of the principal organisms found to the chemical cycles currently under investigation in these marshes.

Procedures: The sediment samples collected in the field will be processed in the following manner. 1. Weighed samples from each sediment horizon will be place in dilution bottles containing the appropriate diluent, serial dilutions made and the final dilution will be selectively treated to enhance the growth of the organisms believed to be present in the sample. The number of bacteria in each sediment horizon will be ascertained by plating aliquotes from each final dilution into solid growth media. Replicate plates will be made for each sample. After incubation, the colonies growing on the plates will be counted. The number thus attained represents the number of bacteria in the sample when multiplied by the dilution factor. 2. Identification will be made of the more numerous bacteria growing on the enumeration plates. This will be done by standard bacteriological tests. These include biochemical reactions of the bacteria in specially formulated media, and morphological reactions of the bacterial cell to selective stains. 3. Water pH will be measured by means of a pH meter. 4. Water salinity will be measured by the conductance method.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Delaware State Government

1.0026, BIOCHEMICAL EFFECTS OF MICROORGANISMS UPON THE SALT MARSH ENVIRONMENT - FIELD TECHNIQUES

F.C. DAIBER, State Board of Game & Fish, *Dover, Delaware*

Objective: To enumerate and identify the microorganisms indigenous to various salt marsh environments, and to relate the known metabolic processes of the principal organisms found to the chemical cycles currently under investigation in these marshes.

Procedures: Sediment samples for bacterial analysis will be collected at locations in Delaware tidal marshes which represent the following conditions: unditched marsh exposed to normal flooding, man- made low level impoundments, high level impoundments, and ditched marsh exposed to normal flooding.

Once every two weeks cores will be taken from each station to a depth which represents the sediment horizons of the station. The sample will immediately be removed from the corer and aseptically transferred to clean polyethylene boxes with tight-fitting lids.

The core samples will be transported immediately to the laboratory so that drying will be prevented or minimized before testing.

In addition, sediment temperatures at the time of sample collection will be measured, and water for salinity and pH determinations at each station will also be collected.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Delaware State Government

1.0027, ROTATIONAL STABILITY OF DILUTE POLYMER SOLUTIONS

M.M. DENN, Univ. of Delaware, School of Engineering, *Newark, Delaware* 19711

The proposed research is an investigation of the stability of rotational flow of dilute polymer solutions. Preliminary theoretical and experimental studies suggest that the flow stability can be used as a means of determining rheological properties of systems too dilute for study by conventional measuring techniques. The ultimate goal is to obtain improved understanding of mechanisms of changes in mass and momentum transport in polymeric systems for application to one and two phase water treatment systems.

1. NATURE OF WATER

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Delaware

1.0028, ROTATIONAL STABILITY IN DILUTE POLYMER SOLUTIONS

M.M. DENN, Univ. of Delaware, School of Engineering, *Newark, Delaware* 19711

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SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Delaware

1.0029, THE HEATS OF MIXING OF STRONG ELECTROLYTES

R.H. WOOD, Univ. of Delaware, Graduate School, *Newark, Delaware* 19711

It is proposed to extend the measurements and the general equations to include mixtures of electrolytes with different charge types. Some measurements of $MgCl_2$ and $BaCl_2$ mixture with LiCl, NaCl, KCl and CsCl have been started in this laboratory and it is proposed to finish these measurements and include $CaCl_2$ and $SrCl_2$ mixtures as well. In addition, a study of the heats of mixing of Li_2SO_4, K_2SO_4, with the alkali metal halides would be useful.

In order to get at the relative influences of water structure and size on the interactions, the preparation of $(HOC_2H_4)_4$ NCl and $(HOC_3H_6)_4$ NCl will be attempted. If successful, the heats of dilution and mixing of these electrolytes would allow the comparison of the properties of large ions with and without hydrophobic surfaces. In addition, the heats of dilution of some strong electrolytes will be measured in D_2O.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0030, A STUDY OF HYPERSONIC WAVES IN WATER AND IN AQUEOUS SOLUTIONS

T.A. LITOVITZ, Catholic University of America, Graduate School, *Washington, District of Columbia* 20017

It is the purpose of this investigation to apply a significant recent advance in the technique of measurement of high frequency ultrasonic waves to the problem of the structure of water and its modification when ions are present. The effect of the ions will be considered from a relaxation viewpoint. The direct effect of the ions on structural relaxation of water will be considered. This will be done through a study of the effect of ions on the high frequency structural viscosity values. In addition the chemical relaxation process involved in the dissociation of ions will be considered at frequencies not possible before advent of the laser.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0031, RADIOISOTOPIC TRACER STUDY TO INVESTIGATE THE MECHANICS OF LITTORAL TRANSPORT AROUND POINT CONCEPTION, CALIFORNIA

D. DUANE, U.S. Army, Coastal Engin. Res. Center, *Washington, District of Columbia* 20016 (AT(49-11)-2988)

A study to develop techniques to measure sediment movement in the littoral zone is specifically designated for the Point Conception area of the Pacific coast. The basic development program includes a radiation monitoring system capable of deep water monitoring of radioisotopes tagged into sand, analysis of data obtained from measurement of the distribution of the radioisotope tagged sand that has been subjected to the normal effects of waves, tides, and along- shore currents; methods for tagging sand without altering its hydraulic properties and hazard evaluations of the entire transport measuring system. The system is adaptable to sediment transport in both fresh and salt water to depths of 175 fathoms.

The isotope used for sand tagging is ^{133}Xe, thus providing no significant radiation hazard and no alteration of the hydraulic properties of sand indigenous to the test area.

The radiation detection system utilizes scintillation type detectors. Data collection is obtained on punched tape and digital readout from a 400-channel analyzer. Data may be simultaneously coordinated with depth, salinity, and temperature during the monitoring operation.

Cooperative program of federal and state agencies, including:

U. S. Army, Corps of Engineers
U. S. Navy, Pacific Missile Range
U. S. Air Force, First Strategic Aerospace Division, SAC
National Aeronautics and Space Administration
U. S. AEC, Oak Ridge National Laboratory
State of California, Department of Water Resources.

SUPPORTED BY U.S. Atomic Energy Commission

1.0032, INVESTIGATIONS IN ISOTOPIC HYDROLOGY

G.L. STEWART, U.S. Dept. of Interior, Water Resources Division, *Washington, District of Columbia*

The objective of this study is the investigation of water movement through the sequences of the hydrologic cycle by means of the labels provided by isotopes and the fractionations and concentration changes that accompany isotopic processes.

The following phases of this project have been established: 1. A survey of tritium in precipitation since the spring of 1959. 2. A survey of tritium in surface waters at sites on 12 major rivers in the United States. 3. Dispersion and exchange of tritium in porous materials. 4. Evaporation and environmental experiment to study the cyclic return of tritium to the atmosphere. 5. A study of water movement through the Savannah River Georgia area. 6. Work with other Geological Survey investigators in applying isotopic tracer techniques (tritium) to specific water tracing problems.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

1.0033, VISCOSITY STUDIES OF AQUEOUS SOLUTIONS

W. DROSTHANSEN, Univ. of Miami, Graduate School, *Miami - Coral Gables, Florida* 33124

Measurements of the viscosity of various aqueous solutions, in particular, with a number of electrolytes to determine B coefficients (in the Dole-Jones equation) and values for dB/dt. These measurements will be carried out over extended temperature ranges and wide concentration ranges. Similar measurements will also be made on electrolytes in mixed solvents (non electrolyte - water solvents).

We intend to measure the viscosity of various non electrolyte solutions in water, particularly aqueous alcohol solutions including tertiary butanol.

It is intended to measure the viscosity of heavy water as a function of temperature to obtain similar information regarding the energy of activation for viscous flow of deuterium oxide as was obtained for pure water in our earlier study.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0034, CHEMICAL ANALYSES

A.J. WILSON, U.S. Dept. of Interior, Biological Laboratory, *Sabine Island - Gulf Breeze, Florida*

In order to evaluate data now being obtained by a nationwide surveillance of organochlorine pesticide pollution in estuaries, studies are in progress to determine rates of uptake and the metabolism of these pollutants in marine species.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

1.0035, STRUCTURE IN SOLVENTS AND CONCENTRATED SOLUTIONS

G.R. CHOPPIN, Florida State University, Graduate School, *Tallahassee, Florida* 32306

The near infrared spectrum of water and saline solutions is to be studied as a function of temperature and solute concentration. The D_2O solvent systems are to be studied similarly. The spectral curves would be analyzed to obtain the mole fractions of solvent molecules in different states of hydrogen bonding. Solutions of H2O and D2O with organic solutes would be studied in the same manner. The primary interest is to ascertain the effect of ionic and organic solutes on solvent structuring via hydrogen bonding. The first question to be considered is the validity of the Buijs and Choppin interpretation of the near infrared spectra of water and aqueous solutions. Careful study of spectral curve shapes and baselines are an integral part of such an evaluation.

The near infrared spectra of hydrated organic ion exchange resins would be studied by the reflectance technique. The analysis would follow that for the aqueous solutions. If successful, comparison of these results with NMR data of hydrated ion exchangers could provide a much more detailed model of the solution state in an ion exchange resin.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0036, ENERGETICS AND STRUCTURE OF THE HYDROGEN BOND

J.C. DAVIS, Univ. of South Florida, Graduate School, *Tampa, Florida* 33620

In order to eliminate the problems of a large variety of hydrogen- bonded species that are present in most aqueous and alcohol systems, this study is limited to investigation of highly-hindered alcohols (such as tri-i-propyl carbinol, etc.) in non-hydrogen bonding solvents. Proton magnetic resonance measurements of the OH chemical shifts and infrared measurements of the OH stretching bands are being utilized to calculate monomer-dimer equilibrium constants and enthalpies of association in these systems. Precision dielectric constant measurements of the same solutions are being employed to estimate apparent dipole moments for the associated species with the aim of discerning the approximate geometry of the dimer species.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0037, A LABORATORY STUDY OF THE SOLUBLE METALS IN ROCKS, SAPROLITE, AND SOIL FROM THE BROAD QUADRANGLE, GEORGIA

C.A. SALOTTI, Univ. of Georgia, Graduate School, *Athens, Georgia* 30602

The primary purpose of this study is to determine in the laboratory the solubilities of extractable trace metals of rocks, saprolite, and soils from the Broad Quadrangle, Georgia in relation to the following variables: temperature; pH; redox potential; organic solutions; and time.

The experiments will be at low temperatures and pressures. The system will be entirely made from fluorocarbon resin.

Analysis will be mostly done in a custom atomic absorption spectrophotometer that is considerably more sensitive than any available commercial unit. Elements present in readily detectible amounts will be determined using a Perkin-Elmer 303 Atomic Absorption Spectrophotometer. Elements already detected in ground water from the Broad Quadrangle without concentration include the following: Mg, Ca, Mn, Fe, Al, Si, Zn, Cu, Pb, and Li. In addition Mo, Ba, Sr, Hg, V, Cr, Ni, Co, Sb, Sc, and As will also be looked for.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Georgia

1.0038, OXYGEN TRANSFER TO WATER DROPLETS

P.G. MAYER, Georgia Inst. of Technology, School of Engineering, *Atlanta, Georgia* 30332

The reaeration of oxygen-deficient streams and lakes is of utmost importance to the full utilization of water resources.

A possible method for obtaining water with relatively high concentrations of dissolved oxygen is that of spraying oxygen-deficient water into a pressurized tank with pure oxygen or with air. The water would fall through the atmosphere, absorbing oxygen as it did so, and collect in a receiving pool from which water could be withdrawn to enrich oxygen-deficient waters.

A preliminary theoretical and experimental investigation was conducted with an oxygen atmosphere. A literature survey was made of the basic interphase mass transfer theories. The preliminary experimental study employed a 75 gallon tank into which water was sprayed through whirl-type nozzles. The operating pressures ranged from zero to approximately 10 atmospheres. Oxygen concentrations were measured with galvanic oxygen analysers. For the pressures applied, a fifteen-fold increase in dissolved oxygen concentration could be obtained.

The present work is carried out with compressed air in an improved reactor. It is proposed to study the cost-efficiency of the method in its application to oxygen-deficient streams and lakes.

SUPPORTED BY Georgia Institute of Technology

1.0039, THE STRUCTURE AND PROPERTIES OF WATER SOLUTIONS

R.A. PIEROTTI, Georgia Inst. of Technology, Water Resources Center, *Atlanta, Georgia* 30332

The research proposed is an effort to separate the interaction of the solute with water into two parts: the solute-water interaction and the solute-solute interaction in the presence of water. Accordingly, the proposed research is made up of two parts: (a) An experimental study of the solubility of simple molecules in both H2O and D2O as a function of temperature and (b) a theoretical study of the nautre of solute-solute interactions in a condensed medium.

The experimental study will be aimed at determining the thermodynamic properties of dilute aqueous solutions and associating these properties with the structure of liquid water and heavy water. The initial studies will be concerned with the solubilities of small organic molecules, i.e., benzene, toluene, carbon tetrachloride, etc.

Comparisons of the solubility of simple non-polar molecules in H2O and D2O can be very important in understanding the effects of the water structure around solute molecules. The measurements made in this part of the research will be in the Henry's Law region and as such are concerned primarily with the nature and magnitude of the solute-solvent interaction energy.

The theoretical study is an attempt to use solubility data in the region of deviations from Henry's Law to ascertain the form of the potential energy function for the solute-solute interaction as perturbed by the solvent. The formalism of statistical thermodynamics will be used to develop a theoretical technique for evaluating the potential functions for solute-solute interactions from gas solubility measurements.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Georgia Institute of Technology

1.0040, APPLICATION OF MODERN ELECTROANALYTICAL TECHNIQUES TO THE ANALYSIS OF HEAVY METALS IN WATER

P.E. STURROCK, Georgia Inst. of Technology, Water Resources Center, *Atlanta, Georgia* 30332

The proposed research plan involves laboratory and field investigations directed at determining the suitability of modern electroanalytical techniques for the analysis of water for trace contaminations by heavy metals. The approach will be to determine the sensitivity limits, accuracy and interferences for a number of metal ions using solutions of known concentrations prepared in the laboratory. Then the procedures and techniques developed will be tested on samples obtained from various points along the Chattahoochee River to see if point to point and day to day fluctuations of heavy metal concentrations can be observed.

Laboratory investigations will employ the following methods: 1. Square-wave polarography. 2. Phase-selective A.C. polarography. 3. Derivative chronopotentiometry.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Georgia Institute of Technology

1.0041, METHOD FOR QUANTITATIVE ANALYSIS OF PHENOLS IN FUEL CELL PRODUCT WATER

H.J. ONEILL, I I T Research Institute, *Chicago, Illinois*

Techniques for determining phenolic material at the 100-ppb level and hydroquinones and quinones at the 1-ppm level in fuel cell product water were developed. The analyses can be performed on 1 ml of water and require approximately 1 hr.

The phenol procedure involves a preliminary steam distillation in a silanized distillation apparatus and spectrophotometric determination with 4-aminoantipyrine as the reagent. In order to achieve adequate resolution and sensitivity, a reagent-blank compensation procedure is described. Techniques for increasing the sensitivity fivefold are recommended.

Hydroquinone and quinone determinations are performed with phloroglucinol as the reagent and by direct ultraviolet scanning. The former method is the method of choice for hydroquinone and quinone because it can be performed directly on the product water and because other extraneous organic matter in the product water does not appear to interfere, at least at the 1-ppm level. Sensitivity to t-butyl hydroquinone by this method is poor. The ultraviolet procedure exhibits greater specificity for individual components, but it requires removal of the aromatic sulfonic acids prior to analysis.

SUPPORTED BY General Electric Company

1.0042, DIFFUSION IN TERNARY AQUEOUS SALINE SOLUTIONS

R.P. WENDT, Loyola University, Graduate School, *Chicago, Illinois* 60611

The objective of this research will be to measure and interpret diffusion coefficients over the concentration range 0.1 to 2.0 molar for each salt in ten solutions, each consisting of two seawater-type salts and water. It is also expected that useful contributions to the theory of nonequilibrium thermodynamics will be made, with respect to predicting diffusion and ionic phenomenological coefficients.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0043, THERMODYNAMICS OF WATER AND WATER SOLUTIONS

M.J. JONCICH, Northern Illinois University, Graduate School, *Dekalb, Illinois* 60115

Heats of solution will be carried out over the temperature range of 0-50 degrees C on salts containing the ions; Na , K , Ca , Mg , Cl-, CO_3, SO_4 and others as well as the gases; O_2, N_2, and CO_2. The integral heat method will be used to determine partial molal heat capacities of the above salts and gases. Extrapolation to finite dilution of the data will permit evaluation of partial molal heat capacities and entropies at infinite dilution.

Use will be made of these data to check the 'Correspondence Principle' of Cobble and to permit calculation of partial molal ionic thermodynamic properties. The changes in the thermodynamic properties of the solutes will be related to the change of structure of water. These results will be correlated with the theories of Nemethy-Scheraga, Frank-Quist, Eryring, and Samoilov concerning the structure of water and the effects of dissolved electrolytes and gases.

The same experimental data will be used to determine co-ordination numbers of the ions and gases using the theoretical approach proposed by Samoilov.

SUPPORTED BY Illinois State Government
University of Illinois

1.0044, INTERFACIAL WATER STRUCTURE AND PROPERTIES

W.F. CLAUSSEN, State Water Survey, *Urbana, Illinois*

A basic study into the nature of the water surface is being undertaken in the following ways: a) Experimentally, the variation of surface tension with temperature for pure water and for water solutions of hydrating gases, such as propane, will permit assessment of the role of the hydrating shell water structure in surface water structure. b) A theoretical approach is being made toward the understanding of surfaces by relating the thermodynamics of surface formation to the critical phenomena and to the vapor pressure, for pure water and for other polar and non-polar liquids. c) Applications of knowledge of the water surface are being sought in the areas of transpiration, corrosion, and fog stability.

SUPPORTED BY Illinois State Government

1.0045, FLOW FIELD IN A PACKED BED

T.J. HANRATTY, Univ. of Illinois, Graduate School, *Urbana, Illinois*

A study of the details of the flow around a single sphere in a packed bed of spheres is being conducted. It differs from previous work since attention is being focused on local happenings on a scale smaller than the particle diameter. An instrumented test sphere located in a cubic array of spheres allows measurements of the pressures and of the instantaneous local shear stress and mass transfer rate to the surface of the sphere. Visual studies are also being conducted.

SUPPORTED BY Amer. Chemical Society

1.0046, CONVECTION IN ROTATING FLUIDS

J.L. HUDSON, Univ. of Illinois, Graduate School, *Urbana, Illinois*

An analysis has been made of centrifugally-driven thermal convection in a rotating cylinder. Fluid motion relative to a coordinant system rotating with the cylinder is produced by the action of the centrifugal force on a vertical density gradient. The analysis points out the effects of the Coriolis and centrifugal accelerations in this system. An apparatus has been built to studt this problem and preliminary measurements have been taken.

Experiments on the isothermal flow near an enclosed rotating disk have also been carried out. The fluid motion is observed by taking photographs of neutrally buoyant beads.

SUPPORTED BY Amer. Chemical Society

1.0047, THE EFFECT OF WATER STRUCTURE ON BIOLOGICAL ACTIVITY

R.J. MILLER, Univ. of Illinois, Agricultural Experiment Sta., *Urbana, Illinois*

Objectives: (l) To determine if water structure, be it that of free water or that associated with ions, is important in membrane transport phenomena. (2) To determine if water structure that is altered by surfaces affects microbial growth.

Work Proposed: The structural integrity of water will be varied using ions, surfaces and temperature. The activity of bacteria and corn mitochondria will be studied as the structure of the aqueous solutions are varied. By correlating changes in the water structure and biological activity it should be possible to determine if the structure of water is important in biological processes.

SUPPORTED BY U.S. Dept. of Agriculture
Illinois State Government

1.0048, CONVECTIVE INSTABILITY IN TRANSIENT SYSTEMS

R.L. SANI, Univ. of Illinois, Graduate School, *Urbana, Illinois*

The primary goal of this investigation is the mathematical characterization of the stability of transient hydrodynamic systems exhibiting transport and transformation processes that are coupled at the macroscopic level. Approximate solution techniques are being developed and utilized in the analysis.

SUPPORTED BY University of Illinois

1.0049, TRANSPORT PROPERTIES OF AQUEOUS ELECTROLYTE SOLUTIONS - AN APPROACH FROM THE HIGH CONCENTRATION LIMIT

C.A. ANGELL, Purdue University, Graduate School, *Lafayette - West Lafayette, Indiana* 47907

The transport behavior of highly concentrated and supersaturated electrolyte solutions, which is clearly intractable using the Debye- Huckel approach, has proven very amenable to analysis by means of simple equations originally proposed to describe the temperature dependence of transport processes in glass-forming organic liquids (which include most liquid polymers and polymer solutions). Transposed forms of these equations which give a convincing first order approximation account of the concentration dependence of electrolyte solution conductance and viscosity, have recently been proposed and discussed by the principal investigator. These equations have as their theoretical basis the assertion that, providing the first order transition to the crystalline state is averted, the liquid state properties of an assemblage of attractively interacting particles must vanish at a temperature T sub zero (where T sub zero is greater than 0 degrees K) due to the vanishing of the configurational entropy content. The phenomenon of the liquid-glass transition is directly related to this circumstance. T sub zero is a function of equivalent concentration and for salts of multivalent cations reaches room temperature for solutions less concentrated than the pure (metastable) liquid salt. The condition (T sub zero equals isothermal temperature) may thus set the high concentration limit (N sub zero) for electrolyte transport in such a system.

The present work is concerned with a determination of the useful limits of this approach and the clarification of the physical nature of the transport equation parameters.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0050, THE PROPERTIES OF CLAY-ADSORBED WATER

P.F. LOW, Purdue University, Agricultural Experiment Sta. , *Lafayette - West Lafayette, Indiana* 47907

Description of Work - During the coming year an attempt will be made to determine whether or not water in a clay paste has sufficient rigidity that a threshold pressure gradient must be exceeded before it begins to flow.

SUPPORTED BY Indiana State Government

1.0051, INTERMOLECULAR FORCES AND THE LIQUID STATE

C.R. MUELLER, Purdue University, Graduate School, *Lafayette — West Lafayette, Indiana* 47907

The research objective is the accurate determination of the intermolecular potential in regions of interest to liquid state theory by means of the crossed molecular beam technique and the calculation of the statistical mechanical properties of the liquid state using these forces.

The substances investigated will include the noble gases and the simple hydrides, CH4, NH3, and H2O. The ultimate aim is to further our understanding of the liquid state both where hydrogen bonding is present and absent and about hydrogen bonding and the structure of H2O.

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SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0052, DISSOLVED GASES AND WATER CLUSTERING IN AQUEOUS SOLUTION

G. GORDON, Univ. of Iowa, Graduate School, *Iowa City, Iowa* 52240

The purpose of this research is to study the kinetic and equilibrium properties of dissolved gases and related materials in aqueous solutions. By means of this type of approach, which utilizes a variety of methods, it appears to be possible to rationalize some of the complexities of the solvent. Thus we should be able to obtain more definite conclusions about the primary steps in chemical reactions and positive information with respect to the species in solution and their interactions with water itself.

Presently, we are studying the C102-H20 system by means of techniques such as classical thermodynamic properties, electron paramagnetic and nuclear magnetic resonance spectroscopy, optical spectroscopy, temperature jump, and other kinetic measurements. By means of the above techniques, we hope to elucidate the modus operandi of these observations. Initially, we are studying chlorine dioxide in water as a model system. We intend to extend our measurements to include other ionic and molecular species such as CO2, SO2, SO3, (t- BU)4NBr and the like.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0053, FIXATION AND AVAILABILITY OF ADDED PHOSPHORUS IN SOILS

J. HAGIN, Technion Res. & Develop. Fdn. , *Haifa, Israel*

Object: To evaluate the phosphorus availability and fixation of various fertilizers, in different soils, as related to their nutritive value.

Plan of Work: Diffusion of phosphorus from the vicinity of a fertilizer particle is determined by (1) the apparent diffusion coefficient--this is a function of the reactions of phosphorus with soil components and properties; and (2) the potential gradient between the solution near the particle surface and the bulk soil solution- this is a function of change in phosphorus concentration in the soil solution and of the path length. In the first phase the solubility of various phosphatic fertilizers in defined solutions as well as in soil systems will be measured. The relation of the phosphorus concentration on the fertilizer particle surface to the amount and rate of solubilization will be studied. In the second phase the influence of soil properties on phosphate diffusion will be evaluated and measured by changes in the concentration of phosphorus in the soil zone surrounding the fertilizer particle, taking into account the concentration gradient between the particle surface and the bulk soil. Fixation rate, in soils, of phosphorus from various fertilizers will be measured. Factors affecting the solubility and availability of phosphates will be measured, for example, solubilization of difficultly soluble coats formed on originally soluble phosphates.

SUPPORTED BY U.S. Dept. of Agriculture

1.0054, MODE OF OCCURRENCE OF MINOR ELEMENTS IN SEDIMENTS AND SOILS

D.H. YAALON, Hebrew University, *Jerusalem, Israel*

Object: To determine the mode of occurrence and geochemical transformations of micronutrients during weathering by measuring their presence in ground water and their distribution among different particle size fractions of various soils and rocks. Elements under study will include copper, zinc, cobalt, nickel, boron, chlorine, iodine, sulfur and possibly others.

Plan of work: Trace elements content in several separate fractions of the materials examined will be determined. This will include the water soluble and acid soluble fractions, and elements associated with the organic matter extract. Soils and silicate materials will be separated into clay, silt and sand size fractions, and additional mineralogical separation accomplished by heavy liquid separation. The noncarbonate residue of limestones and calcareous soils will be similarly treated. Ground water composition will be related to the soil and rock analyses. It is proposed to examine, in the course of three years, the major soil groups and sedimentary rocks occurring in the Eastern Mediterranean. Results may be subjected to a proper statistical analysis and correlated with other known properties of the materials. Samples from other regions may be added subsequently.

SUPPORTED BY U.S. Dept. of Agriculture

1.0055, TRACE ELEMENT CHEMISTRY OF STREAMS OF THE LOWER KANSAS RIVER BASIN

E.E. ANGINO, Univ. of Kansas, State Geological Survey, *Lawrence, Kansas* 66045

Study of the annual variation of trace element content (Co, Ni, Li, Si, Zn, Fe, Mn, Sr) of the Saline, Smoky Hill, Solomon, Delaware, Wakarusa and Kansas Rivers was undertaken for two reasons. (1) To develop methods for trace element analyses of water samples by atomic absorption spectrometry and (2) To accumulate information on the 'back- round' trace element load of these streams for which little elemental data is presently available. This latter consideration was considered in light of studies relating to water pollution studies of the Kansas River. The work consists of collection, preparation, analysis of the samples and interpretation of results.

SUPPORTED BY Kansas State Government

1.0056, UTILIZATION OF OIL FIELD BRINES AS A POSSIBLE FERTILIZER SOURCE

E.E. ANGINO, Univ. of Kansas, State Geological Survey, *Lawrence, Kansas* 66045

Large amounts of oil-field brines are produced annually in Kansas. Experimental work is being conducted to determine the feasibility of recovering a useable fertilizer material from these brines, subsequent to appropriate chemical treatment. Results, to date, are encouraging, but additional evaluation work is required. The work includes (1) determining the nature of the separated product by x-ray diffraction analysis, (2) determining the chemical composition of the complex precipitated product by atomic absorption and emission spectrography, and (3) evaluating the product from different brines to ascertain the constancy of the product produced.

SUPPORTED BY Kansas State Government

1.0057, THERMAL PROPERTIES OF SALT SOLUTIONS

R.J. BEARMAN, Univ. of Kansas, Graduate School, *Lawrence, Kansas* 66045

The objective of the proposed work is to investigate the thermal conductivity of aqueous salt systems. We plan to construct apparatus fo the determination of thermal conductivity, to measure the thermal conductivity and to develop theoretical equations for the interpretation of the results.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0058, INTERACTION OF ORGANIC MOLECULES IN WATER

T. HIGUCHI, Univ. of Kansas, Graduate School, *Lawrence, Kansas* 66045

The proposed study is concerned with elucidation of enzymatic catalytic mechanism and, indirectly, action of drugs. The program is based on series of investigatoins of model systems. Approximately one half of the total effort will be directed towards elucidation of mechanisms of molecular binding or association in aqueous media, the remainder to chemistry of facilitation of reactions in aqueous solution by organic species and functional gropuings. Primary attention has been directed towards hydrolytic reactions of acyl derivatives such as esters, amides, acid anhydrides, acyl halides, etc., and catalyzed oxidation of thioethers.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

1.0059, ION HYDRATION AND ION INTERACTION

G. ATKINSON, Univ. of Maryland, Graduate School, *College Park, Maryland*

Measurements will be made of ultrasonic absorption in aqueous solutions of Mg(II) and Ca(II) salts in an effort to examine the effect of ‘inert electrolytes‘ such as NaCl on ion association processes. Measurements of ultrasonic absorption in aqueous solutions of tetraalkylammonium salts will be expanded and extended to non-ionic clathrate forming compounds. A cooperative program on the measurement of ultrasonic absorption and velocity in aqueous solutions of simple salts over wide ranges of frequency, temperature and pressure will be further implemented. This program involves this research group and the acoustics research groups at Catholic University and American University.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0060, CLOSED SYSTEMS FOR ANIMAL SEWAGE TREATMENT

J.T. CLAYTON, Univ. of Massachusetts, School of Agriculture, *Amherst, Massachusetts* 01003

The specific objectives of the proposed research are: (1) To develop a waste stabilization system that will minimize the polluting strength of manure and other dairy farm wastes; and (2) to clarify, by digestion and subsequent treatment, the liquid (or liquifiable) parts of dairy farm wastes so that the system effluent can be safely disposed of or used as the agent for subsequent cleanings of the dairy facility.

Two experimental sewage processing systems will be used. The first will consist of primary settlement of the influent with secondary aerobic digestion. In the second system aerobic digestion will precede settlement. Effluent quality and the fate of indicator organisms, will be the principal criteria of performance.

Microbiological determinations will be made in order to obtain the following information: (a) the activities in the various states of the process; (b) the public health hazards associated with the final sludge and effluent; and (c) to determine the degree of disinfection necessary before discharge.

Later experiments will include the use of coagulants, coagulant aids, and chemical treatments. Dosage and effectiveness of ion exchange minerals and resins will be investigated with special emphasis on odor and color effects. Chemical treatments for microorganism control and small organic particle removal will be studied.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Massachusetts

1.0061, SPECTROSCOPIC AND DIELECTRIC STUDIES OF NEW HYDROGEN BONDED SPECIES

R.R. HOLMES, Univ. of Massachusetts, Graduate School, *Amherst, Massachusetts* 01003

It is proposed to carry out an appropriate experimental program which will lead to a more precise understanding of the energetics involved in hydrogen bonding phenomena and establish experimental conditions favoring the formation of new hydrogen-bonded complexes involving water. In this regard spectroscopic studies (including far- infrared measurements), dielectric studies, and vapor density measurements will be performed.

In order to aid the development of the theory, it is necessary to provide detailed experimental information describing hydrogen bonding phenomena in water and related substances. Most studies of hydrogen bonding deal with the condensed phase, liquid or solid, and suffer the disadvantage, that because of complications arising from intermolecular interactions, an aggretate of hydrogen-bonded systems are present. What one is then measuring is an average property associated with the aggregate.

Little attention has been given to gas phase systems, even though these systems provide a more ideal environment. In such a system an opportunity is provided to isolate a particular hydrogen bond, free from intermolecular effects. An investigation of a hydrogen bonding system in the gas phase and comparison with the results of the condensed phase study of the same system should provide greater insight, first of all, into the nature of a hydrogen bond and, secondly, the changes that occur in going from the gas to the condensed state.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0062, THE ROLE OF WATER IN ORGANIC REACTIONS

C.G. SWAIN, Mass. Inst. of Technology, Graduate School, *Cambridge, Massachusetts* 02139

Research designed to determine the mechanism of common polar reactions in solution in considerable detail, the exact structures of their transition states, how these change with the structure of the reactants, and the nature of any intermediates, to discover new tools and principles to aid in the study of mechanisms and to develop new quantitative relations between structure and reactivity. Reactions under study include halide and ester solvolyses, ketone enolization, carbonyl addition reactions, and displacements on carbonyl carbons. Also, being investigatedare mechanisms of aicd, base and polyfunctional catalysis, the structure of water and water solutions, and solvent isotope effects in light and heavy water.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

1.0063, EFFECTS OF POLAR ORGANIC SOLVENTS ON ENZYME ACTION

Y. KU, Monsanto Research Corporation, *Everett, Massachusetts* 02149

Objective: a. Problem: The objective of this research is an extensive investigation of enzyme reactions in high concentrations of polar organic solvents to determine the role of water in enzyme catalysis. b. Application: Virtually all speculation on extraterrestrial life begins with the assumption that water is necessary for life, based on the argument that enzymes are necessary for life, and enzymes require water.

Approach: The kinetic parameters of enzyme-water interaction; the real significance of 'bound water' associated with dissolved enzyme; the nature of pH versus activity for enzyme reactions; thermal stabilities of enzymes in the dry state versus aqueous; and enzymatic reactions below 0 degree C will be determined.

SUPPORTED BY U.S. Natl. Aero. & Space Adm.

1.0064, AN INVESTIGATION OF ION MOBILITY IN AQUEOUS SOLUTIONS

S.B. BRUMMER, Tyco Laboratories Incorporated, *Waltham, Massachusetts*

It is proposed to investigate the basic mechanism of translational processes in liquids. The limiting ionic conductance in aqueous solutions will be used as a model for the study. Measurements will be made over a wide range of temperature (0-80 degrees C), pressure (1-3000 atmos) and concentration (10 to the minus 4 power - 10 molar), for a range of simple salts. Such studies of the P-V-T characteristics of the systems as are required will be made, but the emphasis will be on making a careful and thorough investigation of the temperature and pressure coefficients of the limiting ionic conductance. In analyzing the data, particular attention will be paid to separating the effects of temperature and density. These two fundamantal parameters have almost invariably been confused in the past and it is thought that a considerable clarification of the mechanism of transport processes in aqueous solutions will be obtained if their effects are carefully distinguished.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0065, THE USE OF AMALGAM ELECTRODES TO MEASURE ACTIVITY COEFFICIENTS OF METAL SALTS IN MULTICOMPONENT SALT SOLUTIONS

J.N. BUTLER, Tyco Laboratories Incorporated, *Waltham, Massachusetts*

Electrodes consisting of a dilute amalgam of a metal such as Na, K, or Ca, with mercury, can be used to measure directly the activity coefficients of salts of the metal in multicomponent salt solutions. Such measurements greatly extend our present knowledge of the thermodynamics of multicomponent salt solutions.

The important factors in obtaining accurate activity coefficient measurements with amalgam electrodes are (1) purity of reagents, (2) rigorous exclusion of oxygen from the system, and (3) corrections for dissolution of the amalgam. An experimental system for carrying out these measurements is being constructed.

The proposed research program includes measurements on the systems KCl-NaCl and LiCl-NaCl, which can be compared with results of the isopiestic method; and the systems MgCl2-NaCl and CaCl2-NaCl, which are of importance in connection with the chemistry of sea water.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0066, NITRIFICATION BY MARINE MICROORGANISMS

S.W. WATSON, Woods Hole Oceanographic Inst. , *Woods Hole, Massachusetts* 02543

This proposal is for the continuation and expansion of our studies on the role nitrifying bacteria play in the ocean and the molecular mechanisms by which these organisms convert, store and utilize energy derived from the oxidation of ammonia or nitrite. The specific objectives include: (1) the isolation and purification of new marine nitrifying bacteria; (2) the determination of the vertical and horizontal activity and distribution of nitrifying bacteria in the open ocean; (3) a morphological study of the fine structures of nitrifying bacteria; (4) a study of the metabolic pathway by which marine nitrifying bacteria oxidize ammonia to nitrite and nitrite to nitrate using cell free systems; (5) an attempt to elucidate the reason or reasons why nitrifying bacteria are obligate autotrophs (6) a study of the role of the submicroscopic cytomembrane systems and other submicroscopic structures observed in Nitrosocystis oceanus, Nitrosomonas europaea and Nitrobacter agilis; (7) a study of the kinetics of nitrification; (8) the development of new cultural techniques.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

1.0067, ASYMMETRIC BUBBLE COLLAPSE STUDIES 6310

F.G. HAMMITT, Univ. of Michigan, School of Engineering, *Ann Arbor, Michigan* (DAHC04-67-C-0007)

Objective: To investigate the manner of asymmetric collapse of cavitation bubbles in various hydrocynamic situations.

Approach: Both theoretical and experimental methods will be used. It is planned to: (1) Obtain photographic evidence of the actual nature of bubble collapse in a flowing system under substantial pressure gradients, (2) Develop theoretical analyses of collapsing cavities to correlate with the experimental observations in order to better understand the influence of various boundary conditions on the mode of collapse, (3) interpret the theoretical results in terms of the potential of cavities in a liquid to damage solids, drawing on knowledge already obtained and to be obtained in the proposed work from the experimental observations.

Progress: The asymmetric mode of collapse of cavitation bubbles has been studied both experimentally and theoretically. In the experimental investigation, a spark camera capable of taking 12 frames in a period of the order of 20 sec. has been built and tested. The detailed analysis of pictures produced by this camera is under way. A study of the theoretical problem has led to a decision to use a MAC (Marker and Cell) type of computer code as the basis for a numerical solution of the governing differential equations. The code has been written and checked out by application to the symmetrical bubble collapse problem (Rayleigh's problem) to which an analytical solution is known. Work is in hand on the application of the code to the asymmetric problem.

SUPPORTED BY U.S. Dept. of Defense - Army

1.0068, EFFECTS OF LIMNOLOGICAL FACTORS ON UPTAKE OF CS137 BY FISH

N.R. KEVERN, Michigan State University, Institute of Water Research, *East Lansing, Michigan* 48824 (AT(11-1)1795)

Certain limnological factors, theoretically suspected for influencing the accumulation of 137Cs by fish, are being investigated in a series of lake types. Multiple regression analysis will be used to determine which of the factors are the most important. The factors measured in each of the six lakes will be cesium-137, stable cesium, sodium, potassium, and specific conductivity along with standard limnological measurements of pH, alkalinity, temperature, dissolved oxygen, and secchi disc readings. Measurements of the concentrations of 137Cs and stable Cs in samples of largemouth black bass from each lake and in the lake waters will allow demonstration of the importance of the specific activity of the water on the accumulation of 137Cs by fish. A second phase of the project will be directed at testing if trophic position is a factor in the accumulation of 137Cs. Other studies, at least in terrestrial ecosystems, have indicated an increase of 137Cs concentrations of about three-fold between trophic levels. Samples of the aquatic plants and organisms, including fish, from a single lake and representing the trophic levels of producer, herbivore, omnivore, and carnivore will be analyzed for 137Cs content and compared. The overall objective of the study is to gain the knowledge necessary to permit us to predict maximum concentrations of 137Cs in iced fishes from estimated inputs of the radionuclide to natural waters.

1. NATURE OF WATER

SUPPORTED BY U.S. Atomic Energy Commission

1.0069, GEOCHEMICAL INVESTIGATION OF THE GROUNDWATER SYSTEM IN THE LANSING, MICHIGAN, AREA

S.B. ROMBERGER, Michigan State University, Graduate School, *East Lansing, Michigan* 48824

This program involves the collection of baseline geochemical data on subsurface water in contact with the Saginaw formation, the most important groundwater aquifer in the Lansing area. These data will be used to evaluate new sources of potable groundwater to supplement the presently dwindling supply of uncontaminated surface water. Subsurface chemical data will be correlated with water quality data already available for surface waters, and the chemical composition of the enclosing rocks to determine their role in controlling the chemistry of groundwater. The major constituents to be determined are hydronium ion (pH), sodium, calcium, potassium, magnesium, iron, bicarbonate, sulfate, chloride, nitrate, and phosphate. The state of equilibrium of the groundwater with its environment will be calculated using thermodynamic data. Reactions of contaminated surface water with groundwater and earth materials will be investigated both in the field and in the laboratory to determine beneficial and deleterious products. Using the data collected and the environmental factors determined, a geochemical model will be calculated.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Michigan State University

1.0070, TRAVEL OF NITROGEN IN SOILS

G.J. SCHROEPFER, Univ. of Minnesota, School of Engineering, *Minneapolis, Minnesota* 55455

Work on the project began in October of 1962. Initial work included soil lysimeter studies as well as bench experiments in which soils and contamination waters were intimately mixed. These studies were directed at determining the chemical and physical factors affecting the travel of nitrogen compounds. In 1963 a sampling program was initiated to obtain field data to correlate with laboratory results. Ground water observation wells were installed in the vicinity of waste stabilization ponds and septic tank tile fields. This field sampling program is continuing at present on a expanded scale. In 1965 a controlled feed soil absorption system was installed employing synthetic substrate, along with a system of 12 observation wells, to determine the rate of nitrate formation and its movement in ground water.

An additional controlled feed soil absorption system has been installed in a soil with an effective size serveral times smaller than that of the original system. Additional pond studies are also being carried on. These systems, along with a study of the microorganisms involved, are providing data to determine the factors governing the movement of nitrogen compounds through soils and to evaluate the travel limits of nitrogen, in its various forms, under field conditions in the vicinity of underground pollution.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

1.0071, FREE SURFACE VORTEX RESEARCH

G.H. KEULEGAN, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

Technical Objective: Provide basic laboratory information concerning the effects of fluid viscosity on (1) the incipient conditions for vortex formation, (2) its shape and size, and (3) its rate of decay. Compare experimental results with theory and other laboratory information in an effort to improve the understanding of the vortex phenomenon.

Approach: The following variables will be considered in a systematic laboratory investigation of the free surface vortex in a cylindrical tank. Radius of tank, diameter of orifice, depth of fluid in tank, radial velocity, tangential velocity, kinematic viscosity of fluid, density of fluid, surface tension of fluid, acceleration of gravity, depression of surface at a particular distance from the center of the tank, and circulation. The effects of viscous forces on the vortex phenomenon will be studied by varying the Reynold's number while other parameters are held at specified values. This will be accomplished through the use of several differnt liquids (water, glycerine, different grades of oil) in the system. Observations will be made of incipient conditions for vortex formation with each test fluid. Surface profile measurements will be recorded for the stable vortices produced by given test conditions. Velocity measurements will also be made during stable flow conditions. Observations will be made of the time required for the vortex to decay due to viscous forces when the circulation system is closed.

Progress (Jan 66 - Jun 67): Measurements of water depth, discharge and vane angle and the vortex profile were made for a 4-in.-diameter by 24-in.-long outlet tube with free discharge and with a 1-in. orifice at the bottom. Future investigations will use a simple exit orifice at the level of the bottom of the vortex tank. A second piece of apparatus is being built to check viscosity.

SUPPORTED BY U.S. Dept. of Defense - Army

1.0072, ANALYSIS OF MIXING PHENOMENA ASSOCIATED WITH THE RISE OF GASEOUS BUBBLES THRU A STRATIFIELD LIQUID

R.A. SAGER, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

Technical Objective - To study the mixing of an underlying saltwater layer with an overlying freshwater layer, produced by a pneumatic barrier system (bubble screens). The results of this study will be used to determine the optimum design of a pneumatic barrier to achieve maximum vertical mixing at minimum cost of construction and operation, and also to determine possible scale effects attributable to air bubble size and other factors. This work unit is primarily a pilot study for future research to be aimed at increasing the degree of vertical mixing and thereby provide beneficial alterations to the hydraulic, salinity, and shoaling regimens of estuaries.

Approach - Investigations will be conducted in a large basin having the approximate dimensions of 20 ft. wide by 50 ft. long by 8 ft. deep. Tests will be conducted to study such variables as initial density difference between the saltwater and freshwater layers, depth of the pneumatic barrier below the water surface, rate of air supply to the pneumatic barrier, the size and spacing of air outlets in the barrier, and the effects of multiple distribution lines as opposed to a single line.

Progress (Oct 66-June 68): A literature and state-of-the-art review was completed. A general test program was prepared and construction of all test equipment was completed. Evaluation tests of air flow distribution from the diffuser pipe indicated adverse results. Tests to define the effects of size and spacing of air outlets on the mixing rate were completed using 1/8 in. holes on 6 in. centers and 1/16 in. holes on 2 in. centers. Preliminary results of these rests indicate essentially no significant difference in the mixing rate of an initially layered fresh and salt water system into a saline mixture for the two different sizes and spacings of air outlets. Tests to define the effect of flow rate were initiated with two tests completed. Analysis of test data was initiated.

SUPPORTED BY U.S. Dept. of Defense - Army

1.0073, NMR AND X-RAY STUDIES OF STRUCTURE IN AQUEOUS ELECTROLYTE SOLUTIONS

D.W. LARSEN, Univ. of Missouri, Water Resources Research Ctr. , *Columbia, Missouri* 65202

A study is proposed to elucidate the nature of the interactions which occur between oppositely charged ions and between ions and water molecules in aqueous solution. The techniques to be used in the study are NMR spectroscopy and X-Ray diffraction.

The NMR Studies will provide information about configurations in solutions containing large, structural anions and cations. The large- angle X-Ray Studies will provide information about configurations in solutions containing small, structureless ions, and the small-angle X-Ray Studies will be used to study isothermal compressibility and long range structure.

It is expected that the combination of NMR and X-Ray Studies will enable the behavior of a wide variety of ions to be investigated as a function of temperature, from which valuable information concerning the electrostatic potentials surrounding ions will be obtained.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Missouri

1.0074, A STUDY OF THE INTERACTIONS PRESENT IN AQUEOUS SALT SOLUTIONS BY NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY

D.W. LARSEN, Univ. of Missouri, Water Resources Research Ctr., *Saint Louis, Missouri* 63121

A study is proposed to elucidate the nature of the interactions which occur between oppositely charged ions and between ions and water molecules in aqueous solution. The systems to be studied will be composed of tetraalkylammonium ions and paramagnetic complex transition metal anions in deuterium oxide solution. Data obtained from the studies is expected to provide information about the configurations and internal motions of the various species present in solution.

The research will focus upon the correlation of configurations and internal motions with variable parameters of the anion, such as size, charge, nature of the ligand, and nature of the metal-ligand bond. It is expected that studies made on a large variety of paramagnetic complexes will aid in the increase of knowledge of the electrostatic potential surrounding the anion.

Significant advances in many of the aspects of conservation and development of the nation's water resources are necessarily preceded by advances in understanding of the nature of pertinent basic processes. This research project hopefully will add to the basic understanding of the interactions between some species that pollute water.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Missouri

1.0075, WATER-SOIL-PLANT RELATIONS

R.H. RUF, Univ. of Nevada, Agricultural Experiment Sta., *Reno, Nevada* 89507

Objectives: To evaluate the interaction of root medium stress and transpirational stress as imposed by temperature, light and relative humidity on plant growth and cell maturation. To determine the effect of this stress on differential cell maturation and subsequent growth resumption when the stress is relieved.

Procedures: Plants will be grown in nutrient solutions containing polyethylene glycol (Carbowax 1540) as an osmotic agent. Aerial stress will be regulated in controlled environment chambers by light intensity, relative humidity and temperature. Cell maturation and internal cell osmotic concentration will be measured with a Warburg respirometer and vapor pressure osmometer respectively. The growth rate after a stress period will be measured either with whole tubers or tissue discs grown on nutrient agar.

SUPPORTED BY U.S. Dept. of Agriculture
Nevada State Government

1.0076, PHYSICS AND CHEMISTRY OF SOIL WATER AND INTERFACIAL PHENOMENA

D.M. ANDERSON, U.S. Army, Terrestrial Sciences Center, *Hanover, New Hampshire* 03755

Phase relationships and thermodynamic properties will be determined for interfacial water and water adsorbed by earth materials. The measurements are being determined principally in the temperature range 0 degrees C - 180 degrees C to aid in the understanding of the phenomena of freezing and thawing.

SUPPORTED BY U.S. Dept. of Defense - Army

1.0077, METAL ION INTERACTIONS WITH WATER

T.G. SPIRO, Princeton University, Graduate School, *Princeton, New Jersey* 08540

Statement of Objective: The interest which motivates the research proposed here revolves around the mutual interaction of metal ions in aqueous solution, especially under conditions that are biochemically relevant. This interaction arises from the ubiquitous formation of hydroxyl bridged polynuclear complexes in metal ion solutions. Of particular biological interest is the fact that many naturally occurring chelating agents leave one or more metal ion coordination sites occupied by water, hence susceptible to hydrolysis and polymerization. Since the physiological pH range is precisely where hydrolysis is expected for many metal ions, the occurrence of polynuclear structures in biological fluids is entirely probable. That they may be of biochemical importance as well is indicated by our finding that the marked catalysis of ATP dephosphorylation by copper (II) ions involves a dinuclear copper chelate. Of similar relevance is the finding that a citrate stabilized high polymer of iron (III) can be used to reconstitute ferritin from apoferritin.

Our research efforts are aimed at structural elucidation of polynuclear complexes using Raman spectroscopy and other physical techniques; at exploring the kinetic implications of polynuclear species in metal catalyzed ATP reactions; and at studying the formation of chelate stabilized high polymers of metal ions.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

1.0078, DIELECTRIC PROPERTIES OF HYDROGEN-BONDED LIQUIDS

W. DANNHAUSER, State University of New York, Graduate School, *Buffalo, New York* 14214

The purpose of this research is to extend measurements of the dielectric constant of some simple hydrogen-bonded liquids as a function of frequency, temperature, and pressure. Equilibrium data will be analyzed in terms of intermolecular associative equibria involving hydrogen-bonds as a specific function of molecular geometry. The ultimate results will be expressed as the thermodynamic parameters characteristic of the associative equilibria. Dielectric dispersion data will be analyzed in the context of Eyring's theory and also in terms of fluctuation-correlation theory.

One part of the program entails the measurement of the dielectric constant of a number of isomeric octyl alcohols over a wide range of temperature and frequency. By varying the position of the -OH group in the molecule, and thus the extent of steric interference with intermolecular hydrogen-bonding, it is possible to obtain liquids whose extent of association varies widely. Because the isomers all have essentially identical molar volumes and dipole moments, differences in their dielectric behavior must be due entirely to specific differences in the shape of the molecule. The possibility of correlating equilibrium properties with dielectric relaxation will be studied.

The major goal of the project is to extended dielectric constant and lose measurements to about 4 kbars pressure. The thermodynamic functions delta V, delta E, and delta Sv characteristic of the association (hydrogen-bonding) will be determined from the pressure dependence of the equilibrium dielectric constant. Delta Sv in particular is expected to be sensitive to the size and shape of the molecules. Similarly, the activation parameters delta Sv, delta E, and delta Sv will be obtained from the pressure dependence of the dielectric relaxation times. Variations in the molecular environment due to thermal expansion are eliminated when working at constant volume. Thus, when examining chemically similar liquids a comparison of the resulting data will be indicative of intrinsic molecular differences which may be correlated with the size and shape of the molecules. The first test liquids will be the lower aliphatic alcohols.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0079, INVESTIGATIONS OF AQUEOUS SALT SOLUTIONS BY RAMAN SPECTROSCOPY

R.A. PLANE, Cornell University, Graduate School, *Ithaca, New York*

Raman spectra will be measured of a variety of salts in aqueous solution. Emphasis will be placed on halides although other salts may also be studied. Measurements will be made of the vibrational modes of both solute species and the solvent. Primary goals include characterization of actual species present in order to determine conditions under which complex ion formation occurs in a stepwise series, whether intermediate complexes contain coordinated water molecules, and maximum coordination number of cations for anions. Studies will be made of quantitative intensities as a function of temperature in order to obtain thermodynamic data.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0080, SOLUBILITY OF NATURAL GASES IN CONNATE WATER AND OF WATER IN NATURAL GASES

N.O. SMITH, Fordham University, Graduate School, *New York, New York* 10458

The 'Solubility of Natural Gases in Connate Water and of Water in Natural Gases' is a continuation of NSF Grant GP-5066, and it is concerned with the solubility of natural gases in brine and the mechanism of intrastratal fluid flow in sedminetary rocks. Measurements of the solubility of CH4, N2 and He in water containing 1m NaCl from 50 to 125 degrees C at pressures up to 10,000 psi, have been made. Future work will include the solubility of C2H6, H2S and CO2 in similar brines under the above conditions of pressure and temperatures. A study of the water content of the coexisting gas phases will add to the scant knowledge of the vapor pressure of water over water and brine in geological environments, provide a much closer estimate of fugacities at high pressures than is presently available, and provide much needed data on the deviation from ideality of gas-water mixtures at high pressures.

SUPPORTED BY U.S. National Science Foundation

1.0081, GEOCHEMICAL STUDIES OF CONTINENTAL WATERS

W.S. BROECKER, Columbia University, Graduate School, *Palisades, New York* 10964 (AT(30-1)2493)

The purpose of this research is to gain an understanding of the factors controlling the major element chemistry of continental waters. We are contrasting the chemistry of three closed basin saline lakes, a sulfate-rich meromictic lake, and its associated ground waters, two fresh water lakes, lakes within active volcanic regions and subsurface waters in an island coral cap. Measurements of the major elements, pH, and pCO are being made on the lake waters, river and ground waters supplying the lakes, and pore waters extracted from the lake sediments. Stable and radioisotopes (C-14, C-13, Sr-90, Cs-137, Rn-222, ...) provide useful means of tracing sources and determining residence times. The origin of the detrital and authigenic phases in the sediments is also being studied.

A report regarding our study of Green Lake is in press (Limnology and Oceanography). Preliminary reports on our saline lake studies appear in this years Project Report.

SUPPORTED BY U.S. Atomic Energy Commission

1.0082, STRUCTURE OF CARBON-OXYGEN COMPLEXES

R.J. BOBKA, State University of New York, Graduate School, *Plattsburgh, New York* 12901

Objective: The objective for this research is to establish structures for surface oxygen complexes on carbon.

Background: Important commercial uses of various types of carbons as gas or water purifiers, ink coloring agents, rubber fillers and, recently, as fiber fillers in resin composites are markedly affected by the surface area, porosity and surface oxygen content of the carbon. The surface oxygen largely determines whether interaction with other substances will occur by physical or chemical adsorption or whether it will occur at all. For example, oxygen-free carbon is hydrophobic while carbon with surface oxygen is hydrophilic. Surface oxygen exists on carbon in carbon-oxygen complexes whose structures vary according to the method of their preparation. These structures can be studied with infrared spectrophotometry provided that the particle size of the carbon is an order of magnitude smaller than the wavelength of the radiation and the carbon-oxygen complexes are present in sufficiently high concentration. Both conditions are met with 'ultrafine graphite' which the applicant is able to prepare.

General Experimental Procedure: Carbon-oxygen complexes will be generated on ultrafine graphite under controlled conditions of atmosphere and temperature. The infrared absorption bands will be identified. The gross composition of the complexes will then be determined by thermal decomposition in a gas chromatograph and the infrared spectrophotometer, using a gas cell. Structural formulas consistent with both sets of observations will then be assigned.

SUPPORTED BY State University of New York

1.0083, BEHAVIOR OF LIQUID SURFACES DURING EVAPORATION AND CONDENSATION

K. HICKMAN, Rochester Inst. of Technology, Graduate School, *Rochester, New York* 14608

The ultimate purpose is to evaluate the conditions that permit greatest rates of evaporation and condensation for unit area and driving force; and to enumerate or discover factors that interfere. Two general methods will be used: phase change at the surface of rapidly moving streams; and studies of the quietly evaporating stationary (stagnant) surface. The preferred instrument for the former will be the jet tensimeter and for the latter the floating liquid boule. Systems of Schlieren and high speed photography are being further perfected for recording the boule phenomena. The heat balance of the boule and surrounding liquid is being studied by collecting vapor concurrently from the surface of the boule, the surface of the supporting liquid and from the rim which terminates the shroud between the two. The high speed evaporation determined by the jet tensimeter is being increased by propelling the liquid jets at higher pressures thus decreasing the exposure interval of the surface from .001 seconds to .0001 seconds.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0084, STATISTICAL MECHANICAL THEORIES OF FLUIDS

F.P. BUFF, Univ. of Rochester, Graduate School, *Rochester, New York* 14627

It is the main purpose of this investigation to elucidate the interfacial structure of fluids from the triple point to the critical region by statistical mechanical theories. The problems include interfacial width criteria by thermodynamic techniques, a rigorous analysis of surface tension by the method of cluster diagrams and functional differentiation, an examination of density profiles by an extended van der Waals density gradient approach, utilization of capillary waves as a suitable set of collective coordinates for the calculation of leading moments of the interfacial distribution, examination of optical line shapes and explanation of the increased diffuseness of quantum fluids, as well as related problems. In order to compare these theories with optical experiments it is necessary to solve the equations for the E and H waves by means of Green's function techniques. It is also proposed to examine the surface properties of water and ionic solutions. The bulk properties of salt solutions will be studied by means of nearest neighbor functions. The structure of the electrical double layer will be investigated by means of charge fluctuation criteria to test models for the description of the inner Helmholtz plane.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0085, STUDIES OF THE PHYSICAL CHEMISTRY OF ELECTROLYTE SOLUTIONS

H. FRIEDMAN, State University of New York, Graduate School, *Stony Brook, New York* 11790

Statistical-mechanical methods are to be applied to these problems: 1. The calculation of the thermodynamic properties of the 'primitive model' of single and mixed electrolyte solutions with reasonable numerical accuracy at concentrations as high as 1 molar. 2. Calculation of the terms in the equivalent conductance of order c ln c and c, where c is the concentration, for unsymmetrical electrolytes and for mixtures, on the basis of the simplest (Debye-Huckel) model. 3. Calculation of nuclear-magnetic relaxation times in ionic solutions and their relation to transport coefficients, on the basis of the simplest model. 4. Study of the effects on all of the above of using more realistic models.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0086, VOLUME CHANGES ON MIXING SOLUTIONS OF ELECTROLYTES

H.E. WIRTH, Syracuse University, Graduate School, *Syracuse, New York* 13210

The objective is to determine the apparent and partial molal volumes of electrolytes such as MgC12, MgSO4, and CaC12 in binary mixtures with themselves and with other electrolytes such as NaC1, NaBr, KC1, and Na2SO4. Most of the data will be obtained at 25 degrees C, but certain selected systems will be studied in the temperature range of 5 degrees - 40 degrees C. The concentration range will be from 0 - 4 molal. Some work will be done on ternary mixtures as well, with the ultimate objective of being able to compute the apparent and partial molal volumes of any of the above electrolytes in mixtures containing all others. A precision dilatometer capable of measuring directly the small volume changes occurring when solutions of electrolytes are mixed is the basic instrument used.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0087, TRANSPORT PROPERTIES OF CONCENTRATED SALT SOLUTIONS

G.J. JANZ, Rensselaer Polytechnic Inst. , Graduate School, *Troy, New York* 12181

The objective of this research is to obtain data on kinetic properties, such as diffusion, viscosity, and conductivity of concentrated salt solutions. A system of 1:1 sodium salts will be chosen so that the kinetic properties of these systems can also be correlated by spectral means at higher concentrations and several different temperatures. The results will be interpreted to develop an improved understanding of ion-ion and ion-water interactions in concentrated salt solutions.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0088, DISSOLVED ORGANIC PHOSPHORUS IN NATURAL WATERS

E.J. KUENZLER, Univ. of North Carolina, School of Public Health, *Chapel Hill, North Carolina* 27514

The objectives of this proposal are to continue seeking techniques for identification of the major components of the dissolved organic phosphorus (DOP) pool in natural waters, to investigate the seasonal distribution of DOP compounds, and to examine the nature of the DOP eliminated into the medium by cultures of planktonic algae. The geographical and seasonal changes in total DOP are partially known but the chemical compounds making up these pools are completely unknown. Prior work has shown that the DOP present in natural sea waters consists of several important components. The DOP eliminated by healthy algae in pure culture also consists of several components but it is not yet known whether these are the same as occur in natural waters. Co precipitation on Fe(OH)3 is used to remove DOP from sea water. The iron is then removed from the DOP by solvent extraction into acetyl acetone in C Cl4. The organic substances are purified and concentrated, separated by paper chromatography, and detected by spray reagents or by radioautography. To date methods have been developed for concentrating, purifying, and separating organic phosphorus compounds from natural waters and from radioautography. To date compounds from natural waters and from unialgal cultures. The next steps are the final identification of these compounds, the delineation of their spatial and seasonal distributions, and investigation of their ecological significance.

SUPPORTED BY U.S. Atomic Energy Commission

1.0089, STUDY OF TOXIN SYNTHESIS IN SYNCHRONIZED PRYMNESIUM

G.M. PADILLA, Duke University, School of Medicine, *Durham, North Carolina* 27706

Hemolysins from the euryhaline flagellate Prymnesium are preferentially synthesized at a salinity corresponding to that of 75% sea water. The hemolytic toxin appears to be localized in the membrane fraction of cell homogenates separated by sucrose density gradient centrifrugation. Initial purification by passage through Sephadex LH- 20 indicates that the toxin has a molecular weight above 1,000. The extent to which glycerol enhances toxin synthesis is being investigated. The effect of illumination on the time course of toxin production is independent of the rate of protein and nucleic acid synthesis. Radioactively -labelled toxin fractions are being prepared so as to determine the biogenesis and chemical structure of toxins under closely controlled conditions of growth (e.g., light-dark cyclings). We plan to relate toxin synthesis to a specific major cellular function during the cell cycle by inducing cell division synchrony. Similar studies are being initiated wtih toxins from related marine algae of the genera Gonyaulax and Gymnodinium.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

1.0090, THERMODYNAMICS OF MIXING OF SALT SOLUTIONS

H.L. ANDERSON, Univ. of North Carolina, Undergraduate School, *Greensboro, North Carolina* 27412

A research program designed to learn more about the nature of ionic interactions in aqueous solutions has been started at the University of North Carolina at Greensboro. The immediate goal of this investigation is to look at the role of solvent structure in influencing the thermodynamic properties of ionic interactions by measuring the heats of mixing at constant total ionic strength of a wide variety of strong electrolytes as a function of temperature (25 - 100 degrees Centigrade.) and concentration (0.1 - 1.0 molal). The initial mixtures to be studied will be binary electrolyte mixtures of the alkali and tetraalkylammonium cations in the presence of a common anion.

In order to make the above measurements, a high sensitivity calorimeter is currently being built.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0091, FIELD TECHNIQUES FOR CHEMICAL ANALYSIS OF WETLAND CRITERIA

V.A. ADOMAITIS, U.S. Dept. of Interior, Northern Pr. Wlfe. Res. Ctr. , *Jamestown, North Dakota*

Objectives: To develop analytical techniques that will permit multiple chemical analysis of components necessary for the rapid evaluation of water and plant quality criteria. Techniques should be applicable to field conditions in isolated prairie or forest areas for waters ranging from 0-100,000 micromhos/cm2.

Procedures: Translations from German will be made from HELVETICA CHIMICA ACTA, especially the work of Prof. H. Seiler, University of Basel, Switzerland, and from other scientific journals.

Translations from Esperanto will be made from STUDOJ PRI AMELOJ DE LEGUMENOJ, authored by Prof. S. Kawamura, University of Kagawa, Miketyo, Japan, and from other scientific journals.

The above and similar theoretical research work in physical chemistry and phytochemistry will be applied to practical ecochemical chromatography and colorimetry for highly alkaline prairie marshes and acidic forest bogs.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

1.0092, CHEMICAL CHARACTERIZATION OF WATERS OF PRAIRIE AND FOREST WETLANDS

V.A. ADOMAITIS, U.S. Dept. of Interior, Northern Pr. Wlfe. Res. Ctr. , *Jamestown, North Dakota*

Objectives: To determine the general water quality characteristics, nutritional and toxic elements and other compounds present in prairie potholes and forest wetlands, and to determine the influences of such chemical factors on quality of waterfowl habitats.

Procedures: The following water quality criteria will be analyzed by gravimetric, titrimetric and colorimetric methods: alkalinity, chloride, chromate, copper, fluoride, calcium hardness, total hardness, iron, manganese, metaphosphate, nitrate, nitrite, orthophosphate, pH, silica, sulfate, turbidity, total dissolved solids, total residue and other analyses as required.

The following nutritional elements will be determined by atomic absorption spectrophotometric methods: barium, boron, calcium, cobalt, copper, iron, magnesium, manganese, molybdenum, potassium, sodium and zinc.

The following toxic elements will be determined by atomic absorption spectrophotometric methods: antimony, arsenic, beryllium, bismuth, cadmium, chromium, lead, lithium, mercury, nickel, selenium, silver, tellurium and thallium.

Nutritional and toxic compounds will be determined by various specific methods depending on the nature of the chemical knowledge obtained above.

A reference grid of water quality facts will be established for given geographic prairie and forest areas in the North Central States in order to support future research and management activities.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

1.0093, THE INVESTIGATION OF TRANSPORT PROCESSES IN AQUEOUS ELECTROLYTE SOLUTIONS

D.F. EVANS, Case Western Reserve Univ. , Graduate School, *Cleveland, Ohio* 44106

I. Objectives of the Research (1) to determine the transport behavior of small molecules (non-electrolytes) in water and compare their behavior with that of electrolytes in order to establish the effect of ionic charge on the transport properties. (2) to elucidate the nature of ion-ion interactions in aqueous solution.

The first goal will be achieved by measuring the diffusion coefficients of small non-polar (e.g., rare gases and gaseous hydrocarbons) and polar compounds in water as a function of temperature. These measurements on non-polar compounds will subsequently be carried out in aqueous electrolyte solutions. The second objective will involve conductance measurements in two types of solutions: (1) aqueous solutions of new large ions and (2) solutions of multi-valent ions in heavy water. The conductance measurements will be directed towards giving information concerning ion association and should help resolve questions regarding the pattern of ionic association in water.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0094, HETEROGENEOUS NUCLEATION AND CONDENSATION OF VAPORS

A.G. WALTON, Case Western Reserve Univ. , Graduate School, *Cleveland, Ohio* 44106

Apparatus is being set up to examine the energetics of heterogeneous nucleation of vapors on mainly crystalline substrates. Studies of this type are designed to lead to a better understanding of the mechanism of condensation processes and to relate the observed critical supersaturations to the surface adsorption and diffusion processes. Vapors to be studied are water, benzene, cyclohexane and hydrocarbons; substrates include alkali halides and other single crystals, polymers and surface treated metals. It is hoped that the experiments will also form critical tests for current theories.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0095, ION-SOLVENT AND ION-ION INTERACTIONS IN AQUEOUS ELECTROLYTES

E. YEAGER, Case Western Reserve Univ. , Graduate School, *Cleveland, Ohio* 44106

Research objectives are 1) to establish the effects of ions on the structural relaxation of water and to interpret these effects in terms of various models for water and aqueous solutions; and 2) to gain further understanding of the role of solvent molecules in multiple- step ion association-disociation processes. The first will be pursued through the study of the study of the effects of various electrolytes on ultrasonic absorption in the absence of chemical relaxation effects. The depression of absorption produced by large structure-breaking ions will be measured with Carstensen-type equipment, initially at 1 atmosphere and later at higher pressures. Such measurements together with partial molal volume and compressibility data will be used to obtain information concerning the effects of these ions on the equilibrium distribution of structures in water and the structural relaxation times. The research on the role of solvent in ion association-dissociation processes will involve kinetic studies using principally the temperature-jump relaxation technique with laser heating. The volumes and energies of activation will be determined from the pressure and temperature dependence of the kinetic parameters.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0096, SOLUBILITIES OF SILICATES IN SALINE WATERS

A.G. COLLINS, U.S. Dept. of Interior, Petroleum Research Ctr. , *Bartlesville, Oklahoma*

The solubility of serpentine in saline waters is determined using a hydrothermal pressure reactor. Thermodynamic parameters are calculated and empirical equations are developed from the experimentally derived data. This information is needed to develop better desalination and petroleum production methods.

SUPPORTED BY U.S. Dept. of Interior - Bureau of Mines

1.0097, SOLUBILITIES OF THE SULFATES OF BARIUM AND STRONTIUM IN OILFIELD WATERS

A.G. COLLINS, U.S. Dept. of Interior, Petroleum Research Ctr. , *Bartlesville, Oklahoma*

The solubilities of barium sulfate and strontium sulfate in synthetic and natural saline waters are determined by using sulfur-35 tagged salts. Thermodynamic parameters are calculated and empirical equations are developed using the experimentally derived data. This information is needed to develop better petroleum production methods.

SUPPORTED BY U.S. Dept. of Interior - Bureau of Mines

1.0098, SOLUTE PROPERTIES OF WATER

S.D. CHRISTIAN, Univ. of Oklahoma, Graduate School, *Norman, Oklahoma* 73069

Little is known about specific interactions between molecules and solute molecules or ions. The success we have had in elucidating self- association and hydration equilibria in organic solvents has been due in large measure to the application of several physical methods in studying each system. Our approach has also avoided the difficulty experienced in studies of aqueous systems where the preponderance of solvent-solvent interactions as opposed to solvent-solute are overpowering and has permitted us to progressively increase the polarity of the systems being studied.

This proposal outlines a program of research in which the solute properties of water will continue to be investigated. Spectral (infra- red, ultra-violet and nuclear magnetic resonance) colligative property, distribution and dielectric constant measurements will be made to determine the bonding and reaction characteristics of hydrates of polar species in non-aqueous media.

The range of physical methods to be applied will be enlarged where possible and we will place new emphasis upon qualitative information concerning the conformation of water aggregates and hydrates as well as continue our accumulation of quantitative thermodynamic data.

It is expected that the results of the proposed research will be important not only in increasing our understanding of the bonding properties of water, but also in developing improved theories of the hydrogen bond.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0099, MEASUREMENT OF THERMODYNAMIC PROPERTIES OF SALINE SOLUTIONS

A.M. ROWE, Okla. St. Univ. of Agr. & Sci. , School of Engineering, *Stillwater, Oklahoma* 74075

Engineers must determine the thermodynamic properties of aqueous solutions containing various salts and other contaminates in order to design plants to purify water. The purpose of this work is to conduct the necessary experiments to obtain data for prediction of these thermodynamic properties over a wide range of temperatures and pressures. A heat of vaporization calorimeter and a p-v-T cell will be used in the experimental phase of this program. Tests will also be conducted to measure the effect of various parameters on heat of vaporization over a wide range of temperature and pressure.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Oklahoma State University

1.0100, KINETICS OF ADSORPTION VIA DOUBLE LAYER CAPACITY MEASUREMENTS

A.J. DIEFENDERFER, Lehigh University, Graduate School, *Bethlehem, Pennsylvania* 18015

A method of measurement of the double layer capacity of a mercury electrode-saline solution interface is being used which depends upon the application of a linear voltage ramp to the electro-chemical cell. In the absence of electro-active material, the resulting current is directly proportional to the capacity current, thus permitting the recording of the entire curve in a fraction of a second (the time of the ramp).

This technique is being used to examine the effect of partially aqueous and non-aqueous solvent systems upon the electrical double layer. The adsorption of organic molecules is being studied as a function of these solvent changes as well as a function of the adsorbate.

For adsorption processes which are not diffusion controlled, a modification of the above technique will be used in an attempt to evaluate the rate of adsorption.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0101, IONIC SOLVATION

J.O. BOCKRIS, Univ. of Pennsylvania, Graduate School, *Philadelphia, Pennsylvania* 19104

Objectives: There is still some doubt as to whether a primary hydration number really exists for ions like those of the alkali metals (when there is no covalent bonding between the ion and water); there is no widespread acceptance of any particular measurement as the best one to use; and there is still a discrepancy of up to plus or minus 50 percent as to the 'correct' solvation number in a given case.

The objectives of the project, therefore, are to examine critically the validity of the concept of solvation numbers, determine the extent to which various methods yield results in agreement with this concept, and determine, accurately, meaningful solvation numbers.

Problems to be Studied: A wide range of different salts will be studied, under different conditions, by five methods: 1 and 2) Compressibility and Density measurements will give the sum of the solvation numbers for a salt, and provide a test of consistency. 3) Ultrasonic e.m.f.'s will give the difference of solvation numbers. 4) Proton Magnetic Resonance studies will give the life time of the solvation sheath molecules. 5) Raman Spectroscopy studies as a function of temperature will give the bond strengths and other information on the solvation shell, if this contains covalent bonds.

Supplementary measurements will be: i) The use of conductance measurements at high concentrations to deduce the degree of association. ii) The measurement of the pressure dependence of the self diffusion coefficient, to give information on the volume, hence constitution, of the hydration sheath.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0102, THE RELATION BETWEEN THE STRUCTURE AND PROPERTIES OF LIQUID WATER

H.S. FRANK, Carnegie Mellon University, Graduate School, *Pittsburgh, Pennsylvania* 15213

The purpose of this research is to attempt formation of Cox's ice and to study the differences in properties between freshly melted ice and freshly condensed steam.

This investigation will be approached by the compression and cooling of ice-water mixtures; far infrared, Raman and ultraviolet spectra will be used as functions of origin and thermal history of water samples.

Better understanding of the nature of solvent water can be expected to strongly assist in the attack on the problem of separating this solvent from salts dissolved therein.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0103, TRANSPORT AND DIELECTRIC PROPERTIES OF SALINE SOLUTIONS

R.L. KAY, Carnegie Mellon University, Graduate School, *Pittsburgh, Pennsylvania* 15213 (14-01-0001-1729)

Low frequency dielectric constants will be measured at pressures up to about 3,000 atmospheres and in the temperature range 0 degrees - 60 degrees C for heavy water, methanol, ethanol, acetonitrile, formamide or N-methylformamide, dimethylsulfoxide, and possibly n-hexane or carbon tetrachloride. Compressibilities will be measured for those liquids for which adequate data are not now available. A dielectric cell will be designed and constructed for the simultaneous measurement of both compressibilities and dielectric constants.

Ionic mobilities will be determined for selected salts in the above solvent systems at pressures as high as 4,000 atmospheres. These measurements will require transference data as well as conductance measurements. A new method has been devised for determining transference numbers at pressures as high as those contemplated here.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0104, THE EFFECTS OF NONELECTROLYTES AND SELECTED SALTS ON STRUCTURING IN WATER

E.M. ARNETT, Univ. of Pittsburgh, Graduate School, *Pittsburgh, Pennsylvania* 15213

Measurements will be made of the partial molal free energies, enthalpies, entropies and heat capacities that accompany the dissolving of specially selected compounds into water, aqueous saline solutions, and other suitable media such as heavy water. Criteria for salt selection will include importance as components of sea water, known influence on aqueous ordering and solubility in water. The experimental techniques will be solute distribution, calorimetry and spectroscopy. The results should make possible better understanding of solute-water forces and orientations in saline solutions.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0105, STUDIES BEARING ON THE RELATION OF STRUCTURE TO PROPERTIES IN LIQUID SOLUTIONS

H.S. FRANK, Univ. of Pittsburgh, Graduate School, *Pittsburgh, Pennsylvania* 15213

This is a continuation of work on aqueous electrolytes, of which the most recently completed items are the study of $ZnSO_4$ in H_2O and D_2O solutions, and the comparison of activity coefficients of 6 alkali halides in H_2O and D_2O. Under way are experiments, including ones using liquid junction cells, aimed at estimating single-ion activities, particularly of tetra-alkyl ammonium ions in their halide solutions. In addition, theoretical studies are continuing on thermodynamic models for liquid water and comparison of H_2O and D_2O as solvents both for salts and for nonpolar solutes.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0106, EFFECT OF AMINES, ALCOHOLS AND PHENOLS ON THE PHYSICO-CHEMICAL PROPERTIES OF WATER

G.A. JEFFREY, Univ. of Pittsburgh, Graduate School, *Pittsburgh, Pennsylvania* 15213

We propose to study the effect of certain organic substances on the hydrogen-bond structure of aqueous systems. These organic compounds will be such as combine both hydrophobic and hydrophilic properties. The first compounds which will be studied are the alkylamines. this will be followed by investigation of systems involving alcohols and phenols. The experimental approach will be to determine the structures of any high hydrates which are formed, by single crystal diffraction methods. The results will then be compared with the radial distribution function of the aqueous solution of the same composition, firstly at the melting point, then progressively further from this point, both with respect to temperature and composition. Liquid state X-ray diffraction studies will be used for this purpose. The possibility of using infra-red spectroscopic methods on the high hydrate crystal and their corresponding aqueous solutions will also be explored.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0107, FACTORS AFFECTING MINE DRAINAGE AND THE GROUND WATER INTERACTIONS IN SELECTED AREAS OF WESTERN PENNSYLVANIA (PART 1)

R.R. PARIZEK, Penn. State University, Graduate School, *University Park, Pennsylvania* 16802

Rock and water samples were collected from two areas; one containing strip mines producing acid waters and the other yielding non-acid drainages. The samples were analyzed and compared to determine the compositional variations responsible for the divergent water qualities. The acid potential of a rock was related to its sulfur content by three leaching tests. These tests also evaluated the effect of pyrite crystallinity, rock type, iron bacteria and alkalinity on acid production. The hydrology of the two areas was approximated from measurements made on domestic wells of one area.

It was found that the ranges of total sulfur contents of the acid and non-acid areas were similar and could not account for the different water qualities produced. The leaching tests showed acid production to be partly dependent upon the sulfur content of a rock and greatly affected by pyrite crystallinity, iron bacteria and calcium carbonate. Ground waters in the unmined portions of the acid drainage area had low pHs; whereas those in the non-acid area were alkaline. Because iron bacteria prefer an acidic environment, the former area may harbor the bacteria while the latter may not. Consequently, the sterile areas may produce a milder acid which can be further reduced by the available alkalinity.

The hydrologic setting consists of alternating aquifers and aquitards in accord with the cyclicity which is characteristic of the rocks. Under certain circumstances acid mine drainage may be confined to surface water supplies.

SUPPORTED BY Pennsylvania State Government

1.0108, THE APPLICATION OF LASER IONIZATION MASS SPECTROMETRY TO THE IDENTIFICATION OF ORGANIC SALTS IN POLLUTED WATER

F.J. VASTOLA, Penn. State University, Graduate School, *University Park, Pennsylvania* 16802

The purpose of this research is to further develop the technique of laser ionization mass spectrometry particularly with respect to the analysis of organic salts. Mass spectra of detergent materials such as organic sulfonates, sulfates and thiosulfates will be obtained with the view of detecting and identifying trace amounts of detergents in polluted waters.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Pennsylvania State University

1.0109, THE ANALYSIS AND GEOCHEMISTRY OF TRACE ELEMENTS IN THE HYDROSPHERE

J.T. CORLESS, Univ. of Rhode Island, Graduate School, *Kingston, Rhode Island* 02881

An investigation of the chemical situation of trace elements in R. I. lakes, rivers, and Narragansett Bay has been undertaken. Routine procedures based on NAA and gamma spectroscopy have been developed for Cu, Mn, Ni, and Zn.

Results to date indicate: 1. Significant local and regional variations in trace element concentration and distribution exist within Narragansett Bay and the above mentioned river systems. A heavy trace metal load appears to be entering the head of the Bay. 2. Natural seasonal variations exist and may bear directly on the productivity cycle. 3. Neutron activation analysis offers an accurate and extremely sensitive tool for the study of trace elements in natural waters. The availability of tested and trusted radioanalytical techniques for trace element analysis would greatly facilitate the task of the water chemist. 4. An important fraction of these dissolved trace metals exists in a chemical form which cannot be extracted by diethyldithicarbamate until the sample is oxidized (organic complexes).

Future plans (1968-1970) call for a close examination of the partitioning of the trace elements among the particulates, dissolved- inorganic, and dissolved-organocomplex 'phase'. We plan to describe the role played by dissolved and particulate organic matter in the transport and deposition of trace elements. The distribution and partitioning of these trace elements within the water column will be correlated with seasonal cycles, phytoplanktore succession, salinity, and other chemical variables. Analytical procedures for additional elements will be developed. The comparative trace metal chemistries of a natural and a polluted river will be investigated.

SUPPORTED BY University of Rhode Island

1.0110, BIOCHEMICAL OXIDATION OF HYDROCARBONS IN NATURAL WATERS

C.W. HOUSTON, Univ. of Rhode Island, Graduate School, *Kingston, Rhode Island* 02881

The proposed study involves the investigation of microbial degradation of hydrocarbons in natural waters. Although a great deal is known about the bacteria affecting health, relatively little is known about bacteria and biochemical processes that are fundamental to the assimilation of waste products that get into natural waters.

It is intended to evaluate factors which influence the clearance of hydrocarbons for natural waters by - 1. determining cultural conditions and composition in a natural water source and studying the dynamics of the system by a continuous culture study in a simulated environment; 2. investigating the role of co-oxidation phenomenon in the accumulation of toxic hydrocarbon intermediates; 3. correlating the amount, type and the degradation rate of hydrocarbons to seasonal and cultural parameters for the purpose of recommending a suitable decontamination policy.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Rhode Island

1.0111, EFFECT OF DRAG REDUCING ADDITIVES IN WATER TRANSPORTATION

W.E. CASTRO, Clemson University, School of Engineering, *Clemson, South Carolina* 29631

The proposed research consists of laboratory studies directed at establishing the mechanisms involved in the friction reducing effect of small concentrations of certain polymeric additives in water. Once these mechanisms are clearly identified, they may then be applied to the general problem of drag. The proposed investigation will be conducted in two parts.

Part I - Fluid Properties: 1. Laboratory studies of the effect of drag reducing additives on viscosity, density, bulk, modulus of elasticity, surface tension, and thread formation of water-polymer solutions. 2. Degradation studies of additives by high shear-stress and solvent pH. 3. Laboratory study of a new drag reducing additive, okra gum.

Part II - Pipe Flow: 1. Pipe flow experiments with aqueous solution of drag reducing additives in fully developed laminar and turbulent flow. 2. Detailed investigation of the effect of additives on transition which includes measuring the growth and intensity of turbulent flashes and the effect of additives for both self-induced and mechanically generated flashes. 3. Development of an analytical model which will be useful for predicting drag reduction in other configurations.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Clemson University

1.0112, ISOTOPE EFFECT ON THE THERMODYNAMIC ACTIVITY OF WATER

W.A. VANHOOK, Univ. of Tennessee, Graduate School, *Knoxville, Tennessee* 37916

The vapor pressure depression of electrolyte solutions in H2O, D2O and mixed H2O-D2O solvents will be measured over a broad temperature range using precise modern techniques. The results will be interpreted using the statistical theory of isotope effects in condensed phase systems. They should be an aid toward the more complete understanding of liquid water and of water solutions.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Tennessee

1.0113, ENVIRONMENTAL RADIATION STUDIES

J.E. NOAKES, Oak Ridge Associated Univs. , *Oak Ridge, Tennessee* 38117 (AT(40-1)-GEN-33)

The Oak Ridge Associated Universities' environmental radiation program was initiated in 1964 for the prime purpose of carrying out geochronology studies on marine sediments in the Gulf of Mexico.

Two analytical methods have been employed for sediment age measurement. A uranium daughter dating method, which entails the radiometric analysis of Th-230 and Pa-231, is utilized when dating silicious sediments of ages between 10,000 - 200,000 years. A second radiometric method utilizing radiocarbon measurements is employed for carbonate sediments whose age ranges are from recent to 40,000 years. Age measurements from both methods have shown that sedimentation rates for deep water Gulf sediments to be in the range of a few centimeters/ thousand years.

Current studies being carried out include (1) measurement of allogenic and authigenic Th-230 and Pa-231 in marine sediments (2) development of new analytical methods for the analysis of uranium, thorium, and protactinium in marine waters and sediments and (3) improvement in the radiocarbon method of dating for age measurements in the 40,000 to 57,000 year range.

SUPPORTED BY U.S. Atomic Energy Commission

1.0114, MOLLUSK STUDIES

D.J. NELSON, U.S. Atomic Energy Commission, Oak Ridge National Lab. , *Oak Ridge, Tennessee* (W-7405-ENG-26)

Analyses of additional prehistoric Indian midden mollusk shells showed the higher strontium concentrations in these shells may be attributed to higher environmental concentrations of strontium in river water between 1000 and 2000 years old. It was hypothesized that this change was due to the imposition of an agricultural economy on a forested landscape decreasing levels of soil carbon dioxide concomitantly increasing the proportion of rainfall in direct runoff thereby decreasing percolating ground water. The strontium analyses were accompanied by analyses of barium, and potassium concentrations were changed but little. This study showed that the rates of movement of strontium, barium, and manganese in the environment changed within recent times. These results have implications for the long-term behavior of 90 Sr in the environment as well as maintenance of the mineral economy of our terrestrial environment.

SUPPORTED BY U.S. Atomic Energy Commission

1.0115, WATER RESEARCH PROGRAM - SECTION I, PROPERTIES OF SOLUTIONS

R.J. RARIDON, U.S. Atomic Energy Commission, Oak Ridge National Lab. , *Oak Ridge, Tennessee*

The properties of solutions subprogram is intended to provide basic information on the thermodynamic and transport properties of aqueous and non-aqueous electrolyte solutions and on phase equilibrium. Thermodynamic measurements are carried out by various physical-chemical techniques including potentiometry, solubility measurements, distribution coefficient measurements, and vapor-phase equilibria, with emphasis on properties of concentrated solutions, multicomponent systems and aqueous-organic-electrolyte mixtures; there is special emphasis on measurement of solubilities of 'scale-forming' salts (CaSO4) as a function of temperature and in various media. Diffusion coefficients are measured in concentrated aqueous solutions, water organic mixtures, gels, and membranes.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0116, ENVIRONMENTAL RADIATION STUDIES - EVALUATION OF FISSION PRODUCT DISTRIBUTION AND MOVEMENT IN TERRESTRIAL ENVIRONMENTS

T. TAMURA, U.S. Atomic Energy Commission, Oak Ridge National Lab. , *Oak Ridge, Tennessee* (W-7405-ENG-26)

The purpose of this study continued to be the characterization of the behavior of critical radionuclides, such as 90Sr, 137Cs, 60Co, 3H, and selected transuranics, in soils, with emphasis on developing an understanding of observed responses as they relate to pedologic factors, weathering, and erosional processes. By establishing fundamental relationships between radionuclide behavior and soil properties, it should be possible to predict the behavior of radionuclides on different soil types, to predict the uptake of radionuclides in plants, and to be able to suggest remedial or countermeasures when needed.

The scope of this study includes: (1) defining the extent and mode of radionuclide movement off the soil surface by runoff and erosion and into the soil profile by infiltration using laboratory tests, small field plots, and well-defined watersheds; (2) defining causative factors primarily responsible for retention movement and fixation of critical radionuclides in soils; (3) examining the role of organic with particular emphasis on the surface horizons; and (4) developing models which will aid in predicting the behavior of radionuclides in related soil types. The nuclides will provide soil reaction information of agricultural and silvicultural importance and will be valuable for effectively utilizing soils for peaceful applications of nuclear energy.

Results of laboratory investigations of selective sorption of cobalt by minerals and soils reveal that hydrous sesquioxides, which are commonly present in these systems, play an important role. Minerals which had been around for size fractionation and then washed with water, salt, acid, or base released different amounts of components in the extracts, depending on the chemical solution and mineral species. Cobalt sorption by unground pure minerals and soil clay minerals was also investigated by saturating exchange sites with either sodium, magnesium, iron, or aluminum ions. These studies revealed that iron and aluminum saturation of minerals increased cobalt sorption as compared to minerals in their natural state.

SUPPORTED BY U.S. Atomic Energy Commission

1.0117, THE BASIC NATURE OF LIQUIDS

H.W. PRENGLE, Univ. of Houston, School of Engineering, *Houston, Texas* 77004

The purpose of the program is to investigate experimentally and mathematically the intermolecular potential field in which a given molecule moves by making infrared absorption and PVT measurements on certain liquids and observing the IR-shift (change in frequency) and configurational energy changes as a function of volume; pressures from 1 - 10,000 atm are being used.

The problem falls into the category of a 'many body problem' and one approach conceptually, ad discussed by Ter Haar, is to find the self-consistent field in which the molecule moves, and thereby improve the field potential model.

Preliminary measurements were made in 1963-64 to determine the feasibility of the method, and the first part of the project was to construct a research IR-spectrophotometer with a grating monochromator to obtain the required resolution.

Presently, construction and calibration of the equipment has been completed and the first series of measurements following the C double- bond C (in 2-pentene) stretching frequency-shift in various liquid atmospheres, and at reduced volumes (by means of high pressures) are in progress. PVT isotherms, 30-250 degrees C, up to 1000 atm have been completed and isotherms up to 10,000 atm are in progress.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0118, STUDIES OF CONCENTRATED AQUEOUS ELECTROLYTES AND OF MOLTEN ELECTROLYTES BY INFRARED SPECTROSCOPY

R.E. HESTER, Univ. of York, *York, United Kingdom*

A program of research is proposed which will provide fundamental information on the nature of interionic and ion-solvent binding forces in aqueous electrolyte solutions and in molten electrolyte solutions. Primary emphasis is placed on the study of interactions of simple inorganic anions, including the halides, sulfate, carbonate, nitrate, phosphate, perchlorate, with a wide variety of metal ions, and on the role played by water in moderating these interactions. The techniques of vibrational spectroscopy will be used to study the changing symmetries of the polyatomic anions and of the metal complexes formed when inorganic electrolytes are mixed in the molten states and in aqueous solutions. Studies covering a wide range of temperatures and concentrations are proposed in order that infrared and Raman intensity measurements may be used to give values for the important thermodynamic quantities governing the interaction phenomena studied.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0119, CHEMISTRY OF BRINE STRATIFICATION AND RELATED EVAPORATION STUDIES

W.P. HEWITT, Univ. of Utah, State Geolog. & Min. Surv. , *Salt Lake City, Utah* 84112

Detailed water sampling aerially and in depth on a monthly basis. Samples analyzed for all common ions.

SUPPORTED BY Utah State Government

1.0120, SPATIAL DISTRIBUTION OF CHEMICAL CONSTITUENTS IN GROUND WATER

W. BACK, U.S. Dept. of Interior, Water Resources Division, *Arlington, Virginia*

One of the topics in geology and hydrology that has been extensively studied, but that is not well understood, is the solution and precipitation of carbonate rocks. Many laboratory studies have been made on the solubility of calcite, some on aragonite, and few on magnesium-calcium carbonates. Field work related to this topic has been almost entirely related to the origin of linestone caverns and the formation of dripstone deposits. No comprehensive study has been made of ground-water problems, such as the processes that produce solution channels, their subsequent filling, and the chemistry of the water. A fresh approach to this question is now feasible through the application of electrochemistry and thermodynamics.

This project is part of a current broad field of study to determine if exact thermodynamic models can be used to describe the relationships between minerals and aqueous solutions. Models can be developed, but certain parameters significant for use of these models must be measured in the field. If the model can exactly describe the field relation, then a correct explanation for the solutional and precipitational processes and the resultant chemical characteristics of the water and the chemical and physical characteristics of the rocks has been obtained.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

1.0121, NITRATE DETERMINATION USING CHROMIUM (II) COMPLEXES

J.G. MASON, Virginia Polytechnic Institute, Graduate School, *Blacksburg, Virginia* 24061

The determination of nitrate by usual methods is subject to interferences by nitrite and hydroxylamine and is not readily adapted to automatic operation. The objectives of the proposed research are: (1) To develop a rapid, accurate, and selective electrochemical method for the determination of nitrate in water in the presence of nitrite and hydroxylamine using electrogenerated Cr(II) complexes as reducing agents. (2) To explore the extent to which such a technique could be automated. (3) Elucidate aspects of the mechanism of the reduction of nitrate to hydroxylamine to ammonia by Cr(II) complexes.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

1.0122, ADSORPTION OF ORGANIC COMPOUNDS ONTO SOLIDS FROM AQUEOUS SOLUTIONS

J.P. WIGHTMAN, Virginia Polytechnic Institute, Graduate School, *Blacksburg, Virginia* 24061

The proposed research involves a study of factors effecting adsorption of organic compounds from aqueous solution. The compounds selected for study contain functional groups representative of water contaminants. Several solids of different surface energy will be studied.

The surface area, surface constituents, and structural elements of each solid will be established. The measurement of the amount of organic compound adsorbed and the heat of adsorption is proposed.

The results should ultimately support a model for solution adsorption by which predictions concerning the selectivity of adsorption of a given compound in water by a given solid could be made.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Virginia Polytechnic Institute

1.0123, DETERMINATION OF BULK DENSITY & WATER CONTENT OF SOIL THRU MEASUREMENT OF RADIATION ATTENUATION AT TWO DIFFERENT GAMMA ENERGIES

W.H. GARDNER, Washington State University, School of Agriculture, *Pullman, Washington* 99163 (AT(45-1))

Development of equipment and techniques is proposed for concurrent measurement, using attenuation methods and two radiation sources of different energy, of soil bulk density and water content in soil columns in the laboratory and in soil in the field. Preliminary experimental work and analyses indicate probable precisions3 (standard deviation) in bulk density measurement ranging from 0.003 to 0.006 g/cm. and somewhat better precision in water content. These values are obtained using radiation source strengths sufficient to give 106 counts/min. through a 0.1 x 1 cm. collimating slit and empty soil container and for 5 to 10 cm. soil columns and counting for 1 minute. Further investigation of gamma source combinations and of collimation and shielding is required. Additionally, studies are needed for other factors such as precision needed in mass attenuation coefficient and soil column thickness (or access tubing spacing) measurements. Problems in variation of chemical properties of soil from place to place and their effect on mass attenuation coefficients also must be investigated.

Need for non-destructive concurrent measurements of soil bulk density and water content exists in a variety of experimental work both of applied and fundamental nature. A practical technique would have wide application.

SUPPORTED BY U.S. Atomic Energy Commission

1.0124, CLAY MINERAL STABILITY AND WATER COMPOSITION

J.A. KITTRICK, Washington State University, Agricultural Experiment Sta. , *Pullman, Washington* 99163

Objectives and Work Proposed: The broad objective toward which this project would contribute is a better understanding of how the relatively small group of minerals that dominate soils and sediments control and are in turn altered by, the composition of waters with which they are in contact. The specific aim of this project is to obtain standard free energy of formation values of several of these minerals by solubility measurements and to correlate these energy values with what is known of mineral occurrence and water composition in soils and sediments.

SUPPORTED BY Washington State Government

1.0125, CLAY SLURRY FLOW CHARACTERISTICS

W.C. PARRISH, Washington State University, School of Engineering, *Pullman, Washington* 99163

Friction factors for clay-slurries of different clay contents by weight have been determined for a 6-inch, schedule 10 welded steel pipe. The information will be used in a preliminary design of pumping requirements for an 18-mile pipeline from the clay mine to the mill.

Detailed studies of environmental effects on clay slurry flow characteristics will be carried on using the variable-slope, pump-pipe test loop which was fabricated by the University for the friction factor tests.

SUPPORTED BY Washington State University
J. R. Simplot Company

1.0126, HYDROSTATIC HIGH PRESSURE EFFECTS

Y. POCKER, Univ. of Washington, Graduate School, *Seattle, Washington* 98122

(i) It is proposed to determine the enthalpy, entropy and volume of activation in both H2O and D2O of processes subject to (a) general- acid, (b) general-base (c) nucleophilic (d) metal-ion and (e) enzymatic catalysis. The investigation will include, but will not be limited to chemical and enzymatic catalysis of the mutarotation of glucose, hydration of pyridine-aldehydes and hydrolysis of p-nitrophenyl acetate.

(ii) It is also proposed to explore the mechanism of denaturation of enzymes by pressure with particular reference to reversible denaturation.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

1.0127, IMPINGEMENT OF A FLUID ON A FLUID SURFACE

G.H. STEWART, Gonzaga University, School of Engineering, *Spokane, Washington* 99202

Investigation of the effect of interfacial surface tension on the volume, depth, and change in surface area of the indention caused by the impingement of air on a fluid surface near the onset of dispersion.

SUPPORTED BY Amer. Chemical Society

1.0128, DEVELOPMENT OF THE VACUUM FREEZING VAPOR COMPRESSION PROCESS

R.R. BRIDGE, Colt Industries Incorporated, *Beloit, Wisconsin* 53511

The vacuum freezing vapor compression (VFVC) process is based on freezing by flash evaporation with compression of the vapor and subsequent condensation on ice which has been cleaned of brine in a counter-washing column. A pilot plant at the OSW, R & D Test Station, Wrightsville Beach, N.C., has operated successfully producing potable water at capacities higher than the original 60,000 gpd design capacity. During FY 1969 the pilot plant will be operated to improve the performance of the compressor, heat exchangers, and washer. Also, a conceptual design of a 1 and 5 million gpd plant will be made. In addition a systems analysis will be conducted on the process components.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

1.0129, VHF PROPAGATION THROUGH FRESH WATER AND ACROSS THE AIR-WATER INTERFACE

E.M. LONSDALE, Univ. of Wyoming, School of Engineering, *Laramie, Wyoming* 82071

We are conducting this research in conjunction with an investigation of bio-telemetry from fresh-water fish. Miniature transmitters using pulsed radio-frequency in the 100 mhz range, have been immersed in naturally-occurring fresh water and the radiation patterns above water, measured. Relationships between the depth of penetration and salt content are being investigated. In addition studies are underway on determining the optimum polarization for minimum losses at the air-water interface. Usable signals have been detected from transmitters operating at depths as great as 60 feet.

SUPPORTED BY University of Wyoming

1.0130, HYDRODYNAMIC PROBLEMS WITH RANDOM BOUNDARY CONDITIONS

J.W. THOMAS, Univ. of Wyoming, Graduate School, *Laramie, Wyoming* 82071

At this time a paper has been prepared in which a two-dimensional irrotational, steady flow of an incompressible, inviscid fluid, is treated which assumes boundary conditions that are random variables, i.e. functions defined on a probability space. It is planned to extend this to include such things as three-dimensional, non-stationary viscous flows.

SUPPORTED BY University of Wyoming

2. WATER CYCLE

General Studies; Precipitations; Snow, Ice, and Frost; Evaporation And Transpiration; Streamflow; Groundwater; Water in Soils; Lakes; Waterand Plants; Erosion and Sedimentation; Chemical Processes; EstuarineProblems.

2.0001, CHARACTERIZATION OF DYNAMIC PROPERTIES AND PHYSICAL CONDITIONS OF SOIL IN RELATION TO TILLAGE AND TRACTION

W.R. GILL, Auburn University, National Tillage Mach. Lab, *Auburn, Alabama* 36830

Object: To determine and measure the static and dynamic physical properties and conditions of soil which are of importance in the design and operation of tillage and traction devices and required for plant growth

Plan of Work: The triaxial shear apparatus provides a means for applying controlled stresses to volume elements of soil so that basic dynamic behavior can be measured and correlated with applied stresses. The mathematical relations between stresses and soil deformations will contain parameters whose values will depend upon certain physical properties of the soil.. The measurement of soil behavior in various conditions will permit the characterization of soil by means of these parameters. Simple tillage tools will also be used to apply forces to soil and basic dynamics of behavior will be correlated with stresses to develop basic behavior equations that can be used in a soil-machine mechanics.

An environment chamber will be used to provide the means for controlling environment during the growth of plants. With this chamber the basic behavior of plant roots in different soils and conditions will be observed to evaluate the factors limiting plant root growth. Descriptions of the plant, soil, and environment will be developed to characterize soil conditions required for tillage and plant growth. These descriptions will be used to develop soil-plant and soil-machine mechanics and to evaluate the effect of tillage and traction on soil condition. It is estimated that three professional man-years per year will be used on this project.

SUPPORTED BY U.S. Dept. of Agriculture

2.0002, CORRELATION OF SOIL SURFACE AND RAINFALL-RUNOFF-MOISTURE RELATIONSHIPS ON AGRICULTURAL WATERSHEDS ON COASTAL PLAINS SOILS (ABBREV)

J.G. HENDRICK, Auburn University, School of Agriculture, *Auburn, Alabama* 36830

Objectives: 1. To investigate soil surface characteristics such as roughness, strength, surface sealing and tilth as a means of determining infiltration and percolation rates of soils as an aid in evaluating watershed surface runoff, water yield and groundwater recharge. 2. Investigate the influence of type and extent of cover on absorption of water by the soil.

Salient Points: 1. Laboratory studies will be conducted in investigating relationships between soil strength, bulk density and infiltration and permeability for bench mark soils. 2. Rainfall simulator studies will be made to investigate the effect of type and percentage of cover upon infiltration and runoff rates for bench mark soils. 3. Knowledge gained in objective 1 and 2 will be utilized in field studies to determine if relationships developed are valid. 4. After determining some reliable measure of soil surface vs water absorption characteristics, small watersheds will be instrumented to measure rainfall-runoff-antecedent moisture-water table relationships. These instrumented watersheds will be utilized in developing techniques to explore water movement into and through the zone of aeration and into the water table.

2. WATER CYCLE

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Auburn University

2.0003, WATER MOVEMENT CONTROL AND CULTURAL PRACTICES IN COTTON PRODUCTION

J.G. HENDRICK, Auburn University, Agricultural Experiment Sta., *Auburn, Alabama* 36830

1. To investigate methods whereby natural rainfall can be more efficiently utilized in the semi-humid regions.
2. To determine design criteria for control of erosion and sediment production through water movement control and cultural practices.
3. To develop practices for increased efficiency of soil and water management practices which are compatible with mechanized cotton farming systems.

Description of Work Proposed: Study various methods to optimize rainfall utilization and provide adequate drainage and erosion control. Investigate such concepts as terraces designed for 4-row equipment, terraces which can be crossed with modern farm implements, parallel row alignment with variable row gradients, modified bedding techniques, methods of increasing plant rooting depth, and rainfall harvesting.

SUPPORTED BY U.S. Dept. of Agriculture
Alabama State Government

2.0004, HYDRAULIC INVESTIGATION OF SOIL EROSION AND SEDIMENTATION IN HIGHWAY MEDIAN AND SIDE DITCHES

C.H. PETERSON, Auburn University, School of Engineering, *Auburn, Alabama* 36830

The hydraulic flow characteristics associated with erosion and sedimentation in lined and unlined highway ditches will be investigated by constructing prototype test channels on various slopes in different Alabama soil types. Also, methods to prevent scouring and silting will be developed.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Alabama State Government

2.0005, EVALUATION OF NEW TECHNIQUES IN ELECTRICAL RESISTIVITY SURVEYING IN THE PIEDMONT AREA, ALABAMA

J.C. WARMAN, Auburn University, Water Resources Research Inst., *Auburn, Alabama* 36830

This study proposes to evaluate the use of newly devised surveying techniques and interpretive procedures for electrical resistivity surveys in the Piedmont area of Alabama. It is proposed to use the newly devised surveying techniques and interpretive procedures which search for horizontal variations in resistivity at different depth planes. If proven successful, the use of these techniques will assist the development of available groundwater resources and reduce the cost of exploration and development.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Auburn University
Alabama State Government

2.0006, EVALUATION BY TEST DRILLING OF GEOPHYSICAL PROSPECTING FOR GROUND WATER IN THE PIEDMONT AREA, ALABAMA

J.C. WARMAN, Auburn University, Water Resources Research Inst., *Auburn, Alabama* 36830

This study proposes to evaluate by test drilling the results of research completed June 30, 1966, under OWRR Project B-003-ALA, ' Geophysical Prospecting for Ground Water in the Piedmont Area, Alabama.' Included will be construction of test wells in 10 of the 25 prospective areas identified in Project B-003-ALA, completion of pumping tests on 6 of the wells, and analysis of the non-biological chemical constituents in the ground water. It is impossible to evaluate geophysical interpretations without test drilling. A more complete evaluation might include construction of test wells at each of the 25 prospective areas; however, we believe that drilling 40 per cent of the prospective areas and incorporating this data with records available from 6 water wells and core holes in the project area will allow a reliable evaluation and will avoid unnecessary expense. Drill cuttings, well construction records, and test pumping data will be made a part of the permanent files of the Geological Survey of Alabama and thus be available for other studies. If proven successful, the use of geophysical techniques in the Piedmont area will enable more complete development of available ground water resources and reduce the cost of exploration and development.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Auburn University
Alabama State Government
Hefline City Government - Alabama

2.0007, DEVELOPMENT OF CRITERIA FOR TILLAGE MACHINERY THAT WILL REDUCE SOIL EROSION AND RUNOFF

A.W. COOPER, U.S. Dept. of Agriculture, *Auburn, Alabama*

Object: To obtain engineering information useful in the development of new and improved equipment and machinery for soil and crop management.

Plan of Work: Field and laboratory experiments will be conducted to determine the effect different tillage machinery and practices have on seedbeds. Inputs of time, labor and power for various tillage systems will be determined and used in rating these systems. Attention will be given to methods and instruments for measuring soil surface roughness; and the relationship between roughness and surface water retention will be ascertained. Criteria for equipment needed for various soil and water conserving practices will be developed. Models will be used to predict the forces acting upon tools being operated in the soil, the behavior of the soil, and the effects of the operating tools on the soil. The studies will include work on cultivating machinery as well as primary tillage machinery.

SUPPORTED BY U.S. Dept. of Agriculture

2.0008, AQUIFER PERFORMANCE TESTS UNDER TWO PHASE FLOW CONDITIONS

H.R. HENRY, Univ. of Alabama, Water Resources Program, *University, Alabama* 35486

This is a project with two parts. The first part is a laboratory model constructed and developed to study the effects of two phase flow conditions. The second part is a test phase conducted on a water-well field under actual field conditions. The laboratory studies of part 1 will consist of fundamental studies placed in the framework of aquifer dynamics under two-phase conditions. The principal group of experiments will consist of air entrainment studies in well aquifer system by blocking of flow channels by entrained air during intermittent operation. The problem is particularly severe in the recharge case. The laboratory set-up will consist of a model of a portion of an aquifer. The laboratory model will be operated to cause air entrainment in a manner to correspond to field operation. Flow rates, pressures in the well and aquifer and velocities by tracer movement will be measured to determine the change in apparent characteristics of the well and aquifer when air is entrained.

The field study of part 2 will consist of checking the results of part 1 under actual field conditions by conducting aquifer performance test on wells drilled and developed in an aquifer underlying the campus of the University of Alabama. Twelve wells of different depths and diameters will be drilled and developed in an aquifer whose geology and hydrology are known. The wells will be located in an array which will fully penetrate the aquifer and cover the extent of the well field. Field and laboratory tests will be correlated.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Alabama
Auburn University
Alabama State Government

2.0009, THE DEVELOPMENT OF GEOCHEMICAL AND GEOPHYSICAL TECHNIQUES AS AN AID TO DETERMINING AVAILABILITY OF GROUND WATER IN LIMESTONE TERRANES

P.E. LAMOREAUX, Univ. of Alabama, Graduate School, *University, Alabama* 35486

This study is on the effectiveness of geochemical and geophysical techniques in determining the location, quantity, and quality of ground water in massive limestone beds. These limestone beds are the principal source of water for most uses in the Tennessee Valley. Ground water occurs in solutionally enlarged openings along bedding and joint planes of the limestone. Industrial expansion and the resulting increase in population and water use indicate the need for more effective methods to determine the occurence and availability of water in a limestone terrane.

Previous studies indicate that the location and alignment of large-capacity wells and springs in this area are related to factors of geochemistry, topography, geologic structure, stratigraphy, and the thickness of the unconcolidated material overlying the limestone bedrock.

The proposed study will apply geochemical techniques to determine: zones of high permeability and their alignment in the limestone terrane, relation of quality of water to geologic structure, recharge and discharge areas, character and thickness of soil layer, proximity to principal water-bearing solution and fracture systems, periods in water year, and surface-water flow patterns. The geophysical studies will determine the position of the water table and the thickness and type of unconsolidated material overlying the bedrock, the location, alignment, and development of sinkholes, and delineation of potential zones of high permeability in the bedrock. Preliminary investigations indicate that soil thickness and type have a greater bearing on the quantitative aspect and approach to ground-water studies in limestone terranes than formerly realized; therefore, detailed studies of this aspect of the project area include drilling for control purposes.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Alabama
Alabama State Government
Auburn University

2.0010, GLACIAL MELT WATER PREDICTION

W.E. LONG, Alaska Methodist University, Undergraduate School, *Anchorage, Alaska* 99504

A mass balance of a small glacier will be made to determine its sensitivity to climactic and weather changes. The prime purpose of the investigation is to determine the water production characteristics of glaciers. Project to begin in fiscal 1968 and terminate in fiscal 1969.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Alaska Methodist University

2.0011, GEOHYDROLOGY OF THE ANCHORAGE AREA, ALASKA

W.W. BARNWELL, U.S. Dept. of Interior, Water Resources Division, *Anchorage, Alaska*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with State and local agencies in Alaska.

Purpose - To assemble and integrate the facts about the Greater Anchorage hydrologic systems which will be used by city and borough planners for designing an orderly development of the water resources.

Methods - Approximately 4 years of records from 30 stream and lake gages will be obtained. Seasonal and yearly runoff from major streams from the Eklutna River on the north to Twenty Mile River on the south will be evaluated. Samples of ground water and surface water will be collected for chemical analysis to identify changes in chemical quality which result from use of the water resources. Several thousand feet of test drilling, borehole and areal geophysical techniques, and a study of surface and subsurface geology will be used to define geologic boundaries of ground water basins. Test pumping and infiltration studies will be used to determine the hydrologic properties of the aquifers. Dyes or other tracers will be used to determine the direction and velocity of ground-water movement.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Alaska State Government

2.0012, WATER RESOURCES OF THE KENAI PENINSULA BOROUGH AREA, ALASKA

S.H. JONES, U.S. Dept. of Interior, Water Resources Division, *Anchorage, Alaska*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with State and local agencies in Alaska.

Purpose: To provide facts concerning the water resources of the Kenai Peninsula Borough for planners to use in designing procedures for orderly development of the water resources.

Methods: Stream and lake gages will be installed to evaluate seasonal and yearly runoff from major streams. Surface and subsurface flow of water into and out of the area and changes in chemical quality of water resulting from water use in the area will be defined. Sediment discharge of the streams will be determined. The geologic boundaries of the ground-water basin will be defined, and aquifers identified by a study of surface and subsurface geology.

SUPPORTED BY · U.S. Dept. of Interior - Geological Survey
Alaska State Government

2.0013, SCOUR AT BRIDGE CROSSINGS IN ALASKA

L.S. LEVEEN, U.S. Dept. of Interior, Geological Survey, *Anchorage, Alaska*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Alaska.

Only meager information is available on scour of alluvial channels at constrictions and no generally accepted method of predicting depth of scour is presently available. The objective of this project is to develop general relationships between observed depth of scour and measurements of the associated hydraulic and sediment transport variables at selected bridge crossing in Alaska.

The project is designed to obtain detailed information on the cross sectional and longitudinal profile of the streambed utilizing echo sounders from a boat; and to provide measurements of hydraulic and transport variables such as the vertical velocity and sediment distributions, stage-discharge and depth-discharge relationships and particle size of suspended sediment and bed material. The results of this investigation will complement laboratory experiments and aid in understanding the mechanics of scour around bridge piers and abutments.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Alaska State Government

2.0014, WATER RESOURCES OF THE GREATER JUNEAU BOROUGH, ALASKA

J.A. MCCONAGHY, U.S. Dept. of Interior, Water Resources Division, *Anchorage, Alaska*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with State and local agencies in Alaska.

Purpose - To describe the hydrologic system in the Greater Juneau Borough so that city and borough planners can design procedures for orderly development of water resources.

Methods - An inventory will be made of selected wells and an observation well network will be established to observe water level changes. The bedrock-surficial deposits contact will be mapped and test holes will be drilled in the surficial deposits. Geophysical techniques will be used in the examination of wells and test holes. Pump tests will be performed using wells in the surficial deposits aquifer.

Low flow in streams will be determined and a network of eleven gaging stations will be maintained. Sediment load of selected streams will be correlated with discharge. Samples will be selected for chemical analysis.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Alaska State Government

2.0015, COASTAL AND INSHORE OCEANOGRAPHY

H.E. BRUCE, U.S. Dept. of Interior, Biological Laboratory, *Auke Bay, Alaska*

This project is a comprehensive study of the chemical, biological, and physical oceanography of selected estuarine environments in Southeast Alaska.

The objectives are to describe the general physical, chemical, and biological oceanographic conditions of the inside waters of Southeast Alaska and the seasonal and annual variations in these conditions. The oceanographic work is done in conjunction with other investigations of the Auke Bay Laboratory (Marine Biological Investigations and Shellfish Investigations) and with the Federal Water Pollution Control Administration and the University of Alaska. The combined effort by the above groups resulted in detailed 'ecosystem studies' of selected areas.

The oceanographic studies are broken down into physical and descriptive oceanography and chemical and biological oceanography which results in an over-all comprehensive program in oceanography. Biological oceanography includes studies in phytoplankton ecology, taxonomy, primary and secondary productivity, and energy transfer from the primary producers through the primary herbivores. Also included are studies on dissolved and particulate organic materials and their relations to primary and secondary trophic levels and to benthic organisms.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

2.0016, BRISTOL BAY ESTUARINE ECOLOGY

C.J. DICOSTANZO, U.S. Dept. of Interior, Biological Laboratory, *Auke Bay, Alaska*

During the past few years intensive work has been done on the freshwater and the high seas phases of the life history of the sockeye salmon. Recent work has indicated that the ocean survival rates may not be nearly as constant as formerly thought and that estuarine conditions strongly influence these rates. Thus it seems necessary to supplement the freshwater and oceanic studies with investigations into the ecology of the sockeye salmon in estuarine areas.

The early phase of this study will be largely exploratory in nature. The objectives are: 1. To delineate the water masses within the Bristol Bay area and determine the physical and chemical features of the estuarine and adjacent coastal waters. 2. To determine the pattern of movement and distribution of smolts from the parent river into the estuary and ocean waters. 3. To determine the growth and survival of smolts as they pass through this transitional phase of their life cycle.

The first full season of study will utilize aircraft and radiometer to delineate water masses in Bristol Bay.

More specific oceanographic studies will be conducted from a surface vessel. It is expected that much time will be spent in assembling gear and developing standard stations and technique. Sampling of juvenile salmon will be accomplished with various kinds of gear, including tow net, trawls, seins, and gill nets.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

2.0017, ESTUARINE STUDIES OF SOUTHEASTERN ALASKA

J.B. KIRKWOOD, U.S. Dept. of Interior, Biological Laboratory, *Auke Bay, Alaska*

One of the aims of the Auke Bay Biological Laboratory is to accumulate detailed descriptive information on environmental characteristics of several estuarine environments within the inside waters of Southeastern Alaska, and to explain ecological reasons for some of the observed differences between environments. The ecological differences are undoubtedly responsible for the annual fluctuations and distributions and abundances of commercially valuable fish and shellfish species.

It is apparent that descriptive knowledge of local populations and their environments are not sufficient in themselves to provide a clear concept of basic ecological and biological principles controlling an ecosystem however, such knowledge is a prerequisite to planning and conducting more detailed and intensive studies of discrete ecological and biological problems.

A cooperative study was initiated in April 1967 that will involve Oceanography Investigations, Marine Biological Investigations, Shellfish Investigations of the Auke Bay Biological Laboratory, and outside agencies such as Federal Water Pollution Control Administration and the Institute of Marine Sciences, University of Alaska.

Each group submits a separate description of its proposed participation in the cooperative estuarine study. The shellfish investigations study involves the following objectives: (1) To determine species composition and relative abundance of pelagic and benthic invertebrates. (2) To determine the relationship between species composition, distribution, abundance, and the environment.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

2.0018, A STUDY OF THE FREEZING CYCLE IN AN ALASKAN STREAM

C.S. BENSON, Univ. of Alaska, Geophysical Institute, *College, Alaska* 99735

The research which will be assisted by the equipment and logistics provided is in the area of stream icing. The physical properties of the stream ice and its overlying and adjacent snow cover will be studied both in the field and laboratory. The equipment is for obtaining, storing and experimenting with samples of the snow and ice. The equipment and logistics mainly provide for winter sampling.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Alaska

2.0019, CLAY-INORGANIC AND ORGANIC-INORGANIC ASSOCIATIONS IN AQUATIC ENVIRONMENTS

D.W. HOOD, Univ. of Alaska, Inst. of Marine Sciences, *College, Alaska* 99735 (AT(04-3)-310-3)

The overall objective of this year's proposed research is to further our understanding of the chemical processes that accompany passage of sediment systems from glaciers to form marine sediments and the ancillary chemical effects of such processes on the local oceanographic environments. As in the past, the prime emphasis will be on the trace metal associations both in organic and inorganic processes. This years emphasis is on studies of the trace metal exchange equilibrium between the various size fractions of the suspended minerals and the water. The effect of organic material on this exchange will also be investigated. Analysis will be made by neutron activiation techniques. In addition, concerted effort is being made to fractionate the organic matter previously found to contain significant quantities of Cu and Zn. Reverse osmosis and sephedex techniques are being employed.

Mineralogical data for both suspended and deposited sediments are complete for Taku estuary and is in press in Marine Geology. No evidence for major diagenetic changes in the minerals was observed in the estuary. The exchangeable cations on suspended sediments after contact with sea wate show markedly different composition. The significance of this to flocculation processes is under study. Organic association with copper in an extractable form has been found and reported in 'Nature'. Other associations with a non dialyzable fraction have been found and are now being characterized.

SUPPORTED BY U.S. Atomic Energy Commission

2.0020, DISTRIBUTION OF DISSOLVED IONS IN ALASKAN WATERS

C.M. HOSKIN, Univ. of Alaska, Graduate School, *College, Alaska* 99735

Water, in the form of ice, meltwater streams and lakes, and sediment are closely related in the valley glaciers of southeastern Alaska. As these glaciers flow down their valleys, new sediment

particles are produced by grinding of the valley bedrock into gravel, sand and mud. During the grinding process, some of the rock is dissolved and possibly mud particles contribute most because of their small size and consequent potentially great chemical reactivity. This project will investigate the water and sediment of Alaskan valley glaciers, attempting to learn about the relationships between; (1) the kind of rock being ground up (igneous, sedimentary, metamorphic) and the dissolved substances released into the meltwater from each kind of rock, and (2) the kind of rock being ground up and the resultant particles sizes produced. Certain dissolved substances and the resultant particles sizes produced. Certain dissolved substances as iron, calcium and magnesium and large amounts of suspended sediment can restrict the use of water and thus it is hoped that the data obtained from this research will aid in the evaluation of glacial meltwater usage.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Alaska

2.0021, THE EFFECTIVENESS OF CONTACT FILTER FOR THE REMOVAL OF IRON FROM GROUND WATER

***W. KIM*, Univ. of Alaska, Inst. of Water Resources Res. , *College, Alaska* 99735**

The objective of the proposed study is to explore the applicability of the contact filter in the removal of iron from ground water. A contact filter process developed by Minz in Russia consists of a deep sand bed (six feet) through which coagulated suspension is passed in upward direction. Theoretically this process should perform better than conventional sand filter due to the decreasing grain size of filter media in the direction of flow, and due to the greater depth effective in the filtration. Iron removal from ground water requires the oxidation of ferrous iron, and flocculation and separation of ferric precipitate. The contact filter may promote not only flocculation and separation steps but also the oxidation of ferric ion due to the intimate contact of iron-coated filter media with the incoming water.

The relative effectiveness of the contact filter and conventional sand filters, the optimum media characteristics will be determined by running pilot filter tests under controlled conditions.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Alaska

2.0022, THE EFFECTS OF EXTREME FLOODS AND PLACER MINING ON THE BASIC PRODUCTIVITY OF SUBARCTIC STREAMS

***J.E. MORROW*, Univ. of Alaska, Graduate School, *College, Alaska* 99735**

Disastrous floods in early August, 1967, wiped out the bottom fauna of Faith and McManus Creeks near Fairbanks. As late as September 5, 1967, (last date of sampling) there was no sign of recovery. The bottom of these creeks will be sampled at selected stations and intervals to determine the rate of recovery and relative composition of the bottom fauna. Recovery and composition will be related, if possible, to substrate, basic productivity, meteorology and presence or absence of placer mining activity.

Bottom sampling will be done with a Surber sampler and graded screens, productivity will be measured by the C14 technique. Sampling patterns and frequency will be established by appropriate statistical methods.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Alaska

2.0023, FOREST AND BOG OF SOUTH COASTAL ALASKA - INTRATYPE VARIATION AND ASSOCIATED HABITAT FEATURES

***B.J. NEILAND*, Univ. of Alaska, Graduate School, *College, Alaska* 99735**

This project is a continuation of investigations of south costal Alaska vegetation that were begun in 1962. Part of the earlier project included intensive analyses of stands of forest and stands of bog in widely scattered localities in southeastern Alaska. Phytosociological ordinations were developed for the stands of each vegetation type; various attributes of individual species behavor, behavior of groups of species of known or suspected indicator value, the few enviornmentals measures that had been included, etc, were plotted against these ordinations; and hypotheses were developed as to the major factors with which these vegetation varies.

The major purposes of the present work are to ascertain the validity of the proposed hypotheses, to attempt to find the factors of importance in the patterns if the hypotheses are not correct, and to obtain further phytosociological information to refine the original ordinations. Investigations are being made of (1) for forest: drainage patterns, possible sources of soil water, soil profiles, pH, and various nutrient elements; and (2) for bogs: height of the water and sulfide layers, erosion features and drainage patterns, sources of surface water, upper peat profiles, and various chemical and physical characteristic of bog waters and peat.

SUPPORTED BY U.S. National Science Foundation

2.0024, SOIL HEAT TRANSFER - PERMAFROST AND FROST PENETRATION

***H.R. PEYTON*, Univ. of Alaska, School of Engineering, *College, Alaska* 99735**

The results of this work will provide engineers with specific methods of solution for some of the soil heat transfer problems which must be solved for effective utilization of the northlands. These methods will incorporate two aspects; (1) useful methods for the determination of thermal properties of soils, and (2) computer techniques permitting solution to problems too complex for standard mathematical model methods.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

2.0025, PREVENTION AND CONTROL OF CULVERTS AND ROAD ICINGS

UNKNOWN*, U.S. Army, Cold Reg. Res. & Engin. Lab. , *Fort Greely, Alaska

Objective: To develop criteria and techniques for the prevention and control of icing in culverts and on roads by means of proper location, protective devices or heating arrangements.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Alaska State Government

2.0026, RESTORATION AND REHABILITATION OF EARTHQUAKE DAMAGED PINK AND CHUM SALMON STUDIES IN PRINCE WILLIAM SOUND

P.S. ROYS*, State Dept. of Fish & Game, *Juneau, Alaska

Major Overall Objectives: (1) Restoration of earthquake destroyed pink and chum runs in Prince William Sound. (2) Rehabilitation of spawning areas where production has been seriously curtailed.

Initial Objectives: (1) Biological and Engineering studies on 12 major streams in the subsided zone and 43 major streams in the uplifted zone. (2) Monitor streams to which restorative measures were applied during June 1067.

Procedures: (1) Engineering studies of priority streams to determine drainage area; maximum-minimum volumes of flow; flow velocities; bottom composition; bed load; contours; profiles; cross- sections; silt content; and rate of erosion followed by topographic mapping of study sections. (2) Biological studies of priority streams to determine spawning areas utilized by brood distribution within predetermined zones; measurements of spawning areas utilized; lost and gained; sex ratios; egg retention; scale samples; temperature; pH; subsequent egg deposition; and sequential fry production.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.
Alaska State Government

2.0027, CONTROL OF EROSION AND SEDIMENTATION ASSOCIATED BUILDING AND LOGGING

A.E. HELMERS*, U.S. Dept. of Agriculture, *Juneau, Alaska

2. WATER CYCLE

Object: To determine factors related to erosion and mass soil movement; to develop measures to minimize soil movement and to rehabilitate damaged watersheds; and to determine the effects of logging and other land uses on salmon spawning streams and how to effect improvements.

Plan of Work: Pre-logging and post-logging relationships will be developed on experimental watersheds to study post-logging behavior. Variables to be investigated are a (1) flow characteristics of southeast Alaska streams, (2) stream channel character as affected by log jams and high flows, and (3) water quality in terms of stream temperature and quantity of organic and inorganic suspended sediment. Erosion causes and sources will be studied.

SUPPORTED BY U.S. Dept. of Agriculture

2.0028, TOPOGRAPHIC INFLUENCES ON PRECIPITATION

T.R. CANTINE, U.S. Dept. of Interior, Alaska Power Admin., *Juneau, Alaska* 99801

The study was initially undertaken to define precipitation intensities representative of higher elevations in Southeast Alaska for design storm studies. The local concentration of sea level climate stations and streamgages, together with nearby research programs of the Northern Forest Experiment Station, created an opportunity to examine area-wide variations in precipitation with a relatively small expansion in the data collection program. The program is still in the exploratory stages, but there are good indications that study results will be useful in estimating precipitation intensities and runoff for ungaged areas throughout Southeast Alaska.

SUPPORTED BY U.S. Dept. of Interior - Alaska Power Adm.

2.0029, CLIMATE RELATED TO PLANT RESPONSE IN THE MATANUSKA VALLEY

C.I. BRANTON, Univ. of Alaska, Agricultural Experiment Sta., *Palmer, Alaska* 99645

To collect, collate, analyze, and interpret climatic parameters related to plant response in Alaska's Matanuska Valley, with particular reference to net solar radiation received, moisture evaporation rates, and soil temperature.

Description of Work: The following meteorological series will be continued: (1) Maximum and minimum air-temperatures (2) Precipitation (rain and snowfall) (3) Gross radiation (pyrheliometer) (4) Net pan evaporation (5) Continuous wind velocity and direction (6) Evaporation and transpiration losses. (7) Humidity (wet and dry bulb temperatures). The following new series will be initiated in 1961: (1) Soil temperatures under various ground covers (2) Net radiation (Beckman & Whitley radiometer) (3) Net evaporation (from free water surface and Bellanci plates).

SUPPORTED BY U.S. Dept. of Agriculture
Alaska State Government

2.0030, RESPONSE OF ALASKA'S ADAPTED CROPS TO SUPPLEMENTAL WATER

C.I. BRANTON, Univ. of Alaska, Agricultural Experiment Sta., *Palmer, Alaska* 99645

To develop more precise information about the response to supplemental water of crops adapted to Alaska including, but not limited to, interactions between silt mantle thickness and fertility levels, definition of and interaction with other associated environmental parameters, estimates of irrigation input costs and probable returns, and evaluation of alternate irrigation water sources.

The study will continue over a fairly broad front, and will be conducted over a sufficient number of years to supply estimates of seasonal variability.

SUPPORTED BY U.S. Dept. of Agriculture
Alaska State Government

2.0031, FACTORS AFFECTING THE QUALITY OF ARIZONA MELONS

W.D. PEW, Univ. of Arizona, Agricultural Experiment Sta., *Mesa, Arizona*

Nutritional requirements: Nitrogen, chemical tissue tests (nitrate content of leaves and petioles) from plants grown on a wide range of available soil nitrogen are examined in relation to yields.

Irrigation requirements: Irrigation schedules based on Irrometer readings are applied to create plots of varying moisture levels and interactions between moisture levels and stage of plant development, yield, quality, etc. will be measured in relation to irrigation patterns.

Diseases: Observational notes relative to crown blight - a disease the cause or cure of which is unresolved - are taken in the course of other specific tests to provide data for the crown blight problem.

SUPPORTED BY U.S. Dept. of Agriculture
Arizona State Government

2.0032, LETTUCE PHYSIOLOGY

W.D. PEW, Univ. of Arizona, Agricultural Experiment Sta., *Mesa, Arizona*

To gain additional information relating to the physiology and environmental factors influencing growth behavior of lettuce in order to develop cultural measures that will improve production and quality. Among these factors are: planting data in relation to fall temperatures, irrigation levels and frequencies, fertilization rates, methods, and kinds of materials, previous cropping history, and cropping systems and the use of animal manures. Each of these is to be studied so as to give growth conditions that will result in less loss from premature seeding, larger percentage of solid heads of the desirable sizes, earlier maturity for earlier shipments in the fall and later shipments in the spring.

Description of Work: Irrigation levels: Varying levels of soil moisture based on Irrometer readings are maintained and interactions between soil moisture level, and sand stage of plant development are created. Effects of yield, quality and maturity are obtained from the test plots.

SUPPORTED BY U.S. Dept. of Agriculture
Arizona State Government

2.0033, SOIL WATER MOVEMENT IN RELATION TO THE CONSERVATION OF WATER SUPPLIES

L.E. MYERS, U.S. Dept. of Agriculture, *Phoenix, Arizona*

Objective: To determine significance of physical and chemical processes associated with liquid and vapor-phase movement of water in soil as related to water loss from soil and to develop and test means for reducing such loss.

Plan of Work: Conduct theoretical and experimental studies of water movement through soils and of the physical and chemical status of water in soils. Utilize analog and digital computers to solve one and two dimensional water flow problems related to infiltration and evaporation. Study chemical means of controlling water movement.

SUPPORTED BY U.S. Dept. of Agriculture

2.0034, SUPPRESSION OF EVAPORATION FROM WATER SURFACES

L.E. MYERS, U.S. Dept. of Agriculture, *Phoenix, Arizona*

Objective: Develop and evaluate principles, methods, and materials for reducing evaporation from water surfaces.

Plan of Work: Conduct laboratory and field studies of chemical films, reflective materials, and mechanical barriers. Measure temperature gradients, radiation, wind velocity and related factors. Calculate energy balances, determine processes involved and effectiveness of treatment. Determine influence of destructive forces, such as weathering and wind damage. Utilize laboratory and field data to develop practical methods for evaporation suppression.

SUPPORTED BY U.S. Dept. of Agriculture

2.0035, FACTORS GOVERNING EVAPOTRANSPIRATION OF WATER FROM CROPPED FIELDS

L.E. MYERS, U.S. Dept. of Agriculture, *Phoenix, Arizona*

Objective: To determine physical processes involved in water transfer from the soil to plant roots through the plant to the atmosphere, and determine the influence of environmental factors on water absorption and transfer through soil-plant-atmosphere systems with the ultimate goal of controlling transpiration for water conservation.

Plan of Work: Transpiration and factors affecting it will be studied in a controlled environment chamber and under natural field conditions. Environment chamber will be used to study absorption and transpiration under different conditions of radiation, temperature and humidity. Evaporation and transpiration under natural conditions will be studied using precision weighing lysimeters, radioactive moisture meters and other pertinent tools.

W equals per foot of the midship section (lbs/ft); L equals length (ft).

SUPPORTED BY U.S. Dept. of Agriculture

2.0036, EVAPOTRANSPIRATION THEORY AND MANAGEMENT

O.E. LEPPANEN, U.S. Dept. of Interior, Water Resources Division, *Phoenix, Arizona*

The objective of this project is to study the physical processes involved in evapotranspiration and to develop techniques and equipment for measuring evapotranspiration.

Existing and suggested designs for thermal spectrum radiometers will be evaluated. New instruments will be designed if considered advisable. Uncomplicated thermal metric methods involving harmonic analysis will be studied in order to determine simplified methods of measuring conducted heat flow to and from soils. Metabolic processes of vegetation will be examined from a thermodynamic point of view to determine the effects of metabolism upon the energy budget of vegetated surfaces. A practical application of the principles of thermodynamics in describing the movement of water in the vapor phase within soils will be studied.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0037, ELECTRICAL ANALOG MODELS OF HYDROLOGIC SYSTEMS

E.P. PATTEN, U.S. Dept. of Interior, Water Resources Division, *Phoenix, Arizona*

This is a continuing activity that is now progressing along two broad fronts: electric modeling of ground and surface-water systems, and hydraulic modeling of idealized ground water flow systems.

The electric analogs are problem oriented projects whose design incorporates the pertinent regional controls of a particular hydrologic environment. Direct simulation of the hydrologic system is achieved through the use of resistor-capacitor networks and operational amplifiers programmed according to a conceptual model of the system.

Hydraulic models are developed according to needs for better understanding of flow and mass-transport phenomena, and for verification of theoretical expressions by hydraulic experiments.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0038, SYSTEMATIC AND BIOGEOGRAPHIC STUDIES OF AQUATIC AND SEMI-AQUATIC ORGANISMS IN NORTHERN MEXICO

W.L. MINCKLEY, Arizona State University, Graduate School, *Tempe, Arizona* 85281

Abstract.--Aquatic and semi-aquatic habitats of the basin of Cuatro Cienegas, central Coahuila, Mexico, comprise one of the most unique biological areas of North America. Geographic position, and a rich, though scarcely studied, endemic fauna of mollusks, crustaceans, fishes, and reptiles, the only groups studied to date, make the basin especially suitable for systematic and biogeographic research. Modifications of some habitats by man have influenced the biota through desiccation of certain areas and by connection of some formerly-disjunct drainage systems through canals. Sampling to continue present studies, expansion of research on the known biota through collection of ecologic and distributional data, new work on certain groups (aquatic plants, mollusks, crustaceans, and insects), securing of materials for laboratory analyses, definition of natural areas for preservation, and plans for publication of results, are outlined. Assurances of local support, cooperation and interest by individuals and agencies in the United States and in Mexico, accessibility, and the availability of local facilities all favor success of such a project.

SUPPORTED BY U.S. National Science Foundation

2.0039, RESPONSE OF CITRUS TREES TO SOIL MOISTURE

R.H. HILGEMAN, Univ. of Arizona, Agricultural Experiment Sta., *Tempe, Arizona*

(1) Determine the effect of soil moisture upon tree growth and condition, fruit yield, size and quality; determine the most economical use of water; study factors associated with different levels of soil moisture which influence tree condition. (2) Determine the effect of moisture stresses in the fall upon fruit production and quality. (3) Determine the amount of water depletion from the root zone which is caused by evaporation and percolation to lower depths.

Description of work: Tensiometers have been used to establish soil moisture differentials. Yield and quality data has been obtained on fruit from trees subjected to different soil moisture tensions. Transpiration and leaf moisture deficit data are being correlated with soil moisture tensions and tree growth and yield, etc.

SUPPORTED BY U.S. Dept. of Agriculture
Arizona State Government

2.0040, PRECIPITATION PATTERNS ON RANGELAND WATERSHEDS IN THE SOUTHWEST

R.B. HICKOK, U.S. Dept. of Agriculture, *Tucson, Arizona*

Objectives: Improved prediction of precipitation parameters affecting runoff and sediment production.

Plan of Work: Establish precipitation time-depth, areal distribution, storm sequence, and fall-direction expectancy relations to general and local climatic influences.

SUPPORTED BY U.S. Dept. of Agriculture

2.0041, SEDIMENT YIELD FROM RANGELAND WATERSHEDS IN THE SOUTHWEST

R.B. HICKOK, U.S. Dept. of Agriculture, *Tucson, Arizona*

Objective: Develop methods for predicting sediment amounts, types, and delivery characteristics from agricultural watersheds of varying sizes, physiography, land-use and management.

Plan of Work: Establish factors governing amounts and types of sediments produced and their transport. Determine sediment loads in streams and deposited in reservoirs, relating these to rainfall, runoff, topography, geology, soils, land use, and cultural practices. Identify and evaluate production of various types of sediment source areas, and determine and characterize sediment delivery processes to derive improved equations for estimating sediment yields.

SUPPORTED BY U.S. Dept. of Agriculture

2.0042, GILA RIVER PHREATOPHYTE PROJECT

R.C. CULLER, U.S. Dept. of Interior, Water Resources Division, *Tucson, Arizona*

Objectives: 1. To evaluate water salvage by phreatophyte control on a flood plain typical of the areas of existing and proposed application. 2. To describe the hydrologic and ecologic variables for the purpose of extrapolation of observed data to other locations.

Plan of Work: A water budget is being used to measure the evapotranspiration from a 16-mile reach, containing 9,000 acres of phreatophytes, of the Gila River Flood Plain on the San Carolos Indian Reservation, Arizona. This reach has been divided into three subreaches for comparative evaluation. The water budget includes surface inflow and outflow of the Gila River, surface inflow from tributaries to the reach, ground-water movement, precipitation, and change in moisture storage in the saturated and unsaturated soil zones. The energy budget, mass transfer, and phreatophyte well methods of measuring evapotranspiration are being applied and compared to the water budget. All data will be analyzed by digital computer.

The preclearing calibration will cover the period 1963-66. The phreatophytes will be removed and a beneficial vegetation substituted during the winter of 1966-67. The post-clearing calibration will continue through 1969.

The project includes studies of vegetation, chemical quality of water, and sedimentation.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0043, WATER RESOURCES APPRAISAL OF THE TUCSON BASIN, ARIZONA

E.S. DAVIDSON, U.S. Dept. of Interior, Water Resources Division, *Tucson, Arizona*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with State and local agencies in Arizona and the U. S. Bureau of Reclamation.

Purpose - To determine the amount of ground and surface water moving in and out of the Tucson basin including recharge from streams in the area; evaluate the effect of present and proposed pumpage and surface-water flow on ground-water storage; and describe salinity and fluoride occurrence and distribution in ground water and relate to the lithologic variation of the aquifers and to ground-water withdrawal.

Methods - Existing data on ground-water withdrawn, declines in water levels, quality of ground water, aquifer characteristics, surface- water inflow and outflow, precipitation, and basin geometry will be compiled and analyzed. Additional gaging stations will be installed and miscellaneous surface-water measurements will be obtained to define areas of streamflow depletion. Test holes will be drilled to collect water-quality and lithologic information. Water samples will be analyzed to provide additional information on salinity and fluoride distribution. Geophysical studies will be made and will include seismic gravity and aeromagnetic techniques. An electric-analog of the basin will be constructed to predict changes of water levels under various patterns of development.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Arizona State Government
U.S. Dept. of Interior - Bu. Reclamation

2.0044, ELECTRICAL-ANALOG ANALYSIS OF HYDROLOGIC DATA, ARVA VALLEY, ARIZ

O. MOOSBURNER, U.S. Dept. of Interior, Water Resources Division, *Tucson, Arizona*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Arizona.

Purpose - To provide predictions of future positions of the water table in an area where ground water is being pumped at a much greater rate than the rate of replenishment.

Methods - Intensive ground-water development and data collection in Arva Valley began about 1950. All existing hydrogeologic data (water levels, pumpage, and transmissibility) from Arva Valley and adjoining areas will be used in an attempt to approximate the actual ground-water system by the electrical model. When simulated water level changes from the model correlate with historic waterlevel declines resulting from actual pumping rates, it may reasonably be assumed that the model is analogous to the hydrologic system. The electrical model will then be used to predict future water-level changes.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Arizona State Government

2.0045, VEGETATION CHANGES IN SOUTHWESTERN NORTH AMERICA

R.M. TURNER, U.S. Dept. of Interior, Water Resources Division, *Tucson, Arizona*

Arroyo cutting, springs and rivers that run no more, mesquite invasion of impoverished remnants of former grasslands, death of saguaro and oak forests are all changes of recent occurrence in southwestern North America. Though these changes and others are recognized, their extent is not fully known nor their causes understood. Several studies, most of which are inconclusive, have stressed man's role in causing the changes; little critical attention has been given to the possibility of secular trends in climate as one of the causes. Many of the changes do not favor man's increased use and more intense occupancy of this arid region. Whether the trends, can be halted is not known but, if the changes can be arrested or modified, it is necessary to more fully understand the scope of the changes and to more closely analyse the causes.

The study is divided into three parts: (1) Photographic documentation of the scope and nature of the changes; (2) the intensive examination of soil moisture relations and micrometeorology of vegetation zones known to b most greatly affected by the changes; and (3) the study of the climate and vegetation of the area as a means of defining present conditions and of detecting secular trends in climate that may affect differently the several recognizable subdivisions of the arid region.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0046, FACTORS AFFECTING PRODUCTION OF PECANS IN ARIZONA

R.C. BOWERS, Univ. of Arizona, Agricultural Experiment Sta. , *Tucson, Arizona* 85721

DESCRIPTION OF WORK - (1) Soil moisture differentials have been established by setting up different irrigation schedules. Occurence of stick-tight nuts and yield are being correlated with amount of water being applied. Total soluble salts in soil in various plots has been determined and attempts to reduce same are being made by leaching experiments. (2) Occurrence of zinc deficiency symptoms have been noted for individual trees. Leaf samples have been collected for analysis of various nutrient elements.

SUPPORTED BY U.S. Dept. of Agriculture
Arizona State Government

2.0047, HYDRAULICS OF SURFACE IRRIGATION

C.D. BUSCH, Univ. of Arizona, Agricultural Experiment Sta. , *Tucson, Arizona* 85721

Objective 3: By field trials, to test the validity of mathematical equations and laboratory relationships describing the hydraulic characteristics of surface flow.

The Arizona State Experiment Station will carry on field research for the evaluation of the mathematical flow models developed by other contributing stations. The work will consist of two phases: Phase I: 1964-65, development of the necessary equipment needed to measure and record electronically the advance and recession curves for border and furrow irrigation. Phase II: 1965-69, measurement of the component surface flow variables on a range of sites selected to provide differing soil conditions and stages of crop growth. The data will be evaluated for agreement with and refinement of, the mathematical models. It will be made available to other contributing stations for further evaluations.

SUPPORTED BY U.S. Dept. of Agriculture
Arizona State Government

2.0048, CARBON-14 CONTENT OF FRESH WATER CARBONATES

P.E. DAMON, Univ. of Arizona, Graduate School, *Tucson, Arizona* 85721

The carbon-14 contents of southwestern caliche deposits, lake carbonates and spring tufa deposits are being determined.

The radiocarbon content of lake carbonates is being used to define the extent and duration of pluvial lakes. The work on caliche deposits is helping to elucidate the mechanism of deposition and the relation between calichification and paleoclimatology.

Comparison of the radiocarbon content of organic matter, tufa and water is being used to define the paleohydrology of artesian water systems.

In addition to the paleohydrologic and paleoclimatic implications, this study has helped to define the problem of the initial C14/C12 ratio in fresh water systems. Lack of such knowledge may result in large and even absurd errors in radiocarbon dating.

SUPPORTED BY Arizona State Government
U.S. National Science Foundation

2.0049, PREDICTION OF WATER MOVEMENT IN UNSATURATED SOILS

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Objectives: (1) To delineate the influence of structural and electrostatic differences as well as solute concentrations and energy gradients upon the movement of solutes, energy, and water in soils. (2) To devise quantitative, expressions describing the simultaneous movement of water, solutes, and energy in soils.

Work Proposed: The flow of water and energy will be examined under conditions of simultaneous water potential and temperature gradients for the purpose of improving the production of flow to evaporative surfaces. Initially, flow will be restricted to one dimensional, steady-rate flow to an evaporative soil surface when the water potential and temperature are held constant at the surface opposite the evaporative surface. Water potential and temperature gradients, quantity of flow and appropriate soil properties will be measured and the data used to evaluate different equations developed for predicting flow under those conditions.

Individual clay particles will be suspended in an electric field enclosed in controlled environments to study rates and amounts of water adsorption or desportion with changes in the vapor pressure of the environment. The rates of absorption are expected to lead to a better understanding of the kinetics of water adsorption. The amounts of adsorption by individual particles at a specific vapor pressure will be compared to the amount of adsorption by similar particles in a packing at the same vapor pressure.

SUPPORTED BY U.S. Dept. of Agriculture
Arizona State Government

2.0050, SOIL PHYSICAL CHANGES DUE TO MANAGEMENT PRACTICES

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The objectives of the project are (1) to evaluate soil physical changes due to different management practices and (2) to relate encountered changes to water management, tillage practices and crop yield. The soil physical changes which have occurred due to different management practices in certain long-term experiments established at several locations in Arizona will be assessed by selected measurements. It is anticipated that a study of methods will be the initial work done on the project. After an evaluation of methods, field and laboratory measurements will be made on the soil for various practices and the results related to water management, tillage practices, and crop yields.

SUPPORTED BY Arizona State Government

2.0051, HYDROLOGIC CHARACTERIZATION OF FORESTED WATERSHEDS IN ARIZONA

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The purpose of the proposed study is to better describe and predict with emphasis on probabilities streamflow runoff from forested watersheds in Arizona. In addition, hydrologic potentials within forest types in terms of snowpack dynamics will be predicted and management guidelines for increasing snowmelt runoff will be developed.

Streamflow characteristics will be described by electrical analogy including precipitation, interception, infiltration and stream routing components. Hydrologic data for statistical studies will be augumented by dendrochronological techniques that allow objective translations of tree ring records into stationary time series. Models for the relation between tree ring widths and runoff will be developed. Within the framework of fundamental hydrologic principles, snowpack dynamics will be related to biotic, topographic, edaphic and climatic parameters by regression analyses. These analyses will provide a system for predicting snowpack water yield potentials and identifying optimum management goals.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Arizona

2.0052, SPRINKLER IRRIGATION OF CITRUS UNDER SOUTHWESTERN CONDITIONS

K.R. FROST, Univ. of Arizona, Agricultural Experiment Sta. , *Tucson, Arizona* 85721

OBJECTIVES: 1. To determine water requirements for citrus trees under sprinkler and flood irrigation. 2. To determine crop yields and tree growth of citrus under sprinkler and flood irrigation. 3. To reveal other influences resulting from sprinkler application of irrigation water for citrus trees.

PROCEDURE: Work on Lisbon lemons will be carried out at the Yuma Mesa Station and coordinated with Horticulture Department Project 405, Lemon Production Improvement in Arizona.

Work on Valencia oranges will be carried out at the Tempe Citrus Station and coordinated with Horticulture Department Project 371, Response of Citrus Trees (Valencia Oranges) to Soil Moisture; Movement of Soil Moisture in the Root Zone.

SUPPORTED BY U.S. Dept. of Agriculture
Arizona State Government

2.0053, DIFFERENTIAL ION MOBILITY AT COLLOIDAL SURFACES

R.J. HANNAPEL, Univ. of Arizona, Agricultural Experiment Sta. , *Tucson, Arizona* 85721

The objectives of this project are: 1) To assess the mobility of alkali cations at solid phase surfaces in reference to the mobilities in bulk solution 2) To relate surface structural variation to differential ionic mobility 3) To evaluate the effect of hydrophobic bonding and the corresponding quasi-crystalline structure of water at solid-aqueous phase interfaces upon ionic mobility and the resulting selectivity in ion transport in multiion systems 4) To develop a working model which can be applied to surface migration in soil and plant colloids.

Procedure: By using diffusion potential measurements along with simultaneous ion flux measurements (using sensitive radiotracer techniques), ionic mobility in synthetic membrane systems will be measured. The membrane system proposed for use allows the desired manipulations in its surface properties so that the stated objectives can be studied.

SUPPORTED BY U.S. Dept. of Agriculture
Arizona State Government

2.0054, STRUCTURAL CONTROL OF SPRINGS FROM THE MUAV AQUIFER IN WESTERN GRAND CANYON NATIONAL PARK, ARIZONA

P. HUNTOON, Univ. of Arizona, Graduate School, *Tucson, Arizona* 85721

Perennial springs, some with flows exceeding 50 cubic feet per second, discharge from the Muav limestone aquifier in the Western section of the Grand Canyon National Park. These springs are apparently the discharge points of the limestone aquifiers in the western sector of the Kaibab Plateau. It is the purpose of this study to determine if these discharge points are controlled by the tectonic fabric of the region.

Prominent faults in the Grand Canyon will be mapped and traced into the Kaibab Plateau. The springs and cavern entrances in the Redwall and Muav limestones will be mapped to determine if there is any correlation with local tectonic structures. It will be determined if the altitudes of springs are structurally controlled. The physiographic trends on the Kaibab Plateau that suggest structurally controlled recharge to the regional aquifiers will be characterized. The probable magnitude of underground drainage system will be calculated from available spring discharge and rainfall data.

SUPPORTED BY University of Arizona

2.0055, WATER USE EFFICIENCY OF FORAGE CROPS

W.R. KNEEBONE, Univ. of Arizona, Agricultural Experiment Sta., *Tucson, Arizona* 85721

OBJECTIVES: To measure variability within species for the characteristics 'efficient water use' in order to best develop a breeding procedure for changing a species and developing an improved variety. To develop techniques for evaluating efficiency of water use by forage crops.

WORK PROPOSED: Variation within species of several forage crops for water use efficiency will be measured. Less than optimum water for maximum forage production will be applied in order to separate genotypes for their ability to produce forage under these limited moisture conditions. Mature plants will be measured for total forage production, recovery after harvest and survival.

The work now in progress concerned with evaluating survival and forage production of a large number of grass and legume species will be continued.

SUPPORTED BY U.S. Dept. of Agriculture
Arizona State Government

2.0056, RADIOCARBON AS A TRACER IN GROUND WATER PROBLEMS

A. LONG, Univ. of Arizona, Graduate School, *Tucson, Arizona* 85721

The radiocarbon content of ground and surface waters is being used as a tracer to study surface and ground water movement. The data are being related to such ground water problems as the rate of laminar flow through aquifers, their permeability, the source, time and rate of charge, radioactive contamination in water supplies, and the waste disposal problem.

The increase in the carbon-14 content of the atmosphere, biosphere and hydrosphere due to nuclear technology is also being monitored.

SUPPORTED BY Arizona State Government

2.0057, WATER CONSERVATION THROUGH EFFICIENT USE BY CROP PLANTS

M.A. MASSENGALE, Univ. of Arizona, Agricultural Experiment Sta., *Tucson, Arizona* 85721

OBJECTIVES: 1. To determine why genotypes within a species differ in their water use. 2. To determine if plant factors found to be associated with water-use efficiency are heritable. 3. To develop efficient plant-water management systems and improved varieties for greater water-use efficiency.

Plan of Work: Genotypes within a species that differ in their water use will be grown under a range of moisture-stressed conditions in controlled-environmental growth facilities. Physiological and morphological factors which may affect or be related to water-use efficiency will be studied and evaluated. Any unique biochemical, physiological or morphological feature found to be associated with water use will be investigated in detail.

Field work will be initially concerned with determining the best time to apply water, when in short supply, for maximum efficiency per unit of dry matter produced. Later, field studies will be concerned with the development of management systems and improved varieties that favor characters found to be associated with efficient water use.

SUPPORTED BY U.S. Dept. of Agriculture
Arizona State Government

2.0058, GROUNDWATER SUPPLIES

W.G. MATLOCK, Univ. of Arizona, Agricultural Experiment Sta., *Tucson, Arizona* 85721

This is a continuing program of groundwater investigations in the Santa Cruz and Avra-Alter Valley in Pima and Santa Cruz County and in the Little Chino Valley in Yavapai County.

The program includes annual water level measurements in wells, preparation of groundwater level contour maps and depth to water maps, and the collection of well log information. Crop surveys are made to compute irrigation water use and other water uses are tabulated. Special studies are made of volumetric unwatering, natural recharge and quality of water. Well tests are conducted to determine aquifer characteristics.

Data collection started in 1940 and will be continued.

SUPPORTED BY Arizona State Government
Pima County Government - Arizona
Tucson City Government - Arizona

2.0059, WATER-SOIL-PLANT RELATIONS

K. MATSUDA, Univ. of Arizona, Agricultural Experiment Sta., *Tucson, Arizona* 85721

Objective II - Evaluate effect of plant structures, physiological processes and transpiration retardants on water movement and loss from plants. (a) Determine relative resistance offered by different tissues in the root to radial movement of water and salts. (b) Determine resistance offered by the suberin layer on the outer surface of suberized roots to entry of water and salts. (c) Determine the 'leakiness' of roots, or the inability of roots to maintain high concentrations of salts in the stele, for different stages of development and different species. (d) Determine effects of temperature, osmotic potential, and mineral composition of ambient medium on salt accumulation and water absorption by roots. (e) Attempt to correlate root structure and salt and water absorption, particularly active absorption of water.

Work Proposed: Microsurgical techniques will be used to remove layers of tissue from roots. Solutions will be pulled or pushed through treated and untreated roots. External factors, including osmotic potential of medium, will be varied in otherwise constant environment, Anatomical features will be determined by standard histological methods.

SUPPORTED BY U.S. Dept. of Agriculture
Arizona State Government

2.0060, THE EFFECT OF EVAPORATION BARRIERS ON FISH GROWTH AND LIMNOLOGY

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Information is needed on the possible effects on fish and their environment of floating plastic evaporation barriers. Such barriers appear to be more effective and cheaper than mono-molecular films but they reduce light and possibly atmospheric contact by pond water. Measurements of fish growth, aquatic photosynthesis and oxygen levels are being made in a series of experimental ponds having different degrees of coverage.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
University of Arizona

2.0061, PHYSIOLOGICAL CHANGES IN PLANTS PRODUCED BY SALINE SOLUTIONS

J.W. OLEARY, Univ. of Arizona, Water Resources Research Ctr., *Tucson, Arizona* 85721

Plants irrigated with brackish water generally have decreased growth and yields. In previous work at this laboratory the physiological response of red kidney beans (Phaseolus vulgaris L.) was studied in detail. The results of these studies indicated that irrigation with water containing moderate levels of sodium chloride affects the water metabolism of the plant. The resistance to water movement through the plant increased and the water potential gradient decreased. Partial stomatal closure was observed, and there was a significant decrease in the total leaf area of the plants. Both of these factors tended to decrease transpiration and photosynthesis. Recent observations have shown that by growing the plants in a high humidity environment the water lost from the leaves via transpiration can be decreased. This reduction in transpiration tends to bring about a closer balance between the water lost and the water supplied to the leaves. Thus the water stress in the plant is partially relieved, and growth inhibition is decreased. The large air inflated plastic greenhouses developed at our laboratory may make brackish water irrigation feasible on a large scale. The greenhouses are totally closed to the natural environment. Water vapor added to the air by evapotranspiration remains within the greenhouse and the plants are surrounded by a high humidity environment. Under these conditions growth inhibition by brackish water should be greatly reduced.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Arizona

2.0062, GEOPHYSICAL INVESTIGATIONS IN ALLUVIAL BASINS IN SOUTHERN ARIZONA

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The proposed investigation is directed toward the synthesis of geophysical data in the Tucson Basin area and adjoining basins in southern Arizona and the geological and geohydrological interpretation of this information. Gravity coverage will be completed with a station interval of about one reading per square mile.

Refraction seismic profiles will be run over areas of indicated interested, such as edges of pediments, productive water wells, and gravity anomalies.

Surface resistivity surveys and magnetometer traverses will also be tried in some localities. Surface and well samples will be collected and measured in the laboratory for their density, porosity, magnetic susceptibility, and resistivity.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Arizona

2.0063, TREATING AN INADEQUACY OF THE UNIT HYDROGRAPH HYPOTHESIS BY STORAGE ROUTING WITH VARIABLE EMPIRICAL VALUES OF LAG AND STORAGE

J.H. THOMAS, Univ. of Arizona, Graduate School, *Tucson, Arizona* 85721

The outflow hydrograph as predicted by the Sherman unit hydrograph frequently does not agree with the observed outflow hydrograph. It is believed that this lack of agreement is due to the basic hypothesis that each ordinate of the outflow hydrograph is directly proportional to the surface runoff.

Dooge has treated this inadequacy by assuming synthetic partial hydrographs and routing them through various reservoirs throughout the basin. Nash has assumed an instantaneous hydrograph and shaped it according to a gamma distribution by routing it through a series of reservoirs at the outflow point.

It is proposed that results comparable to those of Dooge and Nash could be achieved by assuming a unit hydrograph in the shape of an isosceles triangle with its base equal to the duration of rainfall excess and, by routing it with variable values of storage and lag (using the Kohler Template), reproduce the observed outflow hydrograph. The values of storage and lag would be empirically determined. This method is less complex than those of Dooge and Nash and more amenable to programming in a small computer.

It is further proposed that the method outlined above be tested on a small plot under controlled conditions. The Department of Water Resources at the University has such a plot. It is an area of 1/2 acre, is surfaced with two inches of pea-size gravel over impermeable plastic; has an outflow through a weir with a stage recorder, and has a supply of water available in a 100,000 gallon tank. The additional equipment necessary to this proposed study would consist of plastic pipe, pumps and nozzles. It is understood that such equipment, except for small hardware such as nozzles, is available on the campus.

Rainfall of various intensities and durations would be simulated by spraying the plot from water in the tank. The simulation need not be rigidly controlled although it would be necessary to ensure that the areal distribution be consistent. The runoff hydrographs would be analyzed and an attempt would be made to reproduce these observed hydrographs by the method outlined above. For this analysis, the Kohler Template would be formulated and tested on all of the simulated events. The testing would be done by digital computer.

SUPPORTED BY University of Arizona

2.0064, SNOW HYDROLOGY

D.B. THORUD, Univ. of Arizona, Agricultural Experiment Sta. , *Tucson, Arizona* 85721

Objectives: (1) To characterize snow accumulation under forest canopies and in natural and man-made openings in ponderosa pine and mixed conifer zones of Arizona. (2) To evaluate the energy supply available for snowmelt, evaporation and sublimation for the forest conditions described under objective one. (3) To relate the results of snow accumulation and energy budget studies to forest management practices that can be prescribed for purposes of improving snow water yield. (4) To develop and modify these studies in a form that will permit snow to be an element in a mathematical model for predicting total watershed behavior.

Description: Snow accumulation will be evaluated by measurements of total water content, density, depth and the spacial variation of these factors. The energy flow to the snowpack will be evaluated with pyranometers, net radiometers and measurements of air temperature and wind for determining heat flow from the overlying air. Vegetation conditions will be evaluated by standard and possibly specialized mensuration techniques. The relationship between vegetation and the water and energy budgets will then be determined. The results of these studies will be developed and modified for a mathematical model of watershed behavior.

SUPPORTED BY U.S. Dept. of Agriculture

2.0065, THE MANAGEMENT OF PONDEROSA PINE - NEW METHODS OF THINNING DENSE STAGNATING SECOND GROWTH STANDS

R.F. WAGLE, Univ. of Arizona, Agricultural Experiment Sta. , *Tucson, Arizona* 85721

I. A. Field Study. A one-hundred acre area in an old burn that has been newly planted to ponderosa pine will be studied intensively in an attempt to isolate the environmental phenomena that are limiting to the germination, survival, and growth of the developing seedlings. The phenomena to be studied will include: a. Soil nutrition, b. Soil moisture, c. Soil and air temperatures, d. Variations in soil characteristics, e. Relative humidity, f. Effect of other plants. B. Laboratory Studies. Reciprocal studies will be made in the greenhouse and in a controlled environment chamber to supplement and aid in the interpretation of the field results. Ponderosa pine seedlings will be grown in the greenhouse in surface soils obtained from three different situations: a. An old burn, b. A new burn, c. An area in which no burning has occurred in known history.

II. A study of the role of the different environmental factors in an attempt to find out how to manipulate the density of second growth stands to get good growth. As a part of this study, the role played by nutrients, stand density, soil water, and atmospheric water in the growth of ponderosa pine is being considered.

Nutrient & water and thinning treatments have been made on a number of different plots & under a variety of situations.

Data is being systematically collected at yearly intervals. One interim study has recently been completed and will be ready for analysis, writing, and publication within the next 6 months.

During the coming year growth records and neutron probe soil water data will be collected on plots involving about 1,500 trees. Some measurements will be taken weekly and others will be taken at the beginning and end of the growing season.

2. WATER CYCLE

SUPPORTED BY University of Arizona

2.0066, HYDROLOGY OF LOWER COLORADO RIVER BASIN

C.C. MCDONALD, U.S. Dept. of Interior, Water Resources Division, *Yuma, Arizona* 85364

The objective is to obtain knowledge of the hydrology to provide a realistic basis for managing the water resources. The work includes estimating the amount and quality of ground water that may be obtained to supplement river water; investigating the regional movement of ground water between the Colorado River and Imperial Valley, the movement of ground water into the Salton Sea, from Yuma Mesa to adjacent areas, and across the boundary between the United States and Mexico.

Water losses by evapotranspiration will be studied including the experimental determination of water use of several species of vegetation. Evaporation from Lake Mohave, Lake Havasu, and. Salton Sea will be measured, and salt-balance determinations will be made in selected areas.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0067, LEMON PRODUCTION IMPROVEMENT

D.R. RODNEY, Univ. of Arizona, Agricultural Experiment Sta. , *Yuma, Arizona*

DESCRIPTION OF WORK. (1) Irrigation experiments involving sprinkler, furrow and flood basin types of irrigation have been established on young trees in cooperation with Dept. of Agric. Engineering. (2) Nitrogen-phosphate-manure differentials have been applied annually to lemon trees. Yield and fruit quality factors have been correlated. Leaf samples have been and are being collected for analysis for nutrient elements. Soil samples have been taken and analyzed for movement of phosphate. (3) Five different methods of pruning have been established on young trees. Yield data is being obtained.

SUPPORTED BY U.S. Dept. of Agriculture
Arizona State Government

2.0068, THE DISTRIBUTION OF TRACE ELEMENTS IN IMPOUNDMENTS

J.F. NIX, Ouachita Baptist University, Ark. Water Resources Res. Ctr. , *Arkadelphia, Arkansas* 71924

The distribution of trace elements and common water quality parameters will be determined in two impoundments on the Ouachita River in south-central Arkansas. The sampling sites will be chosen in an effort to present a representative picture of each reservoir. The state of occurrence (solution, particulate, organically bound) of each trace element will be investigated using membrane filters and high speed centrifuging.

Samples will be taken during each season and at different reservoir conditions in an attempt to determine the factors which influence the distribution of these elements in the reservoir.

A section of the Ouachita River below these impoundments will be studied to determine if trace elements are being transported from the reservoir. In the event that they are released from the reservoir during power generation, the fate (precipitation, absorption, etc.) of each of the trace elements will be investigated.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Ouachita Baptist University

2.0069, ENGINEERING PHASES OF IRRIGATION IN ARKANSAS

B.B. BRYAN, Univ. of Arkansas, Agricultural Experiment Sta. , *Fayetteville, Arkansas* 72701

Determine rates at which water may be applied to various soils on which crops are growing; evaluate and develop devices used to determine when to irrigate; determine irrigation efficiency in terms of quantitative measurements of water distribution, losses and application; evaluate systems of irrigation with respect to labor requirements, topographic conditions, power and equipment requirements, and efficient water use; determine mechanics involved in controlling air temperatures with sprinkler irrigation systems.

DESCRIPTION OF WORK - Designed Bench leveling plan and, during construction, collected data on tractor and man hour, fuel, oil and repair requirements at Cotton Bra. Exp. Sta.; conducted length of run and furrow irrigation efficiency studies at Cotton S. W. Bra. Exp. Sta. and Main Exp. Sta.; collected Evapotranspiration and climatological data for various nitrogen levels of cotton at Delta Sub-Station. Designed and graded 3 benches to various slopes for furrow irrigation studies at N.E. Bra. Exp. Sta.

Tests for reduction of temperature by irrigation were run on Veg. Substation on various truck and field crops. On the Main Station, tests were run on an elliptical-shape pipe model with hooded inlet for slopes from O to 40 degrees; and manuscript was redrafted on a moisture measuring device using agar and a strain gage; a field was smoothed in preparation of work on a now furrow irrigation study at Southwest Station.

SUPPORTED BY U.S. Dept. of Agriculture
Arkansas State Government

2.0070, MICROMETEOROLOGY OF SOYBEANS

C.E. CAVINESS, Univ. of Arkansas, Agricultural Experiment Sta. , *Fayetteville, Arkansas* 72701

Objectives: 1. Determine the effects of furrow irrigation on the micrometeorology within and above the soybean canopy. 2. Study the effects of micrometeorological factors on rate or type of insect damage and disease infestations with emphasis on the pathogenic organisms. 3. Study the effects of micrometeorological factors on some agronomic characters such as yield, flower shedding, pod set, shattering, seed quality, fertility responses, and others. 4. Measure evapotranspiration at the O- to 10-inch depth in both irrigated and non-irrigated plots.

Description of work proposed: Studies in the initial stages will, of necessity, be of a general nature because information is limited on which of the micrometeorological factors may be of major importance in disease infestations, insect outbreaks, growth and development of the soybean plant, etc. Then, the second phase will consist of a more critical evaluation of particular micrometeorological factors which appear to affect specific plant responses. Initially, all instrumentation will be accomplished at the Northeast Branch Experiment Station at Keiser under the supervision of a U. S. Weather Bureau agricultural climatologist who is stationed at that location. Personnel from the Agricultural Engineering, Entomology, Plant Pathology, and Agronomy Departments of the University of Arkansas will cooperate in these studies.

SUPPORTED BY U.S. Dept. of Agriculture
Arkansas State Government

2.0071, WATER BALANCE AND ALKALINE EXCHANGE RELATIONSHIPS AS INFLUENCED BY WATER MANAGEMENT PRACTICES IN RICE

J.A. FERGUSON, Univ. of Arkansas, Agricultural Experiment Sta. , *Fayetteville, Arkansas* 72701

OBJECTIVES: To determine (1) the total water balance of a rice crop; (2) the effect of submergence depths on the total water balance of rice; (3) the effect of submergence depths on the micro-climate of rice; and (4) the salt accumulation in a field as affected by submergence depth.

DESCRIPTION OF WORK: Continuous monitoring of pH, conductivity, soil and air temperatures, net and solar radiation, water input and runoff on statistically arranged plots of rice undergoing various submergence treatments varying from none to 8 inches.

SUPPORTED BY U.S. Dept. of Agriculture
Arkansas State Government

2.0072, PHYSIOLOGICAL FACTORS IN WATER NEEDS AND USE OF CROPS

A.A. KATTAN, Univ. of Arkansas, Agricultural Experiment Sta. , *Fayetteville, Arkansas* 72701

(1) Study methods of determining soil moisture in an attempt to find or develop reliable and efficient technique for-use-in these studies and for grower use. (2) Determine range of available soil

moisture that permits optimum growth and fruiting of plants and whether this range varies for different stages of plant development. (3) Determine relationship between nutrient use and moisture ranges for horticultural crops. (4) Study relationship between temperature, optimum soil moisture range and frequency of water application.

DESCRIPTION OF WORK: This work is designed to determine factors which result in maximum yield returns from irrigation and the effect of such practices on growth, minimum yield returns from irrigation and the effect of such practices on growth, mineral uptake yield, and quality of raw and processed products. Four crops have been included in this program: tomatoes, in relation to spacing; sweet potatoes, with recognition of hill spacing and water injury exhibited by this crop; beans, in regard to sensitivity at various stages of development; and peaches, in respect to both intensity of fruit load and stage of fruit development. The following determinationa are made: changes in soil moisture; leaf mineral analyses with respect to gradients between young and old tissues; yield and grade; physical and chemical analyses of quality of raw and processed product, and post-harvest changes during storage.

SUPPORTED BY U.S. Dept. of Agriculture
Arkansas State Government

2.0073, MANAGEMENT ALTERNATIVES ON OZARK FOREST

F.M. MEADE, Univ. of Arkansas, Agricultural Experiment Sta., *Fayetteville, Arkansas* 72701

Objectives: 1. To determine the Physical inputs and outputs, costs and return from forest production of low-grade hardwood areas under different levels of management including conversion to pine. 2. To measure physical inputs and outputs, costs and returns, from forage production on low grade hardwood areas converted to range-land at different levels of management. 3. To determine the siltation, water infiltration and runoff under a forest cover compared with range cover. 4. To compare the economic returns from low-grade hardwood areas managed for forestry purposes with similar areas managed for range grazing.

Description of Work Proposed: The two major soil types of the Ozark uplands, limestone chart and Boston Mtn. Sandstone, supporting forest cover will be sampled by using forestry and range development techniques. Forestry practices appropriate to the Ozark upland hardwood stands will be evaluated and compared with conversion to pine. As an alternative to Forestry, rangeland development studies will be initiated on adjacent alnd using natural vegetation, seeded, and fertilized as the base treatments. Plant succession studies will be carried on under all treatments, on both soil types. Sedimentation as a measure of erosion will be measured in relation to rainfall and runoff on small watersheds in treatment areas. Economic relationships will be evaluated from all treatments.

SUPPORTED BY U.S. Dept. of Agriculture
Arkansas State Government

2.0074, A STUDY OF THE PHYSIOLOGIC AND CULTURAL FACTORS WHICH INFLUENCE PRODUCTION OF TREE FRUITS

R. ROM, Univ. of Arkansas, Agricultural Experiment Sta., *Fayetteville, Arkansas* 72701

Objectives: 1) To study the nutrition of fruit trees using foliar analysis as the diagnostic technique. 2) To investigate the use of chemicals which may affect the physiology of the tree, 3) To study the response to irrigation with reference to need, timing, and amount. 4) To study tree training and pruning with emphasis on bulk methods and adaptation to mechanization. 5) To study cultural methods relating to fertilizer, cultivation and cover crops. 6) To investigate the interactive effects of the above mentioned objectives.

Procedures: Fruit trees to be used in these studies are already found in experiment station plantings; new blocks will be set to meet specific experiments; outlying orchards will be used when necessary.

Repeated tissue sampling of commercial orchards will be made to relate nutrition balance and intensity with production and quality. Specific experiments will be designed to study fertilizer programs required to maintain production. Chemicals and growth regulators to be used to modify plant physiology to make them more adaptable to Arkansas conditions.

Studies on the effects of irrigation on production and quality to be made on basis of short drought, extended drought, and continuous production. Bulk pruning to be simulated for purpose of studying tree response to this management.

SUPPORTED BY Arkansas State Government

2.0075, IRRIGATION INVESTIGATIONS WITH AGRONOMIC CROPS

L. THOMPSON, Univ. of Arkansas, Agricultural Experiment Sta., *Fayetteville, Arkansas* 72701

Evaluate methods of determining critical soil moisture levels for irrigation; determine optimum rate and grade of fertilizer and optimum time and method of application for agronomic crops grown under irrigation; evaluate yield responses of certain selected agronomic crops when irrigation is carried out by sprinkler and furrow methods; determine effect of plant population, planting dates and other cultural management practices on degree of response to supplemental irrigation; evaluate effect of land leveling operations required for furrow irrigation upon soil fertility and resultant yield; study methods of increasing infiltration rate of irrigation water into soil in which the rate is slow.

DESCRIPTION OF WORK: Since 1950, irrigation-fertility experiments have been carried out at four locations. The effect of irrigation and levels of nitrogen upon the yield of three cotton varieties was measured on the Richland silt loam soil at Marianna, the Sharkey clay and the Dundee silt loam at Clarkdale. The effect of land and ferrilization of the Richland silt loam for irrigation upon the yield of corn was also measured at Marianna. At Stuttgart, the combined effects of irrigation, fertilization, and deep plowing, upon soybean yields were measured. Various sources and rates of nitrogen have been used in irrigation experiments on corn, grain sorghum, and Tracy sorghum at Fayetteville. In addition, one greenhouse experiment on the causes of so called crazy cotton has been completed. Help has been given on the multiple-factors cotton experiment at the Southeast Branch Station.

SUPPORTED BY U.S. Dept. of Agriculture
Arkansas State Government

2.0076, SEARCH FOR AND IMPORTATION OF FOREIGN INSECT ENEMIES OF WEEDS

L.A. ANDRES, U.S. Dept. of Agriculture, *Albany, California*

Object: To investigate the natural insect enemies of weeds in foreign countries and to collect and ship to the United States those species which will feed on or otherwise injure weeds.

Plan of work: Research will proceed through the following stages: (1) searching of the literature to establish the world distribution of particular weeds and the insects or other enemies known to feed on or otherwise injure them; (2) visits to areas where weeds originated and searches for predatory insects; (3) obtaining information concerning the interrelationships between a weed and other plants and animals, and the effects of soil and climate on such interrelationships; (4) screening tests to insure that weed control insects are not harmful to useful plants (The ecological studies and taxonomic information regarding related plants will serve as a guide for screening tests.); and (5) shipment of promising insect species to appropriate quarantine receiving stations in the United States.

SUPPORTED BY U.S. Dept. of Agriculture

2.0077, HYDROLOGIC ANALYSIS METHODS

H.W. ANDERSON, U.S. Dept. of Agriculture, Pac. Sw. For. & Rg. Expt. Sta., *Berkeley, California*

Object: To develop, test, and illustrate improved methods of analysis in forest hydrology.

Plan of work: The development and evaluation of variables which influence water yield, floods, and sedimentation will be studied. (A) One aspect of the work is the evaluation of variation of water yield in relation to watershed and meteorlogical variables such as topography, elevation, geology, precipitation, and the evaporation potential. (B) Past records of floods from many watersheds, measured under a variety of changing land use and vegetation, will be analyzed to determine fundamental relationships between land use and floods. (C) Current work on suspended sediment discharge will be extended to include deposition in reservoirs and the relationships between watershed characteristics, suspended sediment discharge, and reservoir deposition. (D) Basic to all watershed evaluations are more accurate measures of the supply factors of precipitation, snow accumulation and snow melt. The relationship of these supply factors to large scale and small scale terrain and forest conditions will be studied.

SUPPORTED BY U.S. Dept. of Agriculture

2.0078, FLOOD AND SEDIMENT REDUCTION IN THE CONIFEROUS TIMBER ZONE OF CALIFORNIA

R.R. ZIMER, U.S. Dept. of Agriculture, Pac. Sw. For. & Rg. Expt. Sta., *Berkeley, California*

Object: To develop management methods that will minimize local floods, erosion and sedimentation, maintain water quality, and improve timing of streamflow; and to develop methods for predicting the effects of forest and land management practices upon sedimentation and streamflow.

Plan of work: Studies of gravitational mass movement will continue; resurveys of inclinometer holes will determine rate and location of surface and subsurface creep; and aerial photo comparisons will point out causes of landslides. The project staff will continue to study the effects of logging on streamflow, sedimentation, and fish habitat, and current studies will relate soil moisture to logging effects and to moisture storage opportunities for flood abatement.

SUPPORTED BY U.S. Dept. of Agriculture

2.0079, SHALES AS FILTERS IN NATURAL WATERS

F.A. BERRY, Univ. of California, Graduate School, *Berkeley, California* 94720

This proposal is concerned with investigating the relative filtration effects of shales upon the various ionic and molecular constitutents of naturally-occurring formational waters. The principal mode of investigation will be to investigate the problem theoretically and to examine chemically the waters from geologic sites that are known to be either effluent or hyperfiltrated waters with respect to natural shale membranes. Dehydration reactions are the principal contributors to the effluent waters in some localities. Experimental laboratory studies will also be undertaken as a secondary mode of investigation.

The field areas of investigation include the Gulf Coast, U.S.; the Indus Plains of West Pakistan; the Po Valley, Italy; sedimentary basins on the north side of the Alps; the Golfo San Jorge basin in Argentina, and others.

SUPPORTED BY U.S. National Science Foundation

2.0080, PROPERTIES OF SOILS RELATED TO APPLIED STRESSES

P.R. DAY, Univ. of California, Agricultural Experiment Sta., *Berkeley, California* 94720

Determine the influence of various factors upon deformation, including: (a) particle size; (b) initial state and composition, including additives; (c) amount of water and magnitude of soil moisture tension; and (d) direction of water content change at time of stress. The changes and effects produced by compaction and the processes of recovery will also be examined, as progress permits.

Description of work --Work will first be directed primarily at (a) and (c) above. Compacted bulk density will be measured in relation to water content of silty clay-sand mixtures, which will be treated as binary mixtures. These will consitute a texture series of seven members. They will be compacted with a machanized 'kneading' compactor set to deliver a maximum pressure of 20 lbs/sq. in./stroke while retained in a rigid-walled vessel with a porous bottom to allow measurement of tension-water content relationships. This will be done for maximum and minimum bulk densities for each texture and the pore size distribution function determined. Measurements will be repeated with the same materials after polymer treatment. Other properties and responses of the compacted specimens will also be examined in an attempt to understand the reversibility of structural alteration. Related work will be done with clay-polymer complexes in an endeavor to elucidate the structure modification. this will continue past use of a Maron-Krieger-Sisko viscosimeter and an RCA-EMU-2 electron microscope.

SUPPORTED BY U.S. Dept. of Agriculture
California State Government

2.0081, STUDY OF TRANSPORT, DEPOSITION AND SCOUR OF FINE PARTICLES THROUGH A POROUS MEDIUM

H.A. EINSTEIN, Univ. of California, School of Engineering, *Berkeley, California* 94720

The results obtained so far in this investigation are for idealized porous media of unisize, spherical balls arranged in a rectangular pattern. However, consecutive layers of spheres are displaced in such a way as to produce critical minimum openings equal to those in the hexagonal pattern. In nature, the soil mass is neither homogeneous nor isotropic. In order to apply the results to the field condition, it is necessary to extend this investigation to a heterogeneous porous medium.

The objective of this investigation is to use porous media with different particle size distributions, the pore openings of which can be expressed statistically. The clogging and non-clogging of this heterogeneous medium is to be examined with unisize moving particles. The result of this study would then lead to a prediction of the behavior of various moving particles through a heterogeneous porous medium.

SUPPORTED BY U.S. National Science Foundation

2.0082, RHEOLOGY OF SOIL-WATER SYSTEMS

L.J. WALDRON, Univ. of California, Agricultural Experiment Sta., *Berkeley, California* 94720

The objectives of the proposed project are to obtain measurements of (a) the strain response of soil to static and sinusoidally oscillating stress and (b) the effect of water content and soil-water suction on these mechanical responses. This data will be used to evaluate stress-strain theories, especially those that express the time-dependence of stress-strain ratios, for example, viscoelasticity.

Dynamic and static shear strain measurements are to be made over a wide range of soil consistence. Water contents are to vary from monomolecularly adsorbed water to near saturation. In general, stress and strain amplitudes will be small so that where linear viscoelastic response is found its upper limit may be defined in terms of stress, strain, strain-rate, water content and soil water potential.

SUPPORTED BY California State Government

2.0083, INDUCTIVE ELECTROMAGNETIC METHODS FOR MAPPING AND EVALUATING AQUIFERS

S.H. WARD, Univ. of California, School of Engineering, *Berkeley, California* 94720

We propose to investigate the theorectical basis for inductive systems of measuring apparent electrical conductivity and apparent dielectric constant, to design and construct a novel 'tilt angle' electromagnetic depth sounding system, and to make a field application of the system to geologically well-documented test areas in California.

Complete catalogues of interpretation curves are necessary for use of inductive systems and these would be obtained by use of a high- speed digital computer and peripheral equipment prior to equipment development.

The development of economical and reliable electrical sounding techniques, especially suited for use in groundwater problems arising in arid and semi-arid regions, is the primary objective of the proposed research.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of California

2.0084, GENERALIZED ANALYSIS OF SMALL WATERSHED RESPONSES

J. AMOROCHO, Univ. of California, School of Engineering, *Davis, California* 95616

The objectives of the investigation are to develop generalized procedures for the establishment of the relationships between inflow and outflow in natural watersheds, with full recognition of their nonlinearity and parameter distribution characteristics. These relationships will be used in the reconstruction and prediction of hydrologic events.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of California

2.0085, GENERALIZED ANALYSIS OF SMALL WATERSHED RESPONSES

J. AMOROCHO, Univ. of California, Agricultural Experiment Sta., *Davis, California* 95616

(a) To expand the theory of functional series representation to the description of non-linear physical systems with particular emphasis on hydrologic systems; and (b) to investigate the application of these nonlinear methods of analysis to the evaluation of the responses of watersheds under the action of ruin.

The work will be conducted in the theoretical area by development of the necessary mathematical procedures of analysis; and in the experim field by laboratory experiments on small catchments and by analysis of small natural watersheds.

SUPPORTED BY California State Government

2.0086, MIXING PROCESSES IN SATURATED AND UNSATURATED SOIL-WATER SYSTEMS IN RELATION TO POLLUTION

J.W. BIGGAR, Univ. of California, Agricultural Experiment Sta., *Davis, California* 95616

Objectives: Analyze the transient nature of the mixing of dissolved organic and inorganic ions in water flowing through saturated and unsaturated soils. Impose the presence of thermal gradients and analyze the transient nature of the mixing of two fluids at two different temperatures for similar and dissimilar salt concentrations. Ascertain the nature of the porous material by comparison of mixing of thermally different solutions with chemically dissimilar solutions.

Description of Work Proposed: Attempt to describe the systems by means of thermodynamic and hydrodynamic models with the aid of computer analysis. Particular attention will be given to the physical properties of the fluids used. This project will augment previous and present work conducted under Regional Projects W-68 and W-82. Experimental laboratory work to test theory and provide ranges of values for parameters will be obtained.

SUPPORTED BY U.S. Dept. of Agriculture
California State Government

2.0087, LIMNOLOGY OF ROSS ISLAND, ANTARCTICA

C.R. GOLDMAN, Univ. of California, Graduate School, *Davis, California* 95616

This proposal requests support for the preparation of a report of data collected at Cape Evans, Antarctica. The work would be carried out at the Institute of Ecology, University of California, Davis.

Field studies conducted in Antarctica during the austral field season of 1961-62, 1962-63 by the principal investigator with the assistance of D. T. Mason, B.J.B. Wood and J.E. Hobbie have been reported in a series of short scientific papers; two of these papers were on dry valley lakes. Much of the research data based on a systematic multidimensional analysis of the Cape Evans lakes remains to be published. This includes weekly sampling of water chemistry, primary production of plankton and benthos as well as plankton and benthos composition, both taxonomic and chemical, energy budget measures and local weather information. While some of those data are reported, teaching, other research commitments and transfer of personnel forced suspension of the work. The proposal allows Mason to work at Davis for three months on a leave of absence from Washington State College during the winter quarter of 1968. This contribution to Antarctic limnology will be submitted for publication in the Antarctic Research Series.

No field work this season.

SUPPORTED BY U.S. National Science Foundation

2.0088, WATER-SOIL-PLANT RELATIONS

R.M. HAGAN, Univ. of California, Agricultural Experiment Sta., *Davis, California* 95616

Objectives: 1. Investigate relationships between water stress in root medium and internal water status of plants as affected by environment and plant development. 2. Evaluate effect of plant structures and transpiration retardants on water movement and loss from plants. 3. Determine effects of plant water stress and nutrients on morphology and metabolic processes determining growth and composition of plants.

Procedures: Investigations will be directed toward evaluating fundamental relations between water and plant growth. It will be necessary to evaluate these water-plant relationships under various conditions of environment and stage of plant development. To the extent that facilities permit, these studies will be conducted in controlled environment chambers, using modern techniques for soil moisture and environmental control and measurements.

SUPPORTED BY U.S. Dept. of Agriculture
California State Government

2.0089, WATER AND SOIL TEMPERATURE IN RELATION TO PLANT GROWTH

R.M. HAGAN, Univ. of California, Agricultural Experiment Sta., *Davis, California* 95616

(1) To correlate the temperature of water in the Feather River with water temperature in the irrigation distribution system in the Feather River Service Area; (2) To evaluate the behavior and yield of important crops irrigated with water at low temperatures under controlled conditions; (3) To correlate field indicators of crop response to low temperature water with behavior of plants under controlled conditions.

The gradients of water temperature from the Feather River above the Oroville Dam site to the growers' turnouts in the Feather River Service Area will be made with thermographs between 1962 - 1964, three years before construction. A continuation of the field measurement program from 1964 through 1971 is envisaged as a future objective to cover temperature changes during and after construction of the Dam. These data will document the effect of construction on irrigation water temperature. They will be gathered by the State Department of Water Resources in cooperation with the Department of Irrigation. The University's research staff will correlate these field temperatures with agronomic and physiologic responses of important crops near temperature measurement sites as well as cross-correlate field responses of crops with the effects of irrigation water temperatures under controlled conditions.

SUPPORTED BY California State Government

2.0090, IRRIGATION MANAGEMENT FOR CROPS

D.W. HENDERSON, Univ. of California, Agricultural Experiment Sta., *Davis, California* 95616

Study moisture content and other soil characteristics relative to compaction and infiltration. Study causes of slow water penetration other than compaction and Na. Determine effect of amendments on structure and infiltration. Study root development in impervious soils and relation of root development and root diseases to available water. Evaluate crop systems and management affecting water supply to future crops. Evaluate from water supply viewpoint crop responses to tillage methods. Develop criteria for land grading, irrigation water management, and drainage of slowly permeable soils. Study accumulation of salts relative to water penetration rates.

Description of Work: Root development and moisture extraction patterns of deep-rooted crops in an excellent soil are compared with those in artificially compacted or naturally firmer subsoils. Differential irrigation treatments are applied, and crop responses to treatment measured.

Water-logging during irrigation and subsequent drainage are being evaluated on natural and artificial profiles, and drainage conditions related to root disease.

SUPPORTED BY U.S. Dept. of Agriculture
California State Government

2.0091, IRRIGATION OF FIELD AND TRUCK CROPS

D.W. HENDERSON, Univ. of California, Agricultural Experiment Sta., *Davis, California* 95616

Most of the work is carried on under natural field conditions, and includes frequency of irrigation on yield and quality of the product. The measurements usually include soil moisture conditions at various stages of plant development, evapotranspiration, and root development in relation to soil conditions and development of the plant. Work has been performed on many crops; at present, the following crops are being investigated: cotton, sugar beets, potatoes, grain sorghum, safflower, and beans. Additional crops will be added from time to time.

SUPPORTED BY California State Government

2.0092, CHANGES IN ENZYMES IN THE PLANT AS RELATED TO WATER SUPPLY AND USAGE

T.C. HSIAO, Univ. of California, School of Agriculture, *Davis, California* 95616

The effects of various degrees of water deficits on the levels of several enzymes in the plant closely related to water usage and organic synthesis will be determined. These enzymes are: amylase, glycolic acid oxidase, the enzymes in the carboxylative phase of photosynthesis (phosphoriboisomerase, phosphoribulokinase, and ribulose- 1, 5-diphosphate carboxylase), and nitrate reductase. Studies will be conducted to determine whether the changes in the enzyme level caused by water stress are due to altered rate of synthesis and activation, or to changes in inhibitor concentrations. Changes in levels of enzymes which may play a role in regulating cell water potential or stomatal aperture will be related to the usage of water by the plant where possible.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of California

2.0093, PROPERTIES OF SUBMERGED SOILS

D.S. MIKKELSEN, Univ. of California, Agricultural Experiment Sta., *Davis, California* 95616

Objectives (1) To study the effects of waterlogging on the biological and physico-chemical properties of California soils. (2) To determine the variable plant responses, particularly with rice, to waterlogged soil conditions and to relate this to physiological processes. (3) To study the changes occurring as a result of waterlogging and alternate drying on soil reaction, redox potential, specific conductance and certain soil chemical characteristics. (4) To identify the redox systems in waterlogged soils as they influence soil productivity and to develop methods of chemical control or modification by cultural practice.

SUPPORTED BY California State Government

2.0094, PREDICTION OF WATER MOVEMENT IN UNSATURATED SOILS

D.R. NIELSEN, Univ. of California, Agricultural Experiment Sta. , *Davis, California* 95616

Objectives: 1. To develop an understanding of soil moisture hysteresis and to define its role in the movement of water, solutes, and energy in soil. 2. To devise and test methods for predicting water transmission through soils from measurable soil properties for known temperature conditions.

Description: Special techniques will be used to study water flowing in alternating directions through soil and other porous materials in order to arrive at an understanding of hysteresis. Uniformity of samples will be measured by gamma ray absorption techniques. Particular emphasis will be placed upon the solute species, their concentration and their distribution within the sample. These results for known temperature conditions will be compared with equilibrium results using volumetric and gamma ray absorption techniques.

SUPPORTED BY U.S. Dept. of Agriculture
California State Government

2.0095, CLIMATIC PATTERNS AND THEIR EFFECT ON CALIFORNIA AGRICULTURE

H.B. SCHULTZ, Univ. of California, Agricultural Experiment Sta. , *Davis, California* 95616

Objectives: 1) To continue analysing climatological data with greater emphasis on temperature patterns throughout the year from medium-long weather records (30-year periods). 2) To add more California stations than used so far (30 stations) to provide more detailed information on probabilities and agricultural risks for certain districts and crops. 3) To verify the results from the use of the 30- year periods by means of analysis of a few stations with very long periods such as Sacramento (100 years). 4. To continue studying weather influence on crop development.

Procedure: Preparing punch cards, and analysis in Computer Center. Field observations of plant development and correlation with temperature and radiation.

SUPPORTED BY U.S. Dept. of Agriculture
California State Government

2.0096, METHODOLOGIES FOR PREDICTING CLIMATIC SUITABILITY OF NEW AREAS FOR IRRIGATED AGRICULTURE

H.B. SCHULTZ, Univ. of California, School of Agriculture, *Davis, California* 95616

The cropping pattern of any potential or existing agricultural area is based upon those species which the climate can support. Increasing population pressures, world over, are pressing agriculture toward sites less suitable than those currently being utilized. Thus deserts, mountain regions and cold locales are being viewed as potential agricultural areas regions where population is currently sparse and climate records limited. A method of predicting climate suitability is desirable. Short term climate data from 81 climate stations in the San Joaquin Valley have been collected since 1963. Data from selected stations have been verified and prepared for machine computation. These data will be correlated with long term weather records, purchased from ESSA - Weather Bureau, to establish climatological records for the field instrument sites. The extrapolated data together with specific crop requirements will be used to predict cropping behavior. 'Watchdog' instrumentation will be continued to evaluate the effect of irrigated agriculture upon desert climate trends.

SUPPORTED BY University of California

2.0097, MECHANICS OF FLOW IN OPEN CHANNEL SYSTEMS

T. STRELKOFF, Univ. of California, School of Agriculture, *Davis, California* 95616

The purpose of the investigation is to develop the theory and computational methods for the analysis of open-channel flow systems in the steady and unsteady states. Analytical and experimental studies are carried out on the propagation of shock waves and continuous wave profiles in prismatic and nonprismatic channel configurations and on the details of flow fields in the vicinity of control structures.

Numerical solutions of the well known St. Venant equations for unobstructed reaches of a canal are obtained for continuous flows by digital computer using both explicit and implicit schemes; discontinuities (shocks) are studied by numerical solution of integral forms of the St. Venant equations expressing conservation of mass and momentum in finite volumes of space over finite intervals of time.

Steady curvilinear flow in the vicinity of overfalls, spillways, and gates is analyzed by potential-flow techniques which permit

exact expression of the boundary conditions as integral equations describing the entire flow field. Waves enamating from a vertical gate moving in its own plane are studied analytically and experimentally.

Submerged, unsteady flow in the neighborhood of tainter gates is studied experimentally by means of hydraulic models.

Separated flow in transitions is studied in air and water models by investigating mean velocity patterns and distribution of turbulence parameters.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of California

2.0098, HYDRAULICS OF SURFACE IRRIGATION

***T.S. STRELKOFF*, Univ. of California, Agricultural Experiment Sta., *Davis, California* 95616**

Objectives: To provide fundamentgal surface irrigation design understanding through the investigation of the hydraulic characteristics of surface flow by (1) further development of mathematical models describing the flow in terms of the many variables involved; (2) laboratory experiments for the description and evaluation of component variables; and (3) field trails to test the validity of mathematical equations and laboratory relations as in 1 and 2 above.

Procecures: Develop mathematical models describing the flow in terms of the many variables. Specifically, study the advance and profile of a water front moving over a dry bed and through vegetation for steady and unsteady flow by developing analytical solutions and testing these solution by laboratory experiments. A numerical solution of the differential equation of the motion of water into a wide, shallow vegetated channel will be investigated. An approach based on the method of characteristics for solving equations of this nature appears to have promise. A digital computer will be used. Experimental vertification of the solution will be obtained by laboratory tests on artificial and real vegetation in 1 and 4-foot wide flumes with adjustable slope.

SUPPORTED BY U.S. Dept. of Agriculture
California State Government

2.0099, IRRIGATION STUDIES WITH APRICOTS AT WOLFSKILL EXPERIMENTAL ORCHARDS

***K. URIU*, Univ. of California, Agricultural Experiment Sta., *Davis, California* 95616**

Objectives: 1. Study of the relation of different irrigation treatments on the growth and production of apricot trees. 2. Study of the effect of subjecting some of the plots to dry soil conditions for different lengths of time during different portions of the growing season. 3. Principal emphasis is being placed on the study of irrigation after harvest, because of the early ripening. The fruit matures most years before the moisture from the winter rains is exhausted.

SUPPORTED BY California State Government

2.0100, STUDIES ON THE MECHANISMS OF COMMUNITY STRUCTURE AND SUCCESSION IN TEMPORARY PONDS

***B.A. TRIBBEY*, Fresno State College, Graduate School, *Fresno, California* 93726**

The proposed research will investigate the fundamental mechanisms of community structure and change utilizing the temporary pond ecosystem and related laboratory experiments. Part of the work will be based upon data obtained through field and laboratory studies of temporary pond communities in Central Texas. Additionally, natural and semi natural temporary ponds near Fresno, California, will be described and compared to earlier findings. Field studies will measure environmental and inter-organismic relationships, providing a basis for controlled experimentation. Laboratory work will emphasize causality. Proposed experimental work will be designed to assist in determining: 1.) The effect of temperature, light intensity, and photoperiod on developing communities; 2.) the factors controlling algal mat formation; 3.) the means by which a developing mat causes corresponding changes in community composition; 4.) the role of the chemical environment in controlling community composition; 5.) the impact of new species on a stable community. Work will also be performed on defined species systems to indicate: 1.) The relative importance of predation, competition, and chemical modification in the elimination of early seral stages by later seral stages; 2.) the presence of reciprocal acceleratory effects between species of similar seral stages; 3.) the importance of environmental variation in determining the outcome of competition between related species. Laboratory work will be based upon results obtained from studies on natural communities.

SUPPORTED BY U.S. National Science Foundation

2.0101, CRATER LAKE VERTICAL TEMPERATURE PROFILES

***L.E. EGEBERG*, U.S. Navy, Radiological Defense Lab., *Hunters Point - San Francisco, California* 94135 (AT(49-7)-3000)**

The purpose of this project was to obtain temperature profiles of Crater Lake. The data obtained will serve as basic information for several other projects devoted to soil and water sampling analysis in connection with a broad program of worldwide radioactive fallout assessment.

The lake is located in south-western Oregon in a sub-alpine environment. It is approximately 5 1/2 mi. in diameter and 1932 ft. deep at its deepest point. There are no surface inlets or outlets to the lake. The surface very rarely freezes and then only for short periods during extremely severe winters.

The profiles were obtained by lowering a platinum thermometer through the water column and measuring the change in electrical potential across the thermometer due to the linear relationship between the temperature and the electrical resistance of the thermometer. Corrections were made concurrently for changes in the battery power supply and fluctuations in the resistance of the thermometer lead wire due to changes in its temperature. The absolute values of temperature are accurate to plus or minus 0.1 degree C.

Four profiles were obtained to depths of 496 ft., 1916 ft., 43 ft., and 696 ft. The first two were taken 2 mi. south of Cleetwood Cove; the third, 1 mi. south of Wizard Island; the fourth, 1 mi. southwest of Llao Rock. All profiles were taken between 3 August and 6 August 1967. Raw data reduction has not been completed.

SUPPORTED BY U.S. Atomic Energy Commission

2.0102, RESEARCH TO DETERMINE THE FEASIBILITY OF NUCLEAR EXCAVATION

B.C. HUGHES*, U.S. Army, Nuclear Cratering Group, *Livermore, California

The overall objective of this research program is to develop the capability to employ nuclear explosive construction techniques on civil works projects which involve large-scale earthmoving or rock excavation. The three major activities being accomplished under this research program are: (1) engineering studies of project feasibility; (2) small- scale cratering experiments; and (3) investigations of engineering properties of nuclear craters.

The purpose of the engineering studies of project feasibility is to isolate problem areas, to develop those items which must be included in a nuclear excavation design and to develop a basis which can be used to adjudge the applicability of the use of nuclear explosives to specific projects.

The small-scale cratering experiments are undertaken in order to establish the design criteria for nuclear emplacement and to obtain model data from which to predict the results of full-scale nuclear events.

The objective of the engineering properties of nuclear craters investigation program is to determine how a nuclear cratering explosion affects the immediate geologic environment and what will be the resulting stability of the crater slopes and the effect on other engineering aspects, such as foundation and utility design for adjacent structures.

2. WATER CYCLE

SUPPORTED BY U.S. Dept. of Defense - Army

2.0103, PRECIPITATION PATTERNS ON UPSTREAM WATERSHEDS IN CENTRAL AND SOUTHERN CALIFORNIA

R.B. HICKOK, U.S. Dept. of Agriculture, *Lompoc, California*

Objective: Improved prediction of precipitation parameters affecting runoff and sediment production.

Plan of Work: Establish precipitation time-depth, areal distribution, storm sequence, and fall-direction expectancy relations to general and local climatic influences.

SUPPORTED BY U.S. Dept. of Agriculture

2.0104, PACIFIC OCEAN INFLUENCE UPON CALIFORNIA RAINFALL

J. BJERKNES, Univ. of California, Graduate School, *Los Angeles — U.C.L.A.*, *California* 90024

In project research for the National Science Foundation carried on by the principal investigator it has been found that the Pacific Ocean temperature varies more from year to year near the equator than it does in adjacent areas to the north and south. It has also been demonstrated that the inter-annual variation in heat and moisture input from the equatorial belt of the oceans in the few instances investigated does influence the global pattern of the atmospheric circulation. On the basis of this experience it is tentatively assumed that the variation of rainfall from year to year in California, and other areas around the Pacific Ocean, primarily results from the variability of the water temperature at the equator.

It is planned to test this hypothesis by assembling maps of the atmospheric circulation for all winter seasons during which equatorial water temperature measurements were carried out. Next, the map types will be correlated on the one hand with equatorial water temperatures and on the other with the historical rainfall record in California.

The problem of estimating the yield of a rainy season on the basis of atmosphere and ocean data, available before the rains start, will be investigated.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of California

2.0105, EFFECT OF RANGE MANAGEMENT ON INFILTRATION, RUNOFF, AND EROSION

R.H. BURGY, Univ. of California, Agricultural Experiment Sta., *Los Angeles - U.C.L.A.*, *California* 90024

Develop improved devices and techniques for hydrologic studies. Determine relationships between precipitation intensity, runoff rates, and erosion rates throughout range improvement program. Develop formulas for estimating the magnitude of flood discharge. Determine the effectiveness of new vegetation in controlling erosion. Determine the effects of fire on infiltration rates of soils. Determine hydrologic effects of various grazing practices used in management programs.

Description of Work Los Angeles: Work is concerned with the disposition of precipitation on watersheds, with erosion and with dry creep. The work included in RRF W-32 is excluded. Major emphasis, at the moment, is in development of techniques to quantitatively evaluate subsurface flows, and plots, therefore, have been established on the San Dimas Experimental Forest, Pacific Southwest Forest and Range Experiment Station, USFS. Other laboratory studies concern evapotranspirational use of water by various types of watershed vegetation.

SUPPORTED BY U.S. Dept. of Agriculture
California State Government

2.0106, HYBRID COMPUTER SIMULATION OF GROUND-WATER BASINS

W.J. KARPLUS, Univ. of California, School of Engineering, *Los Angeles - U.C.L.A.*, *California* 90024

The purpose of the proposed research is three-fold: the primary objective is to establish the feasibility of employing a specialized hybrid (analog-digital) computing technique for the treatment of important mathematical and physical problems arising in ground-water pollution control. To this end it is intended to adapt a computational method developed at the University of California, Los Angeles by constructing a special network specifically applicable to ground water problems. The resulting model then will be applied to several ground- water problems existing in southern California. A second more general purpose of the research is to develop the technical skills required for a long-range attack on ground-water pollution problems. A subsidiary objective of the program is to provide a training ground for doctoral and master's engineering students so as to assure a supply of technical specialists adequately trained in the physics of ground-water control and in computer technology.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of California

2.0107, PHYSIOLOGY OF MINERAL ACCUMULATION IN PLANTS

O.R. LUNT, Univ. of California, School of Medicine, *Los Angeles — U.C.L.A.*, *California* 90024 (AT(04-1))

Studies on the function of calcium in plants may provide insight on plant distribution parameters in an arid ecosystem. The ontogeny of cellular disorganization which occurs at low Ca levels is being studied with the electron microscope, and the electron microprobe technique is being attempted for subcellular Ca analysis.

In separate studies the response of various species, native to the Mojave Desert, to water stress is being studied.

SUPPORTED BY U.S. Atomic Energy Commission

2.[illegible]08, METEOROLOGICAL ANALYSIS OF PRECIPITATION EFFECTS OF SWISS HAIL SUPPRESSION EXPERIMENTS

M. NEIBURGER, Univ. of California, Graduate School, *Los Angeles - U.C.L.A.*, *California* 90024

The attempt to identify the meteorological conditions which were responsible for the marked differences in apparent effects on precipitation of seeding when different forecasters selected the operational days in the Swiss Hail Suppression project, including the following: (1) Preparation of mean surface and upper air weather maps for situations forecast by each forecaster and for the seeded and unseeded days. (2) Grouping of surface weather maps by types of pressure pattern and study of the relation between types and seeding effects. (3) Evaluation of various parameters characterizing the flow pattern, atmospheric stability, humidity distribution, etc., and study of the correlation of these parameters to precipitation and to apparent seeding effects.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0109, ROADSIDE DEVELOPMENT AND BEAUTIFICATION

UNKNOWN, Univ. of California, Graduate School, *Los Angeles - U.C.L.A.*, *California* 90024

Vegetation management practices are being developed and improved to control erosion, provide ground cover and to encourage native species. Guide lines are being developed for evaluation and effective utilization of aesthetic elements in the highway environment. The effects of deicing compounds on water supplies and vegetation are being determined.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
California State Government

2.0110, A COMPARATIVE STUDY OF SODIUM TRANSLOCATION IN PLANTS

A. WALLACE, Univ. of California, School of Engineering, *Los Angeles - U.C.L.A.*, *California* 90024

The major objective of this study is to elucidate the mechanism(s) and/or further characterize the process by which a large number of, but not all, plant species transport water which is almost free of sodium from roots to shoots while simultaneously removing large quantities of sodium from the water and retaining the sodium in the roots. A secondary objective is to study physiological aspects of the adaptability and tolerance of different plants to saline habitats. Tobacco is a species which has a strong root pressure exudation from detopped plants and one in which relatively large quantities of solution are exuded which can easily be collected and analyzed. Under certain conditions such plants can be placed into very saline solutions and exude large quantities of solution essentially free of sodium. We propose to use tobacco for a portion of the present studies. Electrochemical potentials between exudates and external solution will be measured according to the methods of Bowling and concentrations of individual ions in the external solution and exudate will be determined by standard procedures. A wide variety of external solutions for bathing roots of detopped tobacco will be used including single salt and double salt solutions of different concentrations and full nutrient solutions at different temperatures. Inhibitors of metabolism including ATPase inhibitors, electron transport inhibitors, and uncouplers of oxidative phosphorylation will be studied. The amount of sodium appearing in the exudate will be monitored on an hourly basis in many of the studies. This is important because of the fact that a detopped plant has a fixed amount of energy reserves and we already know that sodium translocation to shoots is intimately related to metabolism. We hope from all these data to construct a mathematical and/or biochemical model for translocation of sodium from roots to shoots of at least this one species. For contrast, a series of studies will be made on some of the Atriplex species which readily translocate sodium from roots to shoots.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

2.0111, SOIL TEMPERATURE AS A CRITERION FOR ALLOCATING WATER SUPPLY FOR CROP USE

A. WALLACE, Univ. of California, Water Resources Center, *Los Angeles - U.C.L.A.*, *California* 90024

Responses of different plant species to different soil temperatures at limiting soil moisture is being explored. Since water requirement in terms of amount of water needed for production of a unit weight of plant material sometimes increases with increasing soil temperature, it can be expected that when soil moisture becomes limiting plant growth can, within limits, be better for areas where soil temperature is not extremely high. The study is being made to evalute this concept and to define the limits for which it could be valid. The information is important to those responsible for decisions concerning mass movement of water supplies from one locality to another.

Plants are being grown in soil in containers in existing temperature control tanks so that soil temperature can be varied from less than 50 degrees Fahrenheit to over 100 degrees Fahrenheit. Soil moisture levels are being varied and monitored by daily weighing of pots so that uniform soil moisture conditions can be maintained at different temperatures. Steps will be taken to minimize evaporation from the soil surface as a variable factor. Species that do well under arid conditions are being compared with species that do not do well under arid conditions. Sandy soils are being compared with clay soils. Plant growth and transpiration measurements are being made to assess the effects of soil temperature. Some native desert species are proving to be of considerable interest.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of California

2.0112, TRITIATED WATER STUDIES OF THE SIGNIFICANCE OF DEW AND VAPOR IN PLANT WATER ECONOMY

A. WALLACE, Univ. of California, Water Resources Center, *Los Angeles - U.C.L.A.*, *California* 90024

The contribution of water vapor and dew to the water economy of plants under arid conditions and when soil moisture is limiting is being explored. Such information may make it possible to better select plant species for specific purposes in specific areas to minimize the need for irrigation. Water supplies could, therefore, be conserved if necessary. The use of tritiated water as a technique for evaluation of vapor and dew is being used on a limited basis. Exchange of vapor water with leaf water and free-surface water presents a problem to its use. Other methods are being used for the evaluation of vapor and dew use including the assessment of apparent water use per unit of dry matter production.

The kinetics of water absorption by leaves from a free-water surface by different species grown under conditions to give varying water potential will be measured. The conditions include: salt content, varying soil moisture, day vs. night, and physiological stresses on plants such as phosphorus deficiency.

Water vapor absorption by leaves of plants is being studied at different levels of relative humidity and at varying leaf potential conditions as listed above.

The physiological effects on plant behavior of water availablity as dew and/or vapor through leaves is being explored. Growth measurements will be detailed.

SUPPORTED BY University of California

2.0113, THE STABILITY OF WATER FLOWS OVER A HEATED OR COOLED SOLID SURFACE

A.R. WAZZAN, Univ. of California, School of Engineering, *Los Angeles - U.C.L.A.*, *California* 90024

This is a study of the effects of either heated or cooled walls upon the stability of water flows over solid surfaces. The optimum rate of heating for increased stability is to be determined as a function of free stream temperature and wall temperature.

The stability of laminar boundary layer is sensitive to the pressure gradient. Adverse pressure gradients have a destabilizing effect on the boundary layer which can possibly be countered with laminarization by heat transfer into the boundary layer. Boundary layer velocity profiles will be determined and compared with the isothermal Blasuis profile particularly in the region of the neutral stability profile. The magnitude of the total stabilizing effect of the heat transfer will be determined through comparison of amplification rates for each profile.

SUPPORTED BY U.S. National Science Foundation

2.0114, STUDIES OF TRANSPIRATION LOSSES

J.W. BAILEY, U.S. Dept. of Interior, Geological Survey, *Menlo Park, California*

Make studies of transpiration losses through native vegetation to determine, by use of evapotranspiration tanks and other means, the quantity of water annually consumed by the different species of phreatophytes at selected locations, the quantity, and quality salvageable by elimination or control of these phreatophytes, and related data. Phreatophytes studied are Sarcobatus spp. (Greasewood), Chrysothamnus spp. (Rabbit brush), Salix spp. (Willow), and Rosa spp. (Wild Rose). Water is applied through underground pipes and evapotranspiration losses are metered throughout the year.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0115, GEOCHEMICAL CONTROLS OF WATER QUALITY

I. BARNES, U.S. Dept. of Interior, Water Resources Division, *Menlo Park, California*

Reactions between water and minerals in near surface environments are being studied as apparent controls on the natural water compositions. The properties of surface and ground waters are determined by chemical analysis and electrochemical potential measurements (Eh and pH, for example) in the field. The properties of the water are then described with reference to equilibrium states between the water and possible coexisting phases.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0116, DETERMINATION OF CHANNEL CAPACITY OF THE MERCED RIVER, CALIFORNIA

J.C. BLODGETT, U.S. Dept. of Interior, Water Resources Division, *Menlo Park, California*

Study the distribution of specific trace elements in relation to the distribution of organic matter. 4) Survey the distribution of pesticides in sediment in relation to depositional environment and depth in sediment. 5) Study abundance and composition of organic matter thought to be of prime importance in the engineering properties of sediment. 6) Study the composition of selected geochemical constituents with depth in sediment in relation to source and subsequent alteration of organic matter.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0124, HYDROLOGY OF HUNGRY HORSE RESERVOIR MONTANA

M.I. RORABAUGH, U.S. Dept. of Interior, Geological Survey, *Menlo Park, California*

Operation of the Hungry Horse Reservoir, Montana revealed the need for determining more accurately the volume of water, including bank storage, available for power production, and need for forecasting reservoir inflow during the lowflow season.

The program has included: collection of data to define the components of inflow and outflow with sufficient accuracy to determine the hydrologic parameters of the reservoir, analysis of the components of the water budget to improve procedures for forecasting reservoir inflow volumes during the lowflow period; and the further testing of techniques for expressing the relationship between ground-water storage and stream runoff.

Discharge records were collected at over 30 sites in the area. Stage records were obtained at the upper and lower ends of the reservoir. Stage and water temperature measurements were obtained from 6 groundwater wells around the reservoir. Evaporation from the reservoir was determined by an energy-budget study. Radiation and meteorological data were collected at the dam. Two raft stations furnished water-surface temperature and wind velocities. Thermal profiles were measured at 23 locations in the reservoir and at the raft stations. Additional precipitation data were collected at 3 other sites around the reservoir. Project started July 1964; scheduled for completion fy 1969.

SUPPORTED BY U.S. Dept. of Interior - Bonnvl. Pwr. Adm.

2.0125, UNSATURATED FLOW THEORY APPLIED TO DRAINAGE AND INFILTRATION

J. RUBIN, U.S. Dept. of Interior, Water Resources Division, *Menlo Park, California*

The objective of this is to study critically the applicability of the current theory of fluid flow through unsaturated porous media to the phenomena of drainage and infiltration, with a view of facilitating this theory's utilization in the analysis of ground water flow and runoff problems.

Utilizing the current isothermal unsaturated flow theory, carry out mathematical analysis which makes it possible to predict soil moisture movement under a variety of initial and boundary conditions. Study conditions which can be utilized for examing the soundness of theoretical foundations and those which are pertinent to the hydrologic phenomena of interest. Test in the laboratory the theoretical results obtained. In later phases, start developing means for testing and utilizing the theory under consideration in the field.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0126, INFLUENCES OF WATER-SEEPAGE CHARACTERISTICS ON THE COMPOSITION OF EXCHANGEABLE PORE-WATER SOLUTES

J. RUBIN, U.S. Dept. of Interior, Geological Survey, *Menlo Park, California*

Quality of ground waters often is significantly affected by the solute composition of the recharging seepage. The theoretical tools needed for analyzing and predicting such influences are imperfectly developed.

The first phase of the project will involve a study of the effects of soil moisture content upon cation exchange processes which take place during seepage through water unsaturated soil columns. Interpretation of the results obtained might be aided by supplementary studies of thin film flow on large cyrystals of clay-like minerals and of seepage through clays at various degrees of consolidation.

The second phase of the project will involve theoretical and experimental studies of two-dimensional, exchange-affected dispersion of cations during steady-state flow of solutions through water-saturated slabs of earth materials.

The last phase of the project will involve theoretical and experimental investigations of cation dispersion during one-directional seepage, the dispersion being affected by two interdependent chemical reactions.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0127, WATER QUALITY AND NUTRIENTS, SACRAMENTO-SAN JOAQUIN RIVER SYSTEM

W.D. SILVEY, U.S. Dept. of Interior, Water Resources Division, *Menlo Park, California*

This research is part of the program of water resources investigations conducted by the U.S. Geological Survey in cooperation with the State of California. The total project is to provide the knowledge needed to avoid excess blooms of tidal plankton and undesirable concentrations of dissolved oxygen by determining the relationships between nutrients, tidal plankton, dissolved oxygen, and fish in this estuarian environment. The water quality aspects of the study includes source and concentration of both organic and inorganic constituents in waters in the delta system together with pertinent physical characteristics.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
California State Government

2.0128, RESEARCH IN LIMNOLOGY - INTERRELATIONS OF HYDROLOGY AND AQUATIC ECOLOGY

K.V. SLACK, U.S. Dept. of Interior, Water Resources Division, *Menlo Park, California*

Biological processes are among the major controls on the quality of natural waters. Organic control on solute concentration occurs in two ways: substances enter or leave solution either as the results of changed physico-chemical conditions in the water, or as the results of physiological processes within living cells or at their boundaries.

The work is divisible into three related phases:

Phase 1. Stream Limnology. a. The effect of stream-bed algae on water quality will be studied in flowing-water cultures (laboratory streams) in which temperature, light intensity, flow rate, water composition and algae species can be controlled. The first problem being studied is the uptake and release of combined inorganic nitrogen by mixed populations of stream algae. b. Investigation of the physical, chemical and biological properties of different types of natural streams will continue. The emphasis will be on the interrelations of the biota and water quality.

Phase 2. Lake and reservoir limnology. a. Effects of reservoir destratification. The hydrologic effects of destratification will be studied experimentally by isolating portions of a stratified reservoir in polyethylene cylinders extending from the water surface to the bottom. b. Environmental controls on phytoplankton populations. This will combined the results of field investigation with controlled laboratory studies of static and flowing cultures of nuisance species of algae.

Phase 3. Ecological role of natural organic compounds in water. The particular emphasis will be on the identification of organic compounds which influence biological activity in natural waters.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0129, VERIFICATION OF MASS-TRANSFER AND PAN EVAPORATION RELATIONSHIPS FOR LARGE LAKES AND RESERVOIRS (SALTON SEA, CALIFORNIA)

A.M. STURROCK, U.S. Dept. of Interior, Geological Survey, *Menlo Park, California*

The objective is to determine if existing mass-transfer and pan evaporation relationships can be used to estimate evaporation from large lakes. The control will be the water-budget and energy-budget methods. Areal variations in solar and atmospheric radiation will be measured, thermal surveys will be conducted, and conductivity measurements will be made to define the effect of salinity on saturation vapor pressure.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0130, CRITERIA FOR PUBLIC INVESTMENT IN NATURAL RESOURCES

K.J. ARROW, Stanford University, Graduate School, *Palo Alto - Stanford, California* 94305

Significance: One of the most debated aspects of natural resource conservation and development is the measurement of costs and returns from investment in resources over time. These investments involve returns to future generations and by public as well as private organizations. Much of the debate has taken the form of an argument over the rate of interest to be applied in discounting future benefits from a current investment. A difference of one per cent in the interest rate applied can alter very greatly the estimate of future returns to be compared with current and future costs. There is no other single factor of such crucial importance to the determination of what consitiutes optimum investment in natural resources. A fairly large body of literature exists on this subject, including a number of quite recent studies by competent economists. These contain many disagreements of varying significance. A study which would bring this whole issue into focus and lead to its resolution would be of inestimable value.

Specific Aim: To synthesize the large body of literature on criteria for public investment and to arrive at a statement of the necessary and sufficient conditions under which government should undertake an expenditure, the fruits of which are deferred to the future.

Method of Procedure: The study involves primarily library research and analysis, much of which would be of a theoretical nature. Professor Arrow would be assisted by several research assistants in the examination of existing literature while he would concentrate on the new and creative aspects of the endeavor.

SUPPORTED BY Resources For The Future Incorporated

2.0131, MATHEMATICAL SIMULATION OF CYCLIC SEDIMENTATION

J.W. HARBAUGH, Stanford University, Graduate School, *Palo Alto - Stanford, California* 94305

00NO SUMMARY HAS BEEN PROVIDED TO THE SCIENCE INFORMATION EXCHANGE

SUPPORTED BY U.S. National Science Foundation

2.0132, A STUDY OF PROBLEMS RELATED TO WIND-GENERATED WAVES

R.L. STREET, Stanford University, School of Engineering, *Palo Alto - Stanford, California* 94305

This research will complement theoretical analyses and extend a previous investigation of wind-generated waves. Specific programs to be covered during the course of this research are: 1. Investigations of the characteristics of a turbulent boundary layer over a progressive wavy surface. 2. Investigations of the interactions between the perturbation velocity and natural free-stream (or background) turbulence. 3. Measurements of normal pressures over wind-generated waves.

SUPPORTED BY U.S. National Science Foundation

2.0133, CRITERIA FOR THE DESIGN OF SMALL CRAFT HARBORS

R.Y. HUDSON, Calif. Inst. of Technology, Graduate School, *Pasadena, California* 91109

The objective of this study is to develop design criteria for small-craft harbors by theoretical and experimental research on: (a) response of small vessels, moored to floating docks and piers, to the action of short-period wind wages and seiches; (b) response characteristics of various harbor shapes and dimensions relative to wave period and wave absorbing characteristics of the perimeter walls to waves entering the harbor; (c) the design of protective works (offshore and inshore breakwaters, overlapping jetties, wave resonators, wave traps, etc.) to reduce wave energy entering the harbor, and develop criteria for selection of harbor-entrance plans for waves at start of storm.

By contract with California Institute of Technology, a report, 'Wave-Induced Oscillations of Small Moored Vessels,' by F. Raichlen was completed. This report is concerned with the response of small vessels moored to fixed docks.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0134, GEOCHEMICAL STUDIES WITH STABLE AND RADIOACTIVE ISOTOPES

R.P. SHARP, Calif. Inst. of Technology, Graduate School, *Pasadena, California* 91109 (AT(04-3)427)

The work proposed for 1968 involves the geochemical distribution and behavior of various isotopes in natural systems. Some of these isotopes are the product of currently active radiogenic systems and processes; others are the product of atomic processes long since dead. All are useful for determining what has happened to natural systems and under what conditions.

This next year considerable attention will be directed to the thorium-uranium-lead system. Besides using it as a tool for geochronological determinations, investigations of the vagrancies of the system and its susceptibility to changes in environmental conditions are to be made. The aim is to improve the reliability and versatility of this system for use in solving geological problems. The Th-U-Pb system will be investigated in the field through study of carefully selected rock bodies of similar age but different environmental histories, by comparisons with other radiogenic isotopic systems in these rocks and in individual mineral specimens therein, and by means of laboratory experimentation on selected natural specimens.

Oxygen, hydrogen, and carbon isotopes are abundant and widely distributed elements in most inorganic and organic earth materials. Variations in the ratios of these isotopes, for example, O18/O16,D/H, C13/C12, give useful information on the environmental conditions under which substances containing them formed. They also provide a means of determining alterations in such materials subsequent to their formation.

We anticipate a better understanding of the Th-U-Pb systems that will enhance its use in geological and geochemical investigations. We hope to get an historical perspective on atmospheric pollution. We anticipate improved use of oxygen, hydrogen, and carbon isotopes in determining the conditions and sites of mineral and rock origin and subsequent alteration.

SUPPORTED BY U.S. Atomic Energy Commission

2.0135, GROUND WATER RESEARCH

W.E. STEINER, U.S. Dept. of Agriculture, *Riverside, California*

The U. S. Department of Agriculture, Agricultural Research Service, on a matching fund basis with the California Department of Water Resources performs research on artificial recharge of ground water, including quantity and quality factors. Specific current studies include: field and laboratory investigations of ground water mound build-up and dissipation, and study of mechanism of clogging in recharge ponds and effects on intake rates.

SUPPORTED BY California State Government
U.S. Dept. of Agriculture

2.0136, COOPERATIVE EVAPOTRANSPIRATION RESEARCH

W.E. STEINER, U.S. Dept. of Agriculture, *Riverside, California*

The Agricultural Research Service, on a matching fund basis, conducts research on correlations of evapotranspiration with climatic factors, particularly in regard to the contributions of direct and advective radiation energy to the evapotranspiration process, under coastal climatic conditions at Lompoc, in Santa Barbara County, and under desert conditions at Brawley, in Imperial County.

SUPPORTED BY California State Government
U.S. Dept. of Agriculture

2.0137, IRRIGATION STUDIES WITH VEGETABLES

G.H. CANNELL, Univ. of California, Agricultural Experiment Sta., *Riverside, California* 92502

To formulate better criteria for programming irrigation of vegetables. Factors considered in relation to irrigation are: soil physical properties, fertilizers, and soil salinity. Water requirements for various vegetable crops in a range of environmental conditions will be made.

Little technical information on the effects of irrigation on vegetable crops has been reported for southern California. With irrigation water becoming a high-cost factor in vegetable production in certain areas and with the prospect of higher costs, less water, and water of poorer quality, studies in water use and salt effects from irrigation are thus imperative.

While irrigation based on soil-water relations is basic, a more general approach to measurement of effects in the plant as well as those in the soil will be included as part of this study. Improvement of existing equipment and designing of new devices for the measurements mentioned are being carried out in these studies.

SUPPORTED BY California State Government

2.0138, DISTRIBUTION OF DIATOMS IN DESERT WATERS

L.H. CARPELAN, Univ. of California, Graduate School, *Riverside, California* 92502

This is a renewal of GB-3500 for the completion of studies of desert limnology. Field studies are concerned with the distribution and survival of branchiopods in semi-permanent desert waters (dry lakes), the productivity of the dry lakes, and respiration of the branchiopods. The aim is an analysis of the energetics of this very difficult environment.

SUPPORTED BY U.S. National Science Foundation

2.0139, MOISTURE CONTROL AND ITS RELATION TO CULTURAL PRACTICES FOR CITRUS, TREE, AND VINE CROPS

W.W. JONES, Univ. of California, Agricultural Experiment Sta., *Riverside, California* 92502

Objectives: (1) To measure the response of the tree to water application based on soil moisture suction or other indices of soil moisture status. Evaluation of the interactions between soil moisture, climate rootstocks, fertility and other cultural factors will receive special emphasis. (2) To evaluate various techniques and methods of applying water to the soil. Emphasis will be given to studies concerned with the possibilities and implications of automation in irrigation. (3) To evaluate morphological and physiological responses of trees to soil moisture variables both for newly planted trees and producing trees. (4) To evaluate the moisture flow characteristics of various soils in relation to efficient irrigation application.

DESCRIPTION OF WORK - Soil moisture movement and availability in different soils will be studied in relation to moisture tension in both orchards and the greenhouse. The orchard experiments will be carried out in specific soil and climatic areas of the State to obtain information representing a wide range of conditions. Work will be conducted in university controlled land and on privately owned orchards.

SUPPORTED BY U.S. Dept. of Agriculture
California State Government

2.0140, CHARACTERIZATION OF SOIL NONWETTABILITY AND THE DEVELOPMENT OF CRITERA FOR THE MOST ECONOMIC TREATMENT OF THESE SOILS

J. LETEY, Univ. of California, School of Agriculture, *Riverside, California* 92502

Soils which repel water and are commonly referred to as nonwettable soils have been reported in many areas of the world. Large percentages of areas burned by forest fires exhibit nonwettable soils. Nonwettable soils can be treated with wetting agents to make them wettable and increase water infiltration.

The proposed research will involve developing criteria to predict the most effective and economic treatment of a nonwettable soil with wetting agent to increase water movement through the soil. The necessary parameters will be measured and predicted water infiltration will be compared with calculated values. The parameters to be measured are: critical surface tension of soil, wetting agent adsorption by soil, wetting agent concentration relationship with solution surface tension, and depth of soil affected.

The release of surfactants by soils as affected by various factors will be investigated to predict the longevity of a surfactant treatment and to provide estimates of possible long-range ground water contamination.

A field survey will be undertaken to gain a better evaluation of the extent of nonwettable soils.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of California

2.0141, THE ROLE OF SOIL WETTABILITY AND TREATMENT WITH WETTING AGENTS ON WATER MOVEMENT AND SOIL PHYSICAL PROPERTIES.

J. LETEY, Univ. of California, Agricultural Experiment Sta., *Riverside, California* 92502

A study is proposed to investigate the effect of wettability and treatment with wetting agents on physical conditions of and water movement in soils. The nature of the organic substances causing reduced wettability, and the influence of texture, type of clay, and types of microbial population on soil wettability will be investigat The absorption, replacement, and leachability of wetting agents will be studied to determine most effective treatment practices and probable duration of beneficial effect. The effect of wettability and treating with wetting agents on structure, soil strength, and particle arrangement will be studied because these factors also influence water flow. The results of the proposed research will assist in the proper incorporation of soil wettability in the hydrologic cycle.

SUPPORTED BY California State Government

2.0142, MOISTURE CONTENT OF VARIOUSLY TREATED CHAPARRAL SOILS IN RELATION TO SEEDLING ESTABLISHMENT OF ADAPTED PERENNIAL GRASSES

C.M. MCKELL, Univ. of California, Agricultural Experiment Sta., *Riverside, California* 92502

To study soil moisture depletion patterns and plant development on hand-cleared, herbicide-sprayed, and untreated plots of chaparral. To investigate the establishment and growth of desirable replacement ground cover species.

Gypsum soil-moisture blocks buried at 12, 24, and 36 inches in three different locations in Southern California will provide a monthly pattern of soil moisture use on 40' x 40' plots of variously treated chaparral. Additional cleared and non-cleared sites will provide for studies of seedling establishment and plant development in relation to soil moisture availability.

SUPPORTED BY California State Government

2.0143, INTERRELATIONS BETWEEN THE SUPPLY, UPTAKE, AND USE OF INORGANIC NUTRIENTS AND WATER

J.J. OERTLI, Univ. of California, Agricultural Experiment Sta., *Riverside, California* 92502

Objectives: 1. Investigate relationships between soil and plant moisture conditions and the availability, uptake, and function of inorganic nutrients. 2. Investigate relationships between nutritional conditions and the availability, uptake, and use of water.

Description: Investigations in plant nutrition in the laboratory and in the greenhouse.

2. WATER CYCLE

SUPPORTED BY California State Government

2.0144, LYSIMETER INVESTIGATIONS OF GAINS AND LOSSES OF MINERAL ELEMENTS

P.F. PRATT, Univ. of California, Agricultural Experiment Sta., *Riverside, California* 92502

Study, under the controlled conditions possible with lysimeters, the effect of treatment of soils with fertilizers and other chemicals and irrigation waters on the gains, losses, balance, and trend of all of the important mineral elements of soils, to study the effect of long-term use of chemicals and waters on crop yields, and crop yield trends in relation to the chemical, physical, and biological properties of soils. Specific objective of work of immediate future is to study the effects of acid, neutral, and alkaline-forming nitrogen fertilizers, cropping and irrigation on yields, properties of soils, and gains and losses of mineral elements in the soil or added to the soil.

Description of Work: Two crops are grown each year on four different soils fertilized with three different nitrogen fertilizers. The crops are harvested, weighed and analyzed so that depletion by cropping can be calculated. Samples of all fertilizers and water added to the soils are analyzed to determine the elements added in these materials. At least once each year the soils are leached, the volume of leachate measured and a sample analyzed. Thus, the losses and/or accumulations of fourteen elements are being measured and related to soil type and to the source of nitrogen fertilizer.

SUPPORTED BY U.S. Dept. of Agriculture
California State Government

2.0145, PHYSICAL, CHEMICAL AND MICROBIOLOGICAL FACTORS AFFECTING THE DISCHARGE OF WATER INTO DRAIN TILE

S.J. RICHARDS, Univ. of California, School of Agriculture, *Riverside, California* 92502

Numerous observations have indicated that tile drainage systems have failed, some of them due to combinations of chemical and microbiological factors. It is proposed to set up model studies drain tile outflow boundaries while imposing physical, chemical, and microbiological variables.

Soil and environmental conditions will be patterned after field and model studies relating to the role of soil particles in plugging drainage tile joints. Any leads found in preventing the plugging of tile will be applied to life-size models and field experiments.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of California

2.0146, SOIL PHYSICAL CONDITIONS IN RELATION TO IRRIGATION

S.J. RICHARDS, Univ. of California, Agricultural Experiment Sta., *Riverside, California* 92502

Develop and improve techniques for characterizing and measuring soil physical properties. Evaluate the factors which affect water entry and movement in soils. Evaluate the factors which affect aggregation and aggregate stability.

Description of work: Measure unsaturated water conductivity of soils over wide ranges in soil suction. Develop and calibrate instruments for measuring soil moisture conditions in terms of soil suction in the range 1 to 10 bars. Develop laboratory techniques for evaluating soil structure and correlate these techniques with field and plot irrigation management. Use compacted bulk density and hydraulic conductivity as indices to evaluate the effects of chemical amendments and of soil improving practices being carried out in cooperative trials with growers and farm advisors. Evaluate and improve methods of measuring water retention by soils and soil mixes. Measure oxygen requirements for soil aeration and evaluate soil aeration under irrigation practices where leaching is required. Under commercial practices, compare furrow and sprinkler irrigation of citrus in terms of fruit sizing and leaf analyses.

New laboratory and field procedures are being developed for aggregate analysis and characterization of aggregate stability, and factors affecting same.

SUPPORTED BY U.S. Dept. of Agriculture
California State Government

2.0147, FACTORS INFLUENCING THE FLOW OF SUBSOIL WATER IN THE IMMEDIATE PROXIMITY OF, AND INTO DRAINAGE FACILITIES

S.J. RICHARDS, Univ. of California, Agricultural Experiment Sta., *Riverside, California* 92502

Objectives: 1. Determine the combination of soil grain sizes most likely to plug a tile joint. 2. Investigate a wider variety of filter materials which might be used in practice to reduce tile joint plugging. 3. Look for other soil factors (physical, chemical, or microbiological), in the model studies which might give further leads relative to the general problem of ineffective tile drainage in the Coachella Valley.

Work Proposed: 1. Working primarily at UCR but with soil and filter material initially from the Coachella Valley, set up model drainage systems approximately 2' x 2' x 3' in size. Evaluate the tendency for joint plugging by head loss measurements under measured flow rates. Study the plugging potential of various soil separates and soils of varying structural and mineralogical status. 2. Measure water conductivity and compaction properties of typical soils from the Valley to determine whether these factors can be eliminated in relation to the drainage difficulties. 3. When justified on the basis of preliminary experiments, use radioactive tracer techniques to tag soil particles and study their movement under controlled model conditions.

SUPPORTED BY U.S. Dept. of Agriculture
California State Government

2.0148, SOIL-MOISTURE-PLANT RELATIONS OF AVOCADO TREES

S.J. RICHARDS, Univ. of California, Agricultural Experiment Sta., *Riverside, California* 92502

Objective: Evaluate soil water conditons as a factor in the growth, vigor, and production of avocadoes, and cooperate in the evaluation of the interactions of soil moisture and air temperature with nitrogen fertilization and root rot diseases.

Work Proposed: Modify treatments on Haas avocado trees, CRC 20C, to investigate automatic irrigation and air temperature amelioration during peak temperatures in summer. Establish irrigation and nitogen fertilization treatments on plots, Field 4, at the South Coast Field Station to evaluate their effects on Bacon avocado trees. In greenhouse and lathhouse experiments, study layer soil conditions to explain the lack of normal root growth in 'sandy' type soils.

SUPPORTED BY California State Government

2.0149, A STUDY OF THE PRIMARY PRODUCTIVITY OF NEW AND OLDER RESERVOIRS

R.R. RAWSTRON, State Dept. of Fish & Game, *Sacramento, California*

Premises; Decreasing primary productivity has been blamed for declines in fish population during the years following impoundment. Merle Collins Reservoir (Virginia Ranch Reservoir) is a newly impounded water and offers an opportunity to discover and follow the changes in primary productivity (represented by algae production) which may occur. An attempt will be made to associate these changes with changes in fish production there.

Water withdrawal and climatic conditions affect limnological conditions in large reservoirs; these in turn may affect fish production. Folsom Lake water is generally withdrawn from near the lake surface, whereas Merle Collins has a bottom outlet.

Procedure: Limnological variables including dissolved oxygen, total alkalinity, total organic matter content, temperature, pH, conductivity, and primary productivity as radioactive carbon (C14) uptake will be measured weekly during March through October and biweekly during the remaining months at both Folsom Lake and Merle Collins Reservoir. One station has been established at each water. Limnological data collection will cease on June 30, 1967, at Folsom Lake. Three years of comparable data will be available at that time.

If detectable changes in primary productivity and other limno- logical variables do occur, these changes will be compared to help test the theory that the decline in fish production is related to changes in primary productivity.

Climatic and water withdrawal data for Folsom Lake will be taken from Bureau of Reclamation records. Brown's Valley Irrigation District and Weather Bureau records will supply identical information for Merle Collins Reservoir.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
California State Government

2.0150, DISPOSAL OF SURFACE WATER

UNKNOWN, State Div. of Highways, *Sacramento, California*

Design criteria is to be established for disposal of water from surface runoff by infiltration within the highway right-of-way, with development of test procedures for determining rates of infiltration.

SUPPORTED BY California State Government
U.S. Dept. of Transportation - Public Rds.

2.0151, RESERVOIR SYSTEM ANALYSIS FOR LOW-FLOW REGULATION

L.R. BEARD, U.S. Army, Engineer District, *Sacramento, California* 95814

Increase in development of river basins and increasing emphasis on coordinated development produce new problems of devising and coordinating the operation of a large number of projects to provide a large number of services. Traditional means of analyzing operation of a single reservoir or a pair of reservoirs for several purposes fail by sheer weight of computation requirements when applied to comprehensive basin and interbasin development. First essential step in solution of this problems was adaptation of existing procedures and new techniques to electronic computer.

Analysis techniques previously developed have been reformed and extended to constitute a basic computer package, which includes a framework for economic evaluation of system output. Optimization routines will be included in the package as such techniques are developed.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0152, LAND SUBSIDENCE STUDIES IN THE SAN JOAQUIN VALLEY

J.F. POLAND, U.S. Dept. of Interior, Water Resources Division, *Sacramento, California* 95814

Objectives of this project are to study the extent, magnitude, rate, and causes of land subsidence in the San Joaquin Valley, Calif., to furnish criteria for estimating the amount of subsidence that would occur under assumed hydrologic change, to determine whether subsidence is reversible in part, and to suggest ways for stopping or ameliorating subsidence.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0153, MECHANICS OF AQUIFER SYSTEMS

J.F. POLAND, U.S. Dept. of Interior, Water Resources Division, *Sacramento, California* 95814

The objectives of this project are to determine the principles controlling the deformation (compaction or expansion) of aquifers or aquifer systems resulting from change in grain-to-grain load, caused chiefly by change in internal fluid pressure; to extend existing leaky- aquifer theories to multi-layered aquifer-aquitard systems so that pumping test techniques can be used to obtain meaningful hydraulic coefficients in heterogeneous alluvial deposits; and to appraise the meaning and utility of the coefficient of storage as derived from short-term aquifer tests in relation to long-term values for aquifer systems that have undergone substantial compaction; also the change in the coefficient of storage in compressible acquifer systems as a result of change in hydrologic environment.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0154, SMALL-SCALE CIRCULATIONS OF THE SAN FRANCISCO BAY AREA

A. MILLER, San Jose State College, Graduate School, *San Jose, California* 95114

The objective of the proposed research is to design and carry out specific experiments in atmospheric dynamics in the lower San Francisco Bay region. Physical-mathematical models will be developed of the following phenomena: (1) the sea breeze beneath an inversion; (2) waves within the inversion; (3) formation, oscillations and dissipation of jets within the inversion layer; (4) exchange processes between the marine layer and the dry air aloft; and (5) the channelling of flow by the mountains.

The research will be carried out using the techniques and observational methods developed over the years by the group at San Jose State College. This includes three M-33 tracking radar systems with data acquisition systems. Aircraft instrumentation includes sensors for pressure, dry bulb temperature, and wet bulb temperature. Tetroons, pibals and radiosondes are flown during the experimental periods. It is expected that at least 15 complete field experiments will be conducted during the grant period.

SUPPORTED BY U.S. National Science Foundation

2.0155, EFFECT OF CHARGE UPON COLLISIONS IN WASHOUT

T.G. OWEBERG, T.G. Owe Berg Incorporated, *Santa Ana, California* (AT(04-3)-673)

Objective: To determine the effect of charge of atmospheric particles and rain drops upon collisions in washout of atmospheric debris by rain.

Background: The encounter between a falling drop and a small particle is affected by the flow field around the drop, by forces of inertia and electrostatic forces, and motion of the particle relative to the drop. The particle trajectory is the integrated form of the equation of motion. The probability of collision, the collision efficiency can be determined when the trajectory is known. The collision efficiency in turn determines the collection (or washout) efficiency.

Procedure: Trajectories of particles in the vicinity of drops and particle distributions on drops are determined by high-speed photography through the microscope at various fall velocities of the drops and various charges on drops and particles. So far, water drops of 2 to 2.5 mm in diameter and Lycopodium particles of 32 micron diameter have been used. The fall velocity of the drop has been varied up to 5 m/s. The terminal velocity is 9 m/s for such a drop. So far only the average particle charge has been measured, but means are under development for the determination of individual particle charges.

SUPPORTED BY U.S. Atomic Energy Commission

2.0156, EFFECT OF THE WARM CLOUD BASE UPON CLOUDSEEDING FROM THE GROUND

T.G. OWEBERG, T.G. Owe Berg Incorporated, *Santa Ana, California*

The work is part of Project Skywater. It is conducted in the laboratory of T. G. Owe Berg, Inc., 2189 South Grand Avenue, Santa Ana, California. The interaction of silver iodide particulates with water vapor and water droplets is studied, specially with a view to the effect of exposure to the conditions at the cloud base upon the effectiveness of the silver iodide as a seeding agent. The results obtained indicate that silver iodide forms ice crystals with water vapor that is supersaturated with respect to supercooled liquid water, and that such ice crystals may initiate freezing of cloud droplets provided the droplets and the ice crystals are electrically charged. Observations are made under the conditions of the cold chamber and the expansion chamber and also with single droplets or particles suspended in a nonuniform ac field. Matters of particular concern are the conditions for nucleation and growth of the ice phase and how they are affected by the history of the seeding agent.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0157, FACTORS AFFECTING PRIMARY AND SECONDARY PRODUCTION IN TEMPERATE LAKES

D.W. SCHINDLER, Trent University, Graduate School, *Peterborough - Ontario, Canada*

Field measurements of primary production in four lakes of different morphometry will be regressed upon physical and macro nutrient factors of possible causal importance using multiple regression analysis. Corrections will be made for departures from linearity and elimination of non-significant variables. Schindler (1966) found that 75% of the variance in areal primary production measurement of a small Minnesota lake could be explained by such treatment. This study will be an attempt to expand the treatment to include production at different depths and in different types of lake basins.

Zooplankton production will be calculated using the method of Schindler (1967) from zooplankton birth rates and the average size of animals at death, allowing estimates of production by the entire plankton community, and by each species of zooplankton.

Results will be compared with each other and with those of Severson Lake, Minnesota, in order to identify and quantify general principles affecting production in water bodies of all types.

Data will also be analyzed for inter and intraspecific competition, predation, and their mode of operation.

The effect of micro-nutrient limiting factors on primary production will be investigated experimentally.

SUPPORTED BY U.S. National Science Foundation

2.0158, BOTTOM FAUNA IN THE NORTH ST. VRAIN CREEK, COLORADO

R.W. PENNAK, Univ. of Colorado, Graduate School, *Boulder, Colorado* 80304

A year-round study of bottom fauna in a typical mountain stream system.

SUPPORTED BY University of Colorado

2.0159, ANTIBIOTIC EFFECTS OF ROOTED AQUATICS ON ZOOPLANKTON SPECIES

R.W. PENNAK, Univ. of Colorado, Graduate School, *Boulder, Colorado* 80304

Experimental laboratory study on the growth-inhibiting and growth- promoting of extracts of rooted aquatic plants.

SUPPORTED BY University of Colorado

2.0160, SOUTH PLATTE RIVER DEVELOPMENT PLAN

G. STENSON, S.R. Deboer & Company, *Denver, Colorado*

This program is designed for the Recreational development of the South Platte River bottoms below the proposed Chatfield dam and past the city of Littleton and Belleview Ave.

The plan proposes: A. Bridle path along the edge of the river connecting with Centenniel race track. B. Bicycle path along the whole length of the river. C. Fishing lakes at various spots together with a fish hatchery. D. picnicking and a tree planted park road along the full length of the river.

SUPPORTED BY U.S. Dept. of Interior - Bu. Outdoor Rec.
Littleton City Government - Colorado

2.0161, FEASIBILITY OF USING ATMOSPHERIC WATER RESOURCES IN THE NORTHEASTERN UNITED STATES

E.J. AUBERT, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The objective of this initial study is to assess the potential feasibility (technical, benefit, cost) of utilizing the atmospheric water resource in the Connecticut River Basin.

The specific goals are: (1) Assess major features of stress in supply and demand in the present and planned water resource system, users and uses which are relevant to the atmospheric water resource; (2) Identify requirements for and estimate potential benfits from the atmospheric water resources for preliminary assessment purposes; (3) Estimate the climatology of precipitation potential and seedable situations; and, (4) Assess the preliminary feasibility of developing the atmospheric water resource in the Connecticut River Basin.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0162, ATMOSPHERIC WATER RESOURCES RESEARCH UNIVERSITY OF WYOMING

J.E. BELLAMY, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

During the 1968-69 winter season the activities at the Elk Mountain Water Resource Observatory will be to conduct studies of the environment within which the Elk Mountain cap cloud occurs, the inflow into this cloud, the nucleation of this cloud, the growth of the precipitation particles within the cloud, and finally its precipitation in order to continue the development of sound snowpack augmentation procedures.

The environmental studies will determine the synoptic situation, thermodynamic stabilities, and cloud and ice nuclei activation spectra within which the cap cloud occurs. The source of water vapor which produces the layered cap cloud will also be studied.

The inflow studies will be continued and expanded in order to understand more clearly the air flow over and around a three dimensional mountain. Transport and diffusion studies will also be made to determine the most effective means of seeding a cap cloud.

The nucleation studies will attempt to determine the natural and artificial activation spectra of cloud and ice nuclei and their subsequent activation. The concentration of cirrus crystals which might nucleate the cap cloud will be sampled.

Experimental operations in the Wind River Mountains near Boulder, Wyoming will also be conducted. This program will be a randomized cloud seeding operation using ground based silver iodide generators using a one-day experimental unit.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0163, ATMOSPHERIC WATER RESOURCES PROGRAM

B.P. BELLPORT, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The Atmospheric Water Resources Program is a comprehensive applied research and engineering development program directed toward enhancing e modification. The immediate objective is to determine the practicality f augmenting the streamflow into reservoirs on Reclamation projects. Definite scientific answers will be established regarding the feasible extent to which weather modification can beneficially supplement water resources for other areas.

The many aspects of integrating precipitation modification into the social and natural environment will also be studied and resolved. The necessary instrumentation, techniques and operating systems for modifying precipitation under orographic, convective and frontal situations will be developed. Early development of applicable techniques will be emphasized in regions where water supplies are most critical.

About 90 percent of the program activity is being undertaken through contracts with universities and private meteorological firms and agreements with State and other Federal agencies.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0164, PARK RANGE ATMOSPHERIC WATER RESOURCES PROGRAM

E. BOLLAY, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The Park Range Program, part of the Bureau of Reclamation's Project Skywater, is centered at Steamboat Springs, Colorado and has been in continuous operation since November 1964. Prime purpose of the program is the development of weather modification technology, especially as it applies to the increase or redistribution of precipitation in the mountainous regions of the Colorado River Basin. Major studies include 1) diffusion of AgI artificial nuclei from ground generators into orographic clouds, 2) detection of ice nuclei concentrations in the air, and of silver in precipitation samples, 3) evaluation of artificial nucleation effects, 4) determination of the precipitation meteorology of the area and 5) development of operational criteria and techniques for efficient application of artificial nucleation in this, and similar, regions. In particular, the program is investigating various approaches to intermittent (periodic or other schedule) nucleation as a method of reducing the experimental time required to determine nucleation effectiveness. Results to date indicate that periodic nucleation can be used to detect seeding effects on purely orographic precipitation.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0165, INVESTIGATION OF THE FEASIBILITY OF WARM-CLOUD MANAGEMENT

H.R. BYERS, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Objectives are to explore clouds that are warmer than freezing yet at or near the point of precipitating, or to discover means of influencing their precipitation.

Aircraft penetrations, radar, chaff drops, study of chemicals for modification, later tests of modification. Theoretical and observed models of convective clouds.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0166, AQUIFERS AND DRAINAGE

E.J. CARLSON, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The study deals with the movement of saline water in 1- and 2 layer ground water aquifers. A laboratory investigation was used to observe the movement of the saline water-fresh water interface for various rates of application of fresh irrigation water surcharge on the ground surface. Typical agricultural tile drains and vertical pump wells were studied in the model. They provided a location for the saline water to leave the strata. The movement of the saline water (dyed blue) was observed and the results were compared with the theoretical movement. The study has been extended to deal with drainage of sloping agricultural land. A laboratory investigation is being used to determine the distribution of discharge to tile drains for various drain spacings on sloping land. Dye tracers will be used to determine the relative depth in the aquifer from which water approaches the drain or flows down the sloping aquifer.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0167, AIRFLOW AND DIFFUSION PARAMETERS IN CONNECTION WITH ATMOSPHERIC WATER RESOURCES PROGRAM

J.E. CERMAK, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

A. Determine the full capability for simulations flow and diffusion over mountain barrier in a meteorological wind tunnel.

B. Establish the degree of correspondence between flow and transport characteristics for model and prototype.

C. Evaluate the potentials of laboratory simulation of atmospheric motions over complex terrain for operational considerations of the diffusion and transport of seeding materials.

Laboratory Simulation 1. Necessary conditions for similarity 2. Conditions for simulating diffusion and transport 3. Four topographic models will be studied 4. Some special instrumentation may be required.

Field Study 1. Study of the wind field over mountains 2. Instrumentation will be : Rawinsonde, Pilot Balloons, Kites, and Constant Level Balloons.

Numerical Study (optional) possible computer model for simulating diffusion and transport over mountains.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0168, ECOLOGICAL EFFECTS OF WEATHER MODIFICATION

C.F. COOPER, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

To analyze potential ecological impact of precipitation management programs and other weather modification programs related thereto; to identify those portions of the ecosystem most sensitive to precipitation management; and to prepare research designs by which these portions may be investigated in greater detail.

Procedures include a review and evaluation of information and data already available and of potential pertinence to the ecological effects of weather modification programs. Present and contemplated research related to ecological effects of weather modification programs will be inventoried among universities, individuals and appropriate government agencies such as the U.S. Forest Service, the Bureau of Land Management and the State Agricultural Experiment Stations. Professional specialists will be consulted on a fee basis in areas such as entomology, limnology, human ecology, paleocology, plant pathology and bio-statistics. Computer simulation models will be studied in considerable depth and research designs specifically formulated.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0169, LEGAL IMPLICATIONS OF WEATHER MODIFICATION

R.J. DAVIS, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Legal implications arise from experimentation in weather modification and from development and management of atmospheric water resources. As a part of Project Skywater a study of the legal aspects of intentional weather alteration is being conducted at the College of Law of the University of Arizona in Tucson, Arizona 85721; it will be concluded in July 1968. The study undertakes a legal evaluation of the consequences of rainfall and snow control, fog dispersion, lightning suppression, hail suppression, and hurricane modification. Judicial decisions, statutes, administrative regulations, and scholarly writings that relate to weather modification activities are being examined in order to determine the legal aspects of the application of weather alteration technology. Determination will be made of what legal norms should in the future be applied to the local, national, and international consequences of weather modification activities. Based upon such findings, reports will recommend legislative and administrative action.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0170, HYDROLOGY OF PRAIRIE POTHOLES

W.S. EISENLOHR, U.S. Dept. of Interior, Geological Survey, *Denver, Colorado*

Because prarie potholes of North-Central United States and adjacent areas of Canada are major breeding grounds of migratory waterfowl protected by United States treaties with Canada and Mexico, this study is included in the International Hydrological Decade. One problem being studied is that of identifying those potholes that will contain water long enough that they should be preserved for use by waterfowl rather than be drained for agricultural use. A closely associated problem is that of determining the amount of water needed to keep a pothole useful for waterfowl. Another problem is that of determining the amount of seepage from potholes that may reach aquifers used for water supply in distant areas. Changes in chemical quality are being studied as it may affect the usefulness of a pothole to waterfowl.

The study is being made in North Dakota and is concerned with the processes by which water enters and leaves a pothole and a detailed analysis of the water budget, including separate computations of evaporation and transpiration from potholes filled with aquatic vegetation, to the end that adequate information will be available for the design of observation programs needed to solve water resources problems in the prarie pothole region.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0171, LARGE SCALE DYNAMIC EFFECTS OF CLOUD SEEDING

R.D. ELLIOTT, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Objective: The objective of this contract is to conduct laboratory studies to determine large-scale dynamic effects of cloud seeding, including secondary effects that may develop at a considerable distance downwind from the primary effect.

Procedures: Research work is to include but shall not be limited to the following items: a. Spatial distribution analysis of precipitation and hydrologic data in extended regions in, around, and downwind from long-term cloud seeding projects and dynamic effects in the primary and secondary areas. b. Analysis is to consist of the following: 1) Statistical phase: To determine the general relationship between cloud seeding and dynamic effects in the primary and secondary areas. 2) Development of a physical model to explain the observed dynamic effects relating the magnitude and wave length to the basic wind pattern and terrain configuration. 3) Selection of an area and design of a field test to provide more definitive and acceptable results than can be obtained from postanalysis of historical data. c. To determine the extent of any secondary area of effect that may develop at a considerable distance downwind from the primary effect and at a place where it is unlikely that any artificial nuclei would be present.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0172, SKYWATER--PARK RANGE FOREST HYDROLOGY

H.C. FLETCHER, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Stream gaging and hydrologic analyses of subwatersheds of the Park Range Program area. The effect of forest cover and land management are studied so that the result of possible changes can be segregated from achievements of the weather modification program. Possible differential effects in weather modification results caused by topography or forest cover are considered to aid planning and application of weather modification to other mountain watersheds. Available information is used to develop a conceptual nonlinear model of snowmelt runoff in which streamflow is the transformation of generated snowmelt by a watershed system that delays, modulates, and attenuates input and compared to output.

Field work is carried out in the mountains of north-central Colorado especially near Steamboat Springs and Fraser. This study began in 1964.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0173, PRODUCTION AND DETECTION OF ARTIFICIAL ICE NUCLEI

N. FUKUTA, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The principal objective of this study is to establish the initial part of weather modification technology where ice nucleation is involved. Four major technical problems are to be investigated, i.e., optimization of ice nuclei for use under particular cloud condition, development of seeding materials other than silver iodide for cloud seeding programs, development of airborne and ground nuclei counter and study of cloud seedability in terms of background ice crystal and ice nuclei. Results are directly aimed at the use in the development of cloud seeding technology for precipitation management.

There are two basic approaches to the problem. One is theoretical computer modeling of microphysics of ice crystal and ice nuclei, and the other is an experimental study of it. Construction of nuclei generator testing facilities, a vertical wind tunnel, and a cold room are planned. Every part contains problems; production of organic smoke appears one of the major problems. Good coordination of theoretical and experimental effort is necessary to accelerate the work.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0174, VELOCITIES OF RADIONUCLIDES AT ARNAR GOSA SITE

D.B. GROVE, U.S. Dept. of Interior, Water Resources Division, *Denver, Colorado*

The investigations are designed to obtain information concerning: (a) the ground-water system in the carbonate rocks, rhyolites, and tuffs of the Nevada Test Site, (b) the hydraulic properties of earth material and aquifers that need to be considered in predicting the rate transport of radioactive products produced during a nuclear detonation, and (c) the chemical factors affecting the rate of transport of the same products.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0175, ATMOSPHERIC WATER RESOURCES RESEARCH IN THE STATE OF NEW MEXICO

N.N. GUNAJI, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The purpose of this program is to conduct research in the atmospheric sciences leading to the development of beneficial weather modification procedures and to the development of techniques for atmospheric water resources management methods for application in the Rio Grande Basin upstream from Elephant Butte Reservoir within the state of New Mexico. The program was initiated 1 February 1967. Work plans which include statistical model, field operation procedures, logistics, field measuring equipment, communication system and personnel, have been completed.

A target area of approximately 200 square miles and two control areas have been selected. The target area is located within the Jemez and Sierra Nacimiento Mountain Ranges.

The proposed work for 1 July 1967 to 30 June 1968 shall include the initiation of the following: 1) identification and classification of storm systems; 2) research on agents, instruments, equipment, and techniques which may accomplish changes in cloud systems; 3) research on cloud and precipitation processes, including detection of results from weather modification efforts; 4) refinement of techniques and instrumentation for routine field operations and 5) development of long-range plans for accomplishing the objectives of this contract for the Rio Grande Basin.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0176, BADGER WASH COOPERATIVE STUDY

R.F. HADLEY, U.S. Dept. of Interior, Water Resources Division, *Denver, Colorado*

This study initiated in 1953 and continues for 20 years, is a cooperative effort to determine rates and character of erosion, runoff, and sedimentation at different storm intensities and under different desert vegetation cover conditions, both grazed and ungrazed; and to determine influence of small animals on watershed.

Geological Survey is responsible for installation and maintenance of precipitation gages and water stage recorders. Sediment yield from the drainage basins is calculated from periodic measurements of the reservoirs. Gully erosion and sheet erosion are measured.

Responsibility for vegetative surveys using transect clusters, infiltration, and soils studies formerly conducted by the Forest Service is being assumed by the Geological Survey in the 1968 FY. The studies will include more detailed measuring procedures.

The Bureau of Land Management constructs and maintains all physical structures such as retention dams, check dams, diversion dams, ditches exclosures, etc. The Bureau of Reclamation reimburses BLM for portions of this work.

The Bureau of Sport Fisheries and Wildlife is studying small animal populations and the influence their activities have on vegetation and soil.

The study site is located in western Colorado, 4 miles east of the Colo-Utah boundary and 30 miles northwest of Grand Junction, Colorado

SUPPORTED BY U.S. Dept. of Interior - Bu. Land Mgmt.
U.S. Dept. of Interior - Geological Survey
U.S. Dept. of Interior - Bu. Reclamation
U.S. Dept. of Interior - Bu. Sport Fish.

2.0177, SAN ISIDRO WASH STUDY FLOW LOSSES IN AN EPHEMERAL STREAM CHANNEL

R.F. HADLEY, U.S. Dept. of Interior, Water Resources Division, *Denver, Colorado*

Many of the ephemeral streams in Western United States experience a depletion of surface flow in a downstream direction as a result of infiltration in the dry channel bed.

The objective of this study is to determine, quantitatively, the flow 'losses' on San Isidro Wash near Cuba, New Mexico. This includes determination of whether the infiltrated water reaches an aquifer or is returned to the atmosphere by evapotranspiration; also, the changes in channel geometry that take place with flow losses and changes in sediment concentration. When conservation structures, such as detention reservoirs, are constructed in the basin and land treatment practices are initiated, the hydrologic effects of these practices will be studied.

Gaging stations have been established, channel cross sections have been surveyed, and scour chains have been installed to study channel changes. Precipitation and fluctuations of groundwater level also are being observed. Soil samples of soil-moisture determinations are taken to study the unsaturated zone.

SUPPORTED BY U.S. Dept. of Interior - Bu. Land Mgmt.
U.S. Dept. of Interior - Geological Survey

2.0178, FLOW LOSSES IN AN EPHEMERAL STREAM CHANNEL

R.F. HADLEY, U.S. Dept. of Interior, Geological Survey, *Denver, Colorado*

Many of the ephemeral streams in Western United States experience a depletion of surface flow in a downstream direction as a result of infiltration in the dry channel bed.

Objective of this study is to determine quantitatively the flow 'losses' on San Isidro Wash near Cuba, New Mexico; and if the infiltrated water reaches an aquifer or is returned to the atmosphere by evapotranspiration. Also, what changes in channel geometry take place with flow losses and changes in sediment concentration. When conservation structures, such as detention reservoirs, are constructed in the basin and land treatment practices are initiated, the hydrologic effects of these practices will be studied.

Gaging stations have been established, channel cross sections have been surveyed, and scour chains have been installed to study channel changes. Precipitation and fluctuations of groundwater level also are being observed. Soil samples for soil-moisture determinations are taken to study the unsaturated zone.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0179, THE RELATION OF DRAINAGE NETWORKS AND BASIN DEVELOPMENT TO ROCK TYPE AND CLIMATE

R.F. HADLEY, U.S. Dept. of Interior, Geological Survey, *Denver, Colorado*

The objectives of this project are to related the processes of slope formation and drainage basin development to the rock type and climate over a wide range of conditions over the United States. Specifically, the following items will be investigated as an approach to the problem: (1) Determination of the validity of the statement made by humid regions, (2) Which expression of drainage density or topographic texture is a true reflection of hydrologic conditions for different climates, (3) To determine the processes and rates of basin development as affected by differences in climate. These may include frequency of freeze and thaw, mean annual precipitation, and microclimate; (4) Observations of slope processes and overland flow, such as, soil creep, rilling, and sheet flow in basins representing a wide range of rock types and vegetational covers; and (5) testing of the accuracy of measuring techniques of drainage density using topographic maps and aerial photographs supplemented by field mapping.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0180, A TEST OF CERTAIN EVALUATION DESIGNS FOR CLOUD-SEEDING EXPERIMENTS

W.E. HOWELL, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The proposed work is designed to test an idea, first proposed by G.P. Wadsworth that if a contour map of precipitation depth from a given storm can be satisfactorily approximated by a simple geometrical surface, then any local artificial influences will show up as significant departure from this surface. As a first approximation, a geometrical plane is fitted by least squares to the precipitation contours of a control area that surrounds the target and an estimate of the target precipitation is obtained by extending the actual target precipitation and a suitable test-variate is used to estimate the probability that the observed difference could be expected by chance alone.

The above model was tested on actual unseeded precipitation data from the Washita River Network located in central Oklahoma. Corresponding upper wind data were used to determine hypothetical seeding plumes for any given storm. Stochastic augmentation of target rainfall was used to determine the power of the method in detecting real seeding increases and the investigation covered other such subjects as transformation and normalization of precipitation data, the developement of a suitable test-variate, and the sizes and shapes of applicable target and control regions.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0181, MECHANISMS AND RATES OF HEAVY METAL SORPTION AND DESORPTION

E.A. JENNE, U.S. Dept. of Interior, Water Resources Division, *Denver, Colorado*

The principle objective is the elucidation of the mechanisms and processes whereby manganese and iron oxides sorb cobalt (and other heavy metals). An additional objective is the determination of the rates of cobalt sorption and the effect of the natural variables of pH, redox potential, competing cation, cobalt concentration, etc. on the sorption rates.

Reaction kinetics, reversibility of sorption, and new phase formation are being utilized in determining the mechanism of the sorption reactions.

Sorption mechanisms and rates will allow a semi-quantitative description of the concentration of cobalt (and other heavy metals) in waters.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0182, SPECIFIC YIELD INVESTIGATION

A.I. JOHNSON, U.S. Dept. of Interior, Water Resources Division, *Denver, Colorado*

Methods of estimating the specific yield of aquifers will be studied in an attempt to obtain improved estimates of the water resources of ground-water basins and water use by phraetophytes.

The principle field and laboratory methods of estimating specific yield and the quantity of drainage as realted to time of drainage are being investigated, evaluated, and correlated. Column drainage, centrifuge, moisture tension, and unsaturated permeability techniques will be emphasized in the laboratory, and moisture-content sampling and nuclear soil moisture-density logging in the dewatered zone will be emphasized in the field. Field work is done at selected sites in California.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0183, PERMEABILITY RESEARCH

A.I. JOHNSON, U.S. Dept. of Interior, Water Resources Division, *Denver, Colorado*

This study will determine and evaluate the factors involved in saturated and unsaturated fluid flow through porous media and would lead to more accurate and reliable analytical methods for the hydrologic evaluation of ground-water systems. The principal methods now commonly in use for estimating permeability will be compared and evaluated - these are laboratory methods utilizing permeameters and field methods utilizing pumping or flowing wells - any additional methods will be investigated as proved advisable.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0184, HYDROLOGIC BEHAVIOR OF SELECTED WATERSHEDS IN THE NORTHERN APPALACHIAN REGION

E.B. JONES, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Develop a procedure for predicting hydrologic behavior of watersheds in the northern Appalachian region including the impact of the application of precipitation modification techniques.

Representative watershed will be selected and certain existing simulation techniques will be utilized, (being modified as necessary to better meet regional conditions). Once the simulation techniques have been finalized, the effect that weather modification might have on the streamflow will be studied for periods of low flow.

Watershed selection is currently in progress and two simulator techniques have been adapted to the local computer (IBM 360 Model 67).

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0185, GENERAL EVALUATION OF SOIL AND MOISTURE CONSERVATION TREATMENT PRACTICES

N.J. KING, U.S. Dept. of Interior, Water Resources Division, *Denver, Colorado*

The objective is to appraise the effectiveness of structures on streams, waterspreaders, and other measures in the Western States. The effectiveness of the measures employed are evaluated particularly with respect to runoff, erosion, and sedimentation.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0186, ARIZONA WEATHER MODIFICATION ENGINEERING RESEARCH, ATMOSPHERIC WATER RESOURCES

P. MACCREADY, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

To perform certain procedures and techniques in the general vicinity of Flagstaff, Arizona, to develop operational cloud nucleation methods with especial emphasis on major convective cloud systems and winter storm systems over a larger area.

Information will be obtained on ice crystal concentration, buoyancy effects, hydrometers, electrification, cloud system growth, etc. Work will also include quantitative engineering of the convective seeding techniques used, including design with respect to dispersal method, diffusion, and entrainment theories, with verification by field measurements. Exploration will be made of the effects of the San Francisco Mountains on cloud and precipitation patterns, during the summer and winter months. The establishment of a seedability climatology for summer and winter for the San Francisco Mountains will also be made. Applied Research 100 percent. The project was begun in FY65 and should be completed by the end of FY68.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0187, EVAPORATION FROM LAKES AND RESERVOIRS

J.S. MEYERS, U.S. Dept. of Interior, Water Resources Division, *Denver, Colorado*

The gross annual evaporation from exposed water surfaces has been estimated to be over 23,000,000 acre-feet for the 17 States lying wholly or partly west of the 100th meridian. If any of this annual evaporation loss could be reduced, an additional supply of water would be available to the arid West.

The objective of this study is the determination, by improved techniques, of variations in evaporation rates from representative lakes and reservoirs in the United States.

The energy-budget and mass-transfer methods of computing evapotranspiration are being compared for two large reservoirs: Garrison Reservoir in North Dakota and Pomme de Terre Reservoir in Missouri.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0188, ION DISTRIBUTION AND WATER MOVEMENT IN SOILS

R.F. MILLER, U.S. Dept. of Interior, Water Resources Division, *Denver, Colorado*

The objectives are (1) to define the relationship between water movement and ion distribution in soil profiles, (2) to evaluate the effect of cation exchange, and salt solubility on water movement, (3) to investigate the effect of water distribution in down drainage basins o ion distribution, soil-moisture relationships and plant distribution on arid lands.

In the past, emphasis has been placed on the effect of particle-size distribution (texture) on infiltration, runoff and erosion. The present study emphasizes the investigation of soil chemistry because it affects the swelling or shrinkage of soils and may have as great an effect on hydrologic characteristics as texture.

The soluble calcium plus magnesium and sodium distribution in consecutive portions of soil profiles with a variety of internal drainage conditions are being investigated with respect to evidences of watermovement and moisture-storage characteristics such as moisture distribution, root distribution, soil structure and the nature of plant communities at equilibrium with these conditions. Other factors such as type of clay mineral, particle-size distribution and climatic factors are also evaluated.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0189, MATHEMATICAL METHODS OF EVALUATION OF RESULTS OF ATMOSPHERIC WATER RESOURCES PROGRAMS

H.J. MORELSEYTOUX, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The project has two primary objectives: (1) the determination of criteria for selection of river basins in Central Mountains Region of the United States suitable for weather modification with a maximum chance of success and (2) the design of statistical techniques or tests to detect weather modification attainments with reliability.

To achieve these above objectives two additional accessory, but vital, studies are conducted: (a) a study of the change in the relationship between meteorologic, hydrologic and physiographic parameters of a basin for a given weather modification process and mode of operation (e.g., cloud seedings from ground-based generators) and (b) a study of the nature and magnitude of errors in the measurement and collection of data.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0190, SKYWATER

E.A. MOULDER, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Install streamflow station with heated artificial control on Colorado Creek near Spicer, Colorado. Operate, compute, and compile streamflow records for the following stations: Fish Creek near steamboat Springs, Colo. Service Creek near Oak Fork Elk River near Clark, Colo. Walton Creek near Steamboat Springs, Colo. Colorado Creek near Spicer, Colo. Reconnaissance for expansion of the streamflow data collection program in Colorado.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0191, GROWTH SUPPRESSION AND REDUCTION IN REGROWTH POTENTIAL OF AQUATIC WEEDS

N.E. OTTO, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Successful continued control or eradication of rooted submersed aquatic weeds requires information on methods to reduce or eliminate the regrowth potential of the aquatic plant to a point where they produce insignificant problems. Studies have been conducted to gain a better understanding of organism ability to reproduce itself in subsequent growing seasons. These studies include influence of treatment on stage of growth, number and type of herbicide applications necessary to reduce the amount of vegetative growth and propagule development, amount of propagative material produced by a clone of plants and food reserves in the propagule.

Laboratory investigations show that pondweeds treated with repeated aromatic solvent and acrolein applications in one growing season significantly reduced vegetative propagule production. A significant reduction in number and size of propagules was accomplished in successive treatments. Preliminary studies on the development of vegetative propagules of sago pondweed indicate that they commence development with the onset of plant flowering and fruiting. Continuing laboratory and field studies suggest that low rate, long contract period applications of a number of aquatic herbicides show promise on significantly suppressing the growth of rooted aquatic weeds, thus reducing potential residue hazards as well as controlling weed growth.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0192, DENVER MULTIPHASE FLOW

E.S. SAMMEL, U.S. Dept. of Interior, Geological Survey, *Denver, Colorado*

From an earlier survey and evaluation of theory applicable to flow in the unsaturated zone it appears that the principal needs are for procedures to predict unsaturated flow and methods for obtaining field measurements of the hydraulic properties of the unsaturated zone. Thus electric analog computing techniques will be devised for calculating unsaturated flow for specific boundary conditions, such as rate of infiltration, depth to the water table, and nature of the unsaturated sediments. Instrumentation involving electronic transducers will be applied for obtaining the desired field measurements. Theoretical results will be tested through field measurements.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0193, CONVECTIVE CLOUD SYSTEMS, NORTHERN GREAT PLAINS, ATMOSPHERIC WATER RESOURCES

R.A. SCHLEUSENER, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The program is designed to study the characteristics of both warm cloud and cold cloud convective systems with a view in mind of increasing the natural occurring precipitation from such systems by the introduction of artificial nuclei, since a major portion of the water supply of the Great Plains area comes from convective systems. Climatological studies, numerical model studies (as an attempt to simulate the natural growth of cumulus clouds), cumulus cloud penetrations by instrumented aircraft, and randomized seeding experiments will be made.

Cloud physics studies will be conducted with instrumented aircraft and radar aimed at determining the presence or absence of natural ice pellets in the convective clouds of the area. A systematic cloud census in regions of high frequency of cumulus cloud formation will also be conducted. Applied Research 100 percent. The project was begun in FY65.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0194, DEVELOPMENT OF ATMOSPHERIC LASER RADAR

R.M. SCHOTLAND, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The purpose of this research project is to develop a laser radar suitable for the study of the profile of atmospheric water vapor from a ground based location. The vertical distribution of water vapor is a basic parameter which enters all meteorological work and is of particular importance in the field of weather modification. The major problem areas are: (1) the design of a high energy switched ruby laser which is mode controlled and tunable, (2) the design of a receiving system which can handle a large dynamic range, (3) the design of data handling equipment which can reduce the radar return to atmospheric moisture content.

The design of the laser system is being based upon a saturable Q switch element operating in conjunction with a tunable resonant reflector. The receiving system will be designed about a 10 cassegrain telescope which will feed an s-20 photo-multiplier tube. A 30 mhz log amplifier will be used to cover the dynamic range of the optical return and to obtain the water vapor density function.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0195, STATE OF WASHINGTON DEPARTMENT OF WATER RESOURCES CASCADE ATMOSPHERIC WATER RESOURCES PROGRAM

S.E. SHUMWAY, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

This program is designed to develop reliable cloud treatment techniques and reproducible engineering procedures to accomplish a beneficial redistribution of precipitation across the Cascade Mountains to bolster the water resource in the arid intermountain region of the east.

Field experiments in cloud physics are being conducted in an area straddling the divide and centered around Snoqualmie Pass. Artificial nucleation practices are applied to the numerous wintertime Pacific Coast storms crossing this region during the months of October through April.

Cloud seeding operations are systematically employed and quantitatively monitored to provide a classification of the modification potential for each precipitating event; said events to be characterized by measurable, concurrent, meteorological parameters.

Efforts are directed toward developing methods to utilize the latent heat release from supercooled clouds subjected to artificial glaciation near the Cascade crest to stimulate cloud buoyance for the purpose of prolonging precipitation on the leeward side.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0196, ANALYTICAL METHODS - WATER CHEMISTRY

M.W. SKOUGSTAD, U.S. Dept. of Interior, Geological Survey, *Denver, Colorado*

Analytical methods and techniques for many constituents that are found in water, such as aluminum, the halogenides, zinc, nitrate, nitrite, selenium, and detergents and other pollutants, frequently require modifications and refinements before they can be adopted specifically for water analysis. Improvements in all analytical procedures, including special instruments and techniques, are necessary to meet the requirements of expanding research efforts in the field of water chemistry.

The work consists of evaluating the potential of a technique and refining it to the minute concentrations significant in water chemistry. Fundamental chemical methods are studied as well as methods employing specialized equipment and instrumentation, such as X-ray and emission spectroscopy, electrometric, flame photometric and chromatographic instruments.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0197, ENGINEERING DEVELOPMENT OF ICE NUCLEI DISPERSION SYSTEMS

R.L. STEELE, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Many ice nuclei dispersion systems are in field use today. Most are unsatisfactory for one reason or another, e.g., the required engineering development has not been done to render these systems simple and reliable. Performance under laboratory conditions is known in some cases. However, field performance is largely unknown. This program provides for the engineering development of simple, reliable and economical dispersion systems for ground and later aircraft use. Further, it will provide information for prediction of field performance of dispersion systems. Current and future field programs in Project Skywear demand ice nuclei generators ranging in capacity of 0.02 kg to possibly as high as 200 kg of effective nuclei per hour. Systems which are reliable with predictable actual performance are and will continue to be required.

To meet these needs, three separate, concurrent investigations are being carried out. These are: a) Coagulation in generator plumes as a design parameter, b) Development of low and medium output ground based manual/automatic dispersion systems, c) evaluation of existing aircraft generators and development of a new generator.

The ice nuclei dispersion systems developed in the program will represent the latest technology in this important phase of current and future weather modification programs. The basic engineering and science for carrying out this work is known. This will be synthesized from the atmospheric sciences, engineering sciences and recent technological development in the aerospace and process industries.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0198, EXPERIMENTAL DESIGN & STATISTICAL EVALUATION OF WEATHER MODIFICATION EXPERIMENTS

P.J. STINSON, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The overall objective of the research program is to develop experimental design criteria and statistical methods to aid in the evaluation of atmospheric water resources programs. Specific objectives are as follows. 1. A critical evaluation of past weather modification experiments will be made. Special emphasis will be placed on the evaluation of research methodology, statistical techniques, and interpretation of findings to determine their suitability for a particular experiment or for general application. 2. Conduct analyses to determine the effect of individual parameters such as (a) treatment techniques, (b) terrain factors, and (c) weather conditions on the reliability and validity of the results of weather modification experiments. 3. Develop design criteria for field experiments with special consideration of the above named parameters. 4. Develop statistical computer programs and analytical techniques for evaluating and comparing a wide variety of weather modification experiments.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0199, EVALUATION OF PRECIPITATION MANAGEMENT PROGRAMS BY PRECIPITATION RATE MEASUREMENTS

G.E. STOUT, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Objectives. The objectives are to undertake a study to define the applicability and limitations of rainfall rate measurements to enable verification and quantitative evaluation of cloud seeding activities on surface rainfall, and to determine the type and density of sampling required to apply such knowledge. a. Prepare a feasibility study to establish the potential applicability of utilizing rainfall rate measurements in cloud seeding evaluations and to define further research approaches leading to [illegible] effective cloud seeding evaluations using rainfall rate measurements. b. Study of area-depth curves of average and enveloping rainfall rate to aid in the definition of spatial characteristics and to detect additional properties useful for precipitation modification evaluation. c. Study the feasibility of using time distribution and duration of rainfall rates as evaluation procedures for determining overall additional rainfall quantities resulting from cloud seeding and for determining rate of change of rain intensity with time under natural and seeded conditions.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0200, SKYWATER

A.B. SUPER, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Phase one, completed in September, 1966, defined a program for evaluating the downwind effects of cloud seeding when applied upwind to the orographic barrier of the Bridger Mountain Range (average ridge height 8500 ft ASL) in Montana. Limited operations from February through May, 1967 provided an assortment of data from a network of sites extending from Bozeman to Billings, Montana. The data included rate of snowfall from compressed scale weighing gauges with large aperture for high resolution thermograph traces, barograph traces, ice nuclei background count, and visual observations of ice deposits on the ridge line during the storms in the area.

Analysed data which display the periodic variation of snowfall intensity at each site have been interpreted in terms of a precipitation vector which is defined as the horizontal speed and direction of the precipitation surges and/or intervening lulls. Some success has been achieved in isolating an orographic component of precipitation at some sites and in following the periodic variations in precipitation intensity through the network. Interpretation of the data in relation to surface, 700mb, and 500mb analysis has resulted in a rough typing of precipitation as related to fronts, troughs and upslope conditions. Thermograph traces and visual observations of ice deposits on the ridge indicate an abundance of supercooled water droplets in a temperature range in which silver iodide can be expected to be effective in nucleation.

Additional sites will be instrumented and measurements expanded to better define precipitation vectors. The classification of storm situations and their potential for seeding will be investigated in more detail. Background nuclei counts will be continued in the network using the NCAR type counter. Aircraft will be utilized for both atmospjeric soundings and tracking plumes released from the Bridger ridge to gain a rough idea of diffusion characteristics. Actual weather modification will probably begin in the winter of 1968-69.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0201, HYDROLOGY OF LIMESTONE AND RELATED ROCKS

F.A. SWENSON, U.S. Dept. of Interior, Geological Survey, *Denver, Colorado*

The general objectives of this research project are: 1. Define the geologic and hydrologic parameters that control the movement and storage of water in limestone and related rocks. 2. Determine the importance of primary and secondary porosity and permeability in limestone and related rocks, and of folding, faulting, and jointing to the development of solution cavities and their enlargement. 3. Determine the spatial relationship of caverns and secondary porosity and permeability and relate these to structural, geomorphic and other factors. 4. Determine sources of acid which may be instrumental in solution of limestone and related rocks. 5. Develop instruments and techniques needed to get answers to the numerous questions which remain to be solved regarding hydrology of limestone and related rocks.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0202, HYDROLOGY OF ARKANSAS RIVER VALLEY, CANON CITY TO STATE LINE

O.J. TAYLOR, U.S. Dept. of Interior, Water Resources Division, *Denver, Colorado*

This research is part of the program of water resources investigations conducted by the U.S. Geological Survey in cooperation with the State of Colorado. The irrigation systems in the Arkansas Valley have grown haphazardly around surface supplies and storage. Irrigation supplies are largely derived from surface water that varies in amount appreciably with climatic conditions. The existing irrigation systems do not supply adequate amounts of water throughout the year to all irrigated lands. Water development projects in the valley have had little concern for a systematic evaluation of the total water supply.

This project involves (1) the measurement of the effects of the present water-management practices on the hydrologic regime, (2) determination of the relation between pumpage of ground water and streamflow, and (3) a study of the management changes that could increase the supply and improve the quality.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Colorado State Government

2.0203, PROJECT SKYWATER - NEW MEXICO

J.N. WASHICHEK, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Object of the snow survey program is the gathering of snow and precipitation data in the Jemez Mountain Range of New Mexico.

Eight snow courses, established prior to this project, will be read every ten days by manual methods. An additional band of 8 snow courses and 8 precipitation gages will be installed along Highway 126 east of Cuba. This winter, these will also be measured manually.

A new type precipitation gage is eing developed for this project. Instead of the dip stick or standard weighing methods, a load cell will be used. These stations can be readily converted to an automatic gage if desired.

One automatic telemetered station may be activated near the center of the sector. This station will have an automatic snow pillow sensor and an automatic precipitation gage. Telemetry will be to base station, located in the area.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0204, PROJECT SKYWATER - COLORADO - STEAMBOAT SPRINGS

J.N. WASHICHEK, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Object of the snow survey program is to collect snow data on the Park Range. There are now 24 snow courses ranging in elevation from 6,750' to 10,700' that are being measured. Numerous methods are being employed. Manual methods, employing snow tubes and scales, automatic sensors (pillows), and precipitation gages.

Six automatic sensors are in operation. These utilize onsite recorders as well as radio telemetry to a base station in Steamboat Springs. The base station has a visual read out as well as paper punch tape.

The on-site recorder is a modified A-35, designed to operate 6 months without attendance. It up-dates every hour.

A transducer at the pillow converts the pressure to electrical resistance for measurement.

Several different type pillows and transducers will be employed to ascertain the most usable.

Standard precipitation gages that can be maintained at snow level are used and compared to other types of measurements. Precipitation cans with different size orifices will be checked.

Manual measurements are used as a cross check of all data.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0205, THE DEVELOPMENT OF SYNOPTIC CLIMATOLOGY AND STATISTICAL FORECASTING METHODS AND OROGRAPHIC PRECIPITATION

R. WHITE, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The following services to be provided: 1. The development of synoptic climatology and statistical forecasting methods and orographic precipitation. 2. Numerical dynamical circulation studies, including evaporation, cloud formation, and precipitation. 3. Case studies of storm types and associated precipitation patterns.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation
U.S. Dept. of Commerce - E.S.S.A.

2.0206, ATMOSPHERIC WATER RESOURCES RESEARCH

M.C. WILLIAMS, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The program is designed to investigate increasing water supplies in the Southern Sierra Nevada mountains of California and related regions through weather modification. Weather modification projects have been conducted in the general area considered for a number of years with the result that the effectiveness of cloud seeding as a means for production of increases of water supply of the order of ten percent has been accepted. The current program is thus designed to provide an engineering approach to investigations of the atmospheric parameters and mechanisms involved in an effort to extend and improve existing techniques. The program is composed of a series of projects designed to cover a period of five years. Specific projects within the overall program deal with hydrologic aspects, summer cumulus potential, winter storm potentials, seeding dispersal effects, and program design. Instrumentation is dealt with as a part of the individual projects.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0207, ECONOMICS OF GROUNDWATER DEVELOPMENT IN THE HIGH PLAINS OF COLORADO

P.W. BARKLEY, Colorado State University, Agricultural Experiment Sta. , *Fort Collins, Colorado* 80521

Objectives: 1. Evaluate on farm and off farm consequences of various patterns of ground water development in the High Plains region. 2. Examine effects of alternative economic criteria as aids in establishing an institutional framework for guiding or regulating ground water development.

Proposed Work: Field surveys will be conducted to determine adjustments occurring on individual farms as a result of ground water development. These individual farm adjustments will be aggregated to determine effects on communities in the High Plains area. Results of these two efforts will be used as an aid in exploring various institutional provisions for use in regulating development of this essentially stock resource.

SUPPORTED BY Colorado State Government

2.0208, DRYLAND SOIL MANAGEMENT

K.G. BRENGLE, Colorado State University, Agricultural Experiment Sta. , *Fort Collins, Colorado* 80521

1. To evaluate cropping systems, tillage practices and fertilizer use on dryland regions of Colorado. 2. To study soil-water-plant interactions, including evapotranspiration, in relation to yield and quality of dryland crops. 3. To study the effect of soil management practices on the soil properties affecting wind and water erosion in Colorado.

Field and controlled environment experiments will be conducted to study various aspects of dryland soil management as related to crop production. All experiments will be randomized and replicated.

Cropping sequence-fertilizer-tillage experiments will study the effect of these variables on crop production, water utilization and runoff, and soil properties affecting wind erosion.

Water use efficiency and fertilizer response will be studied in relation to yield and quality of crops.

Crop yields and soil moisture storage will be related to methods and timeliness of tillage in the fallow period, chemical evaporation retardants and precipitation.

SUPPORTED BY U.S. Dept. of Agriculture
Colorado State Government

2.0209, DIFFUSION OF ENTRAPPED GASES IN POROUS MEDIA

A.T. COREY, Colorado State University, School of Engineering, *Fort Collins, Colorado* 80521

Entrapped air can have an effect on several significant properties of porous media which (except for the entrapped air) are fully saturated with a liquid. Two of the most significant properties affected are permeability to liquid and compressibility of the bulk medium.

Two ways in which gas may become trapped are (1) by a liquid moving into an originally gas-filled medium and isolating some of the gas and (2) by gas coming out of solution in an originally fully saturated system to form gas pockets.

Among the situations in which entrapped gas may be significant are: (1) the invasion of a pocket of natural gas by surrounding brine in an aquifer when a well is installed to recover the gas, (2) seepage from an irrigation canal, especially in the period shortly after water has been turned into a dry canal, (3) the consolidation of partially saturated compressible soils under loading, (4) infiltration of precipitation or irrigation water into soil, (5) cavitation in the conducting vessels of plants during rapid transpiration, among other physiological processes in living organisms.

The objectives of this research are: A. To study the process whereby a gas in isolated pockets (surrounded by liquid) diffuses from porous media under the influence of interfacial energy. B. To develop and to test equations describing the rate of diffusion of entrapped gas from porous media.

2. WATER CYCLE

SUPPORTED BY U.S. National Science Foundation

2.0210, INFLUENCE OF IRRIGATION PRACTICES

R.E. DANIELSON, Colorado State University, Agricultural Experiment Sta., *Fort Collins, Colorado* 80521

To determine effect of methods of: application of irrigation water on moisture distribution, surface crusting, and plant emergence and growth; and, land preparation for irrigation and effect of subsequent tillage operations on soil tilth.

Description of Work: Field plots are used to evaluate the influence of soil structure deteriorating cultural practices on the growth and yield of various agronomic crops. Other factors effecting the crop are maintained as nearly uniform as possible. Soil physical measurements are made in an attempt to relate the physical status of the soil with plant response.

Laboratory investigations, pertaining to the ability of the plant to elongate its root system in a rigid system of given pore size, are included.

SUPPORTED BY U.S. Dept. of Agriculture
Colorado State Government

2.0211, WATER-SOIL-PLANT RELATIONS

R.E. DANIELSON, Colorado State University, Agricultural Experiment Sta., *Fort Collins, Colorado* 80521

Objectives: A. Investigate relationships between water stress in root medium and internal water status of plants as affected by environment and plant development.

B. Determine effect of plant-water stress and nutrients on morphology and metabolic processes determining growth and composition of plants.

Work Proposed: Plants will be grown under uniform and controlled conditions of environment until the desired vegetative growth has been obtained, at which time the water status of the plant tissue will be changed either by changing the water intake of the root system or by changing the evaporative potential of the foliar environment or both. Changes in the water intake by the root system will be obtained by using such methods as alterations in temperature, osmotic pressure, soil moisture suction, or carbon dioxide pressures. The evaporative potential of the foliar environment will be altered by changes in temperature, air movement, humidity, or light.

The water status of the plant tissue will be measured by one or more of the methods already developed or by new techniques developed as the investigation proceeds. The growth responses of the plant to the varied conditions under which it will be exposed will be measured. Such responses as rate of transpiration, not CO2 assimilation, dry weight increase, and concentration of simple sugars in the plant tissue will be evaluated.

SUPPORTED BY U.S. Dept. of Agriculture
Colorado State Government

2.0212, FACTORS INFLUENCING THE FLOW OF SUBSOIL WATER IN THE IMMEDIATE PROXIMITY OF, AND INTO DRAINAGE FACILITIES

N.A. EVANS, Colorado State University, Agricultural Experiment Sta., *Fort Collins, Colorado* 80521

Objectives: To analyze and describe the sub-surface flow of water and those factors which affect it in the immediate vicinity of the drain facility (tile line, ditch, drain well, etc.) for the preparation of improved criteria and procedures for design, installation and operation of drains.

Description: A full scale drainage model constructed at California under W-65 will be utilized to provide measured variables pertinent to flow toward a drain tile. The soil of the tank will be analysed to determine pore-size distribution and characteristic functional relationships between capillary pressure, saturation and permeability. A synthetic medium will be sought which will provide similitude as a model. The model behavior will be finally compared to the California model.

SUPPORTED BY U.S. Dept. of Agriculture
Colorado State Government

2.0213, MICROBIOL ADSORPTION IN SOILS

N.A. EVANS, Colorado State University, Agricultural Experiment Sta., *Fort Collins, Colorado* 80521

1. Investigation of factors affecting biological quality changes in water percolating through soils. Electrokinetic characterization of numerous media and micro-biological materials are made. Adsorption isotherms under both static and dynamic conditions will be measured and compared with theoretical isotherms developed from electrokinetic studies.

SUPPORTED BY Colorado State Government

2.0214, EFFECTS OF EARLY WATER ON WATERFOWL PRODUCTION

F.A. GLOVER, Colorado State University, Graduate School, *Fort Collins, Colorado* 80521

Waterfowl nesting and brood observations on the Monte Vista National Wildlife Refuge, correlated with records on water availability suggest that high waterfowl production occurs when water is available abundantly before the spring migration. This research project was designed to determine (1) what effect the application of water to a breeding area prior to the normal irrigation season will have on waterfowl production; (2) the cost-benefit ratio of an area that is supplied early water from supplemental sources as compared to an area which receives a normal supply of water during the regular irrigation season; and (3) the progress of ecological succession on the study areas during the course of the study and its effects on waterfowl production and use. The research is being conducted on two study areas on unit 6 of the Monte Vista National Wildlife Refuge in the San Luis Valley in south central Colorado.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

2.0215, HYDRAULICS OF SURFACE IRRIGATION

D.F. HEERMANN, Colorado State University, Agricultural Experiment Sta., *Fort Collins, Colorado* 80521

Objectives: To provide fundamental surface irrigation design understanding through the investigation of the hydraulic characteristics of surface flow: 1. By laboratory experiments to control certain variables in order to obtain relationships between variables. 2. By field investigations to test validity of mathematical equations and laboratory relationships.

Description: Field data will be collected on flow resistance in irrigation furrows from many sites covering a wide range of site and soil conditions. Application of spectral density analysis and similar new ideas to characterize roughness will be made. Flow mechanics thus formulated will be related to application efficiency.

SUPPORTED BY U.S. Dept. of Agriculture
Colorado State Government

2.0216, EVAPORATION FROM SOIL SURFACES AS AFFECTED BY SALT, STRUCTURE AND TEXTURE

W.D. KEMPER, Colorado State University, School of Agriculture, *Fort Collins, Colorado* 80521

Theory and equations governing the movement of water in response to salt concentration gradients in soils will be developed. Studies will be set up to test these theories and equations and to determine the portions of the water movement which are in the liquid and vapor phases.

The practical significance of this osmotic movement on evaporation will be studied. Reduction of the thickness of the dry layer of soil (which prevents liquid flow) is predicted when appreciable amounts of salt are in the soil profile. This prediction will be tested and equations, amenable to computer solution, will be developed from which quantitative predictions can be made.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Colorado State University

2.0217, PREDICTION OF WATER MOVEMENT IN UNSATURATED SOILS

W.D. KEMPER, Colorado State University, Agricultural Experiment Sta., *Fort Collins, Colorado* 80521

Objectives: 3. To delineate the influence of structure and electrostatic differences as well as solute concentration and energy gradients upon the movement of solutes, energy and water in soils and clays.

4. To devise quantitative expressions describing the simultaneous movement of water and solutes and energy in soil.

Procedures: Restriction coefficients of ions which determine the degree to which salts move water, will be determined in clay and soil systems. Effects of the electrostatic and geometrical properties of soil on these restriction coefficients will be determined from both experiment and theory. The mechanisms involved in the simultaneous flow of water, solutes, and energy will be delineated. The understanding of these mechanisms will be used in the development of thermodynamic equations valid for such simultaneous flow.

SUPPORTED BY U.S. Dept. of Agriculture
Colorado State Government

2.0218, HYDROMETEOROLOGY

W.E. MARLATT, Colorado State University, Agricultural Experiment Sta., *Fort Collins, Colorado* 80521

A. To investigate the wind structure on the high mountains. B. To investigate the actual occurrence of precipitation and the arrangements of precipitating clouds in relation to the mountains.

Description of Work: Initial work is concentrated on the period of winter build up of snow pack. Detailed observations of wind and temperature will be obtained from the top of one of the high mountain peaks during the winter to determine the turbulence structure of the atmospheres function of wind speed and durations.

SUPPORTED BY Colorado State Government

2.0219, A SYSTEMATIC TREATMENT OF THE PROBLEM OF INFILTRATION

H.J. MORELSEYTOUX, Colorado State University, School of Engineering, *Fort Collins, Colorado* 80521

The overall objective of the research is to develop a mathematical model of infiltration capable of responding to any spatial and temporal pattern of rainfall or its lack. In this form the model would be readily capable of integration into a general model simulating the hydrologic response of a watershed.

In a first phase the objectives will be more limited. In essence the two principal objectives are:(1) The development of a one dimensional model of water infiltration into a soil column under realistic conditions of varying water supply at the surface, nonuniform initial moisture conditions, heterogeneous soil characteristics and the effect of hysteresis, and (2) The development of a less general two-dimensional model of water infiltration to model primarily the influence of spatial variation of the available water supply on infiltration.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Colorado State University

2.0220, WIND EFFECTS ON THE DISPERSION OF PARTICULATE POLLUTANTS IN TURBULENT OPEN-CHANNEL FLOW

E.J. PLATE, Colorado State University, School of Engineering, *Fort Collins, Colorado* 80521

This is a study of the dispersion of solid particles in a liquid stream. The flow in the stream is turbulent with a free surface. Air is blown across the free surface in such a manner as to create waves in the water and thus to simulate the turbulence generated by wind over streams. A quantitative understanding is sought through experimentation for the effect of wind on the diffusion of particles in the water.

The results should lead to data which can be used in the solution of the diffusion equation in open channel flow with and without wind. A measure of the increase due to wind in diffusivity can be obtained in this way. The effect of wind on oxygen absorption in the stream is also to be investigated.

SUPPORTED BY U.S. National Science Foundation

2.0221, STRATTON SAGEBRUSH HYDROLOGY STUDY

R. PRICE, Colorado State University, U.S.D.A. Rky. Mtn. For. & Rge., *Fort Collins, Colorado* 80521

Objectives: To determine quantities and rates of runoff from rainfall and snowmelt, sediment movement and production,soil moisture regimes, sagebrush effects on snow accumulation of storage, etc., from watersheds in natural stands of big sagebrush and after treatment to eliminate sagebrush by chemical spraying; and to obtain other data necessary for the determination of hydrologic soil-cover complex numbers from sagebrush sites before and after treatment.

Procedures: Five small watersheds (100 or more each) will be selected within the big sagebrush vegetative type, representative of similar areas on which brush conversion by chemical treatment is a standard procedure. Each will be instrumented for climatic data, runoff and sediment yields, soil moisture and temperatures, etc. Detailed soil and vegetation samplings and measurements will be made. When satisfactory calibration has been obtained, one or more watersheds will be treated by chemical spraying and the studies will be continued until the effects can be determined.

SUPPORTED BY U.S. Dept. of Interior - Bu. Land Mgmt.

2.0222, ATMOSPHERIC WATER BALANCE AND THE FORECAST OF ANNUAL RUNOFF FROM THE UPPER COLORADO RIVER BASIN

J.L. RASMUSSEN, Colorado State University, School of Engineering, *Fort Collins, Colorado* 80521

The atmospheric water balance of the Upper Colorado River Basin will be evaluated to determine the net deposition of water over the basin during winter. This deposition will be compared with the annual runoff to determine a forecast equation. Periods of dryness will be investigated to study the large-scale evaporation occurring over the basin during winter and summer.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Colorado State University

2.0223, ATMOSPHERIC WATER

J.R. RASMUSSEN, Colorado State University, Natural Resources Center, *Fort Collins, Colorado* 80521

Nearly all of the runoff into the Colorado River for the principal water supply of the Southwestern United States comes from precipitation in form of winter snowfall over a very small fraction of the watershed area at high altitudes. Even there, however, runoff is only 50 percent and the other 50 percent of the snowpack evaporates, partly by windblowing of the snow over the expanse of tundra above timberline. If the wind driven snow could, in part, be channelled into now vacant glacial cirques east of the high ranges, it would be stored in depth at locations where exposure to sunshine is minimal. Even a moderately successful channelling scheme would greatly increase the available water supply, especially for the badly needed late season water delivery.

Feasibility studies for such channelling are underway in the laboratory and on a mountain in central Colorado, where experimental fencing designs have been erected for a preliminary look in the 1965-66 winter. A more elaborate experiment is planned for the succeeding winter.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Colorado State University

2.0224, REAERATION IN OPEN CHANNEL FLOW

W.W. SAYRE, Colorado State University, U.S.D.I. Water Rsour. Div., *Fort Collins, Colorado* 80521

2. WATER CYCLE

The capacity of a body of flowing water for assimilating biodegradable wastes depends heavily on the supply of dissolved oxygen which is required for the decomposition of organic material by bacteria. The amount of oxygen available for this purpose in turn depends on a complex balance among a number of processes which include various sources and sinks, and also the inflow and outflow of dissolved oxygen by convection. The principal sources augmenting the dissolved oxygen supply are atmospheric reaeration, and photosynthetic production by aquatic organisms, mainly green plants. Typical sinks depleting the supply, some of which are due to man-made pollution, are respiration of bacteria and algae, benthal deposits, and chemical oxidation.

The oxygen balance can be described qualitatively by a fundamental continuity equation. Before this equation can be used with confidence for predictive purposes, however, much remains to be learned about the source and sink processes, how they relate to one another, and how they relate to measurable physical and biochemical characteristics of a stream system.

This project is concerned with investigating the reaeration process in open channel flow, with particular emphasis on natural surface reaeration. Although no fundamental research on the biochemical processes involved in the oxygen balance is contemplated, they must be accounted for.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0225, STABLE ALLUVIAL CHANNELS

H.W. SHEN, Colorado State University, School of Engineering, *Fort Collins, Colorado* 80521

The proposed research is an analytical and experimental study of alluvial channels. The objectives are to study: 1. The shear distribution on the rigid boundary of channels with different cross section shapes. 2. The ultimate stable cross section shapes of alluvial channels under different hydraulic conditions and sediment sizes without sediment inflow based on the variation of shear distributions along the boundary. 3. The effects of sediment load, seepage force and flood plain material on the ultimate stable channel cross section. 4. The application of the results obtained from laboratory studies to explain the fluvial morphology of rivers.

SUPPORTED BY U.S. National Science Foundation

2.0226, EFFECTS OF FIRE ON HYDROLOGY AND EROSION

W.D. STRIFFLER, Colorado State University, Agricultural Experiment Sta., *Fort Collins, Colorado* 80521

Objectives: 1.) to determine the amount and timing of downslope soil and ash movement. 2.) to determine the effects upon the physical and chemical characteristics of the soil. 3.) to determine the effects upon the hydrologic characteristics of the slope. 4.) to establish a series of permanent sample plots for an evaluation of vegetative re- establishment.

Procedures: A series of plots will be established within and adjacent to the burn area with plots located at upper, middle, and lower slope positions. Measurements to be taken at each plot will include soil loss, soil moisture, infiltration rates, and soil samples for physical and chemical analysis. Analysis will primarily be a comparison of measured properties between burned and unburned plots by slope positions. In addition sediment measurements will be taken during storm runoff periods from a small stream flowing through the burned area.

SUPPORTED BY U.S. Dept. of Agriculture

2.0227, LAMINAR AND TURBULENT FLOW OF FLUIDS THROUGH POROUS MEDIA

D.K. SUNADA, Colorado State University, School of Engineering, *Fort Collins, Colorado* 80521

The proposed study will be devoted to the development and verification of a general theory describing compressible and incompressible fluid motion in porous media. The theory will be based upon an analysis of the classical Navier-Stokes equations for fluid motion and upon considerations of energy dissipation due to laminar and turbulent action. The physical parameters of the porous medium which affect the flow phenomena will be analyzed by statistical methods and correlated with hydraulically measurable quantities.

SUPPORTED BY U.S. National Science Foundation

2.0228, THE EFFECT OF VARIOUS COMMERCIAL FERTILIZER PLACEMENTS AND IRRIGATION PRACTICES ON THE YIELD AND QUALITY OF RUSSET BURBANK POTATOES

J.G. WALKER, Colorado State University, Agricultural Experiment Sta., *Fort Collins, Colorado* 80521

Objectives: 1. Compare various combinations of fertilizer placements and irrigation on optimum yield and quality. 2. Determine the effect of treatments on nitrate-nitrogen movement, moisture distribution, temperature on the uptake of N and P by the potato plant.

Procedure and Description: The study will be undertaken in San Luis Valley of Central Colorado. Fertilizer treatments will be banded at planting time 4' wide beside or below seed piece with irrigations made on every furrow or every other furrow for comparisons. Tensiometers and thermograph recordings will be made. Soil and leaf samples will be correlated to determine amount of N and P. Soil profiles will be developed as part of this study.

SUPPORTED BY Colorado State Government

2.0229, GEOHYDRAULICS AT THE UNCONFORMITY BETWEEN BEDROCK AND ALLUVIAL AQUIFERS

J.P. WALTZ, Colorado State University, Graduate School, *Fort Collins, Colorado* 80521

The proposed research is to develop principles and methods for estimation of water transfer at bedrock-alluvium contacts in groundwater basins.

Fundamental to the concept of an alluvial basin is the isolation of water. That is, neither surface water nor groundwater should flow from one basin to another. If groundwater basins can be designated such that water transfer is minimized, then it is feasible to determine availability of water in each basin and to develop laws and management policies for water use.

Three designated groundwater basins in Colorado will be studied to determine the magnitude of water flux into or out of the underlying bedrock. Considerable data are available on bedrock and water level elevations within each of the three basins.

Procedures for the study will include: use of digital computer models and trend surface analyses, piezometric studies in both bedrock and alluvial aquifers, and general geologic and geophysical techniques.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Colorado State University

2.0230, SEDIMENT PRODUCTION, YIELD, & DELIVERY RATIO IN RELATION TO CLIMATIC, GEOLOGIC, & WATERSHED CHARACTERISTICS OF THE NORTHERN PLAINS

D.A. WOOLHISER, Colorado State University, School of Engineering, *Fort Collins, Colorado* 80521

Object: To develop procedures for predicting the sources, amount, and rate of gross erosion; character of sediment yield; and delivery from agricultural watersheds of varying sizes in principal physiographic and climatic regions.

Plan of Work: Information on quantities of sediments carried by streams is obtained by means of reservoir sedimentation surveys and through suspended load sampling on selected watersheds. Records of precipitation, runoff, topography, channel characteristics, soils and geology, land use, conservation practices, and watershed treatment measures are compiled for the areas for which sediment yield records are available. Studies are made to determine and evaluate the processes and rates of erosion on land surfaces including gullies, roadbanks, and stream channels. Radioactive elements and other tracers are used in a studying the movement of sediment from erosional sources to points of deposition. Required instrumentation is developed. Data on sediment yield rates and associated casual factors are analyzed and interpreted to derive improved techniques and equations for estimating sediment yield and sources in ungaged watersheds.

SUPPORTED BY U.S. Dept. of Agriculture

2.0231, FLOODS FROM SMALL WATERSHEDS

V.M. YEVDJEVICH, Colorado State University, School of Engineering, *Fort Collins, Colorado* 80521

The flood response of rural watersheads within the size range of one-fifth to fifty square miles distributed throughtout the United States is being studied. Three complementary approaches are to be pursued simultaneously. Systems investigations will be undertaken with theoretical conditons involving rainfall as input and runoff as output. Hydrodynamic prototypes will be investigated by applying artifical rain to a one-to-two acre outdoor facility. Provisional results from both of these will be checked against, and appraised in the light of, storm and flood events observed in nature on many experimental and other watersheds. This latter data assembly, which is already underway, will itself facilitate statistical and hydrological analyses of natural basin response. July 1965 is the starting date for the five year program.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Colorado State University

2.0232, EXPERIMENTAL INVESTIGATION OF SMALL WATERSHED FLOODS

V.M. YEVDJEVICH, Colorado State University, School of Engineering, *Fort Collins, Colorado* 80521

Project Objectives: The design, construction and operation of a rainfall-runoff experimental facility, one acre in size, for the purpose of observing prototype-scale response of a watershed under controlled conditions. The general objectives are to increase the understanding of processes making up watershed response and to improve our ability to apply knowledge of the processes to the estimation of the response of real watersheds.

Work Description: The work proposed for the Rainfall-Runoff Experimental Facility is as follows: 1. Design and construction of the facility including site preparation, water supply system, runoff measuring system and rainfall simulators. 2. Experimental program of rainfall-runoff pattern studies for a given range of precipitation intensities.

SUPPORTED BY Colorado State Government

2.0233, PHASE TWO - EXPERIMENTAL INVESTIGATION OF SMALL WATERSHED FLOODS

V.M. YEVJEVICH, Colorado State University, School of Engineering, *Fort Collins, Colorado* 80521

For Phase Two, the principle effort will include the completion of the rainfall-runoff experimental facility, and the testing of the facility to determine its operating characteristics and refining the design of the more critical components to provide more uniform conditions or more flexible operations if such appears appropriate. Initial test data will be used for some comparison studies with mathematical models. In particular, an evaluation will be made of the mathematical description of convergent overland flow on conical shaped catchments. An objective of this proposed research effort will be the completion of preliminary studies on some simple conceptual models to the point that some significant conclusion will be justified with respect to non linearities in the response of the total catchment or its component parts to rainfall.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Colorado State University

2.0234, SAN LUIS WATERSHED STUDY

E.F. ALDON, U.S. Dept. of Agriculture, Rocky Mtn. For. & Rg. Ex. Sta., *Fort Collins, Colorado*

Three small watersheds, about 58 miles NW of Albuquerque, New Mexico, of comparable size (WS I, 555 acres; WS II, 471 acres; WS III, 338 acres) and similar topographic, edaphic and climatic conditions have been investigated since 1952.

The primary objective of the study is to determine the effects of conservation and range management practices on the net yield of water, sediment, and forage. Controlled grazing, ripping, fertilization, and seeding have been studied.

The present agreement has been made for the period of July 1, 1967 until June 30, 1978, with the same primary objectives.

The objectives for 1968 FY are: a. Determine the vegetation density, production, and utilization as affected by a mechanical treatment, grazing, and protection grazing. b. Determine germination requirements of native grass species. c. Study effects of fertilization on ground cover density of flood plains. d. Determine factors affecting seedling survival.

SUPPORTED BY U.S. Dept. of Interior - Bu. Land Mgmt.
U.S. Dept. of Agriculture

2.0235, IMPROVEMENT OF WATER YIELDS BY MODIFICATION OF RADIANT ENERGY OVER LAND SURFACES (ABBREV)

B.C. GOODELL, U.S. Dept. of Agriculture, *Fort Collins, Colorado*

Object: To determine the amount of radiant energy available and that necessary to melt snow and to vaporize water from soil, plant, and snow surfaces; to explore means of altering the regimen of radiant energy by vegetative manipulation and snow surface modification.

Plant of Work: The project leader and his graduate student cooperators will continue to measure and relate to each other the various components of solar radiation, and albedo of various vegetative, soil, and snow surfaces. These will be studied in terms of their usefulness in estimating evapotranspiration, and how intercepted rain and snow changes net radiation. They will continue to refine a dye- dilution method of measuring streamflow.

SUPPORTED BY U.S. Dept. of Agriculture

2.0236, MECHANICS OF FLOW STRUCTURE AND FLUID RESISTANCE

P.S. MCQUIVEY, U.S. Dept. of Interior, Water Resources Division, *Fort Collins, Colorado*

The objective of this study is the exploration and measurement of the internal flow field of turbulent shear flow in an open channel in order to obtain a fundamental understanding of the mechanics of fluid resistance and sediment transport.

The study is designed to answer the following questions: 1. What are the measures of turbulent characteristics which best describe the structure of turbulence? 2. How can these measures of turbulent characteristics best be measured in open channel flow? 3. Will the selected measures of the turbulent characteristics and measurement techniques be adequate to permit experimental verification of the equation of motion for steady uniform flow in an open channel? 4. How does the structure of turbulence vary with respect to distance from the boundary for steady uniform flow in a wide open channel? 5. How are the turbulent characteristics related to mean flow properties, fluid properties, and channel geometry? 6. What are the effects of the properties of suspended matter (density, concentration and size) on the turbulent characteristics of open channel flow? 7. How are the lagrangian and eulerian measures of turbulent characteristics related?

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0237, EVALUATION OF VARIABLES IN ALLUVIAL CHANNEL FLOW

C.F. NORDIN, U.S. Dept. of Interior, Water Resources Division, *Fort Collins, Colorado*

The understanding of the mean flow parameters and channel adjustment characteristics for flow in alluvial channels is substantial, but complete understanding is limited by the large number of variables involved, their interdependency, interchange between dependent and independent variables with time and space, and limited scope of laboratory studies.

Laboratory studies will be broadened to (1) determine the mean flow parameters and channel adjustments when bed material transport is an independent variable; (2) determine the importance of depth, as a scale parameter and as a driving force; (3)

determine time for adjustment from one equilibrium flow to another when an independent variable is altered; (4) determine the variance of slope, depth, velocity, bed materials and bed forms in time and space.

of data on the known distribution of tropical bryozoan species with those of the Hawaiian Island species, and the assembling of data relevant to the question of endemism among bryozoans.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0238, MEADOW SOD MAT ACCUMULATION AND DECOMPOSITION

F.A. NORSTADT, U.S. Dept. of Agriculture, *Grand Junction, Colorado*

One project of mine deals with meadow sod mat accumulation and decomposition. Irrigated mountain meadows of Colorado buildup a sod mat 2- to 15 cm thick depending on altitude and soil water content. I am studying physical, chemical, and biological factors which are thought to affect the accumulation and decomposition of the sod mats. I am using electronic probes to instrument sites in the meadows that represent wet, dry, and intermediate soil moisture conditions to measure temperature, redox potential, oxygen content, and pH. A neutron probe measures soil water content. These measurements are at 3 depths in the soil profile. We are plating soil samples from the 3 moisture sites to measure the numbers of bacteria, fungi, and denitrifiers at 3 depths in the soil. These physical, chemical, and biological parameters will guide design of laboratory experiments. In the laboratory I am studying the effect of temperature, water content, and fertilizer amendments on the decomposition of sods by the indigenous soil microorganisms. In the sod decomposition study the evolution of CO2 is used as the index of mineralization of the carbon skeleton of the sod material.

SUPPORTED BY U.S. Dept. of Agriculture

2.0239, NUMERICAL SIMULATION OF THE MACROPHYSICAL AND MICROPHYSICAL PROCESSES OF MOIST CONVECTION

G. ARNASON, Travelers Research Center Inc. , *Hartford, Connecticut*

BRIEF DESCRIPTION OF PROPOSED RESEARCH: The main objective of the proposed research is to simulate realistically by numerical methods the conditions within and in the immediate surroundings of a convective, non-freezing cloud. A secondary objective is to form an opinion as to the feasibility of artifically modifying such a cloud and in particular to assess at which stage of development the cloud is most sensitive to an external stimulus. To obtain the above objectives it is necessary to include both the macrophysical and microphysical processes known to be important to cloud development in an effort to study in considerable detail all the major phases of the evolution of a non-freezing cloud. To do that it will be necessary to specify a realistic initial state; take into account the dynamics of the situation, excluding friction but including shallow convection; use bulk thermodynamic equations; distinguish between the mixing ratio of the vapor and liquid phases of water; specify an initial droplet distribution; use growth of the droplets though condensation and coalescence processes; and take into account the evaporation of the rain. The numerical solutions will be obtained by solving the systems of equations by finite differences. A mesh of 100m and a grid of 1,000 points will be used. Computational schemes of Lax-Wendroff and Lilly will be used. It is anticipated that in two years it will be possible to formulate the problem and to prepare and check out the computer program. It is possible that within the time period results may be obtained that show a realistic simulation of all phases of cloud development.

SUPPORTED BY U.S. National Science Foundation

2.0240, ESTIMATING RUNOFF RATES FROM SMALL RURAL WATERSHEDS

P. BOCK, Travelers Research Center Inc. , *Hartford, Connecticut*

In the design of culverts, better hydrological procedures, productive of more reliable results, are needed for estimating runoff from small rural watersheds. Reliable procedures will permit more confident selection of the flow to be accommodated and, with recent advances in hydraulic and structural design, should help to optimize the expenditures for drainage structures. Runoff information is being collected from selected small rural watersheds as well as information related to a better understanding of the phenomena involved in the generation of runoff from small drainage areas. A number of investigations have developed methods for synthetically determining maximum discharge and hydrograph definition in relation to the parameters exerting a major influence on runoff. With this background it now appears possible, by analyzing the information and interrelating functionally the major parameters affecting runoff, to develop computer programs, or other procedures, that will, upon definition of the various parameters involved, produce an estimate of the maximum discharges likely to occur from small rural watersheds for selected recurrence intervals. It is desired that the method developed will: (1) require only data that can be readily obtained by the designers, (2) use parameters and functional relationships which are logically justified, (3) take cognizance of differences due to geographical characteristics, and (4) present the information desired in a readily usable form.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Amer. Assoc. of State Highway Officials

2.0241, SOIL-PLANT-WATER RELATIONSHIPS

J.S. BOYER, Conn. Agric. Expt. Station, *New Haven, Connecticut* 06504

Description of Work: Psychrometric and pressure techniques for measuring water potential will be compared. Sites of resistance to water will be determined. Estimate water potential in shoots of several species by methods of Richards and Ogata and of Scholander et al., and compare results. Measure potentials in various parts of several plants and environments and infer where resistance to water lies.

SUPPORTED BY U.S. Dept. of Agriculture
Connecticut State Government

2.0242, STUDY OF LIGHT ISOTOPES IN LACUSTRINE ENVIRONMENTS

M. STUIVER, Yale University, Graduate School, *New Haven, Connecticut* 06520 (AT)

Objective: To obtain information on the changes in oxygen isotope ratio of atmospheric precipitation during post-glacial times. This information is obtained by determining O18/O16 ratios of carbonates deposited in lakes. The variations in this ratio are caused, amongst others, by changes in O18 content of atmospheric precipitation that are associated with long-term changes in climate. Also proposed is the determination of O18/O16 ratio of marine shells from the 12,000 years old Maine marine invasion. These ratios will be influenced by the freshwater contributions of glacial run-off and might possibly provide information on the O18 content of the former ice-cap.

SUPPORTED BY U.S. Atomic Energy Commission

2.0243, RELATION OF BEDROCK FRACTURE SYSTEMS TO UNDERGROUND WATER IN STAFFORD SPRINGS, SOUTH COVENTRY, SPRING HILL & WESTFORD QUADS

J.M. AITKEN, Univ. of Connecticut, Graduate School, *Storrs, Connecticut* 06268

Fractures represent one of the easiest avenues of ingress for groundwater penetrating bedrock. Such fractures are a product of regional deformation. Expansion of present structural studies is proposed which would emphasize detailed analysis of fractures (orientation; frequency-in numbers and spacing; projection of zones of possible intersection of depth).

The data obtained would provide information pertinent to problems of potential supply, questions of a typical or excessive flow-and potential contamination. The work would serve as training in recognition of bedrock structure as a factor in controlling supply and quality of water.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Connecticut

2.0244, RATE AND DIRECTION OF GROUND WATER CIRCULATION IN CLOSE SPACED BEDROCK AND GRAVEL WELLS UNDER THE INFLUCENCE OF NON-SYNCHRONOUS PUMPING TIME

L. FRANKEL, Univ. of Connecticut, Graduate School, *Storrs, Connecticut* 06268

Storrs, Connecticut is an urban area without a central water supply or sewage disposal facilities. Individual wells and septic tanks are utilized. With the gradual transformation of the area over the past twenty-five years from a rural community, with separation of homes by many acres, to an urban community with separation by less than 150 feet in many cases, has come the problem of well contamination.

Contamination has occurred in many situations where the topography, percolation indices, and hydraulic gradient are favorable to 'good' water and when there is separation of water supply and sewage disposal in accordance with state regulations. It is therefore suspected that contamination is the result of changes in the rate and direction of groundwater flow as the result of nonsynchronous and variable rates of pumping from closely spaced wells.

To test this hypothesis, well fields will be constructed and certain wells will be contaminated with nontoxic chemical and biological contaminants, and the rate and pattern of flow under natural conditions and pumping will be determined.

The end purpose of this project is to obtain data which might aid in determining before home construction occurs under what conditions (e.g., well depth, rate of pumping, distance of separation of water supply and sewage disposal) seemingly safe topographic and earth material situations can become areas of contaminant concentration.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Connecticut

2.0245, THE NATURE AND MAGNITUDE OF THE RESISTANCE TO FLOW OF WATER IN ROOTS

B.E. JANES, Univ. of Connecticut, School of Agriculture, *Storrs, Connecticut* 06268

This project is designed to obtain information needed to expand current theories on the nature and mechanics of water flow through semipermeable membranes of the root. Measurements will be made on the effect of (a) osmotic stress, (b) oxygen concentration, (c) temperature on transpiration of intact plants and exudation of decapitated roots.

SUPPORTED BY U.S. National Science Foundation

2.0246, EXPERIMENTAL STUDIES OF AIR AND WATER INTERFACIAL INTERACTION

J.D. LIN, Univ. of Connecticut, School of Engineering, *Storrs, Connecticut* 06268

The proposed research is an experimental study of the interaction on the air-water interface to be conducted in the Hydraulic Laboratory of Civil Engineering Department by utilizing most of the existing wind tunnel and instrumentation facilities. A test section, consisting of a wind tunnel over a channel of variable depth and of sufficient fetch, will be constructed for this investigation. The transient and equilibrium surface waves generated by various turbulent wind profiles with zero pressure gradient along the tunnel will be investigated. The turbulence in the wind and possibly in the water will be measured in addition to the mean quantities and the surface wave spectrum as previously studied by other investigators. The wind generated wave theories and previous experiments under somewhat different conditions will be examined. The correlation of experimental data among the wind, waves and water should provide a basic understanding and the mechanism of disperson, mixing and perhaps diffusion of contamined surface water or pollutant spreading over the surface of water under the action of turbulent wind.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Connecticut

2.0247, MEASUREMENT AND ANALYSIS OF NATURAL-TYPE SURFACES AFFECTING FLUID FLOW

C.J. POSEY, Univ. of Connecticut, School of Engineering, *Storrs, Connecticut* 06268

Measurements of natural surface roughness (which have already been used in some hydraulic friction experiments in preference to geometrical roughnesses) will be made with special micrometer equipment and recorded on tape or punch-cards which will then be analyzed for slope and curvature distributions with the aid of the computer program developed in the Connecticut Institute of Water Resources project 'Analysis of Quasi-Periodic Weather Data.'

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Connecticut

2.0248, OXYGEN STATUS OF SOIL AIR AND SOIL WATER AS INFLUENCED BY OXYGEN TRANSFER THROUGH THE SOIL PROFILE

R.W. WENGEL, Univ. of Connecticut, School of Agriculture, *Storrs, Connecticut* 06268

The purpose of this research will be to investigate and define those factors affecting the diffusion and mass transfer of oxygen through the soil profile with particular emphasis on the resultant oxygen status of water moving laterally or downward toward the ground water system.

The factors to be investigated are: soil air-space porosity distribution over the soil moisture release characteristic, oxygen sink sources within the soil profile and their relative importance in oxygen consumption, and the mass transport of oxygen during infiltration.

Soil porosity and soil water will be determined using standard pressure plate and pressure membrane technique. Gaseous oxygen in the profile will be determined from diffusion chamber samples by gas chromatography. Dissolved oxygen will be determined by polarographic techniques on soil water samples during periods of saturation and by oxygen solubility calculations based on gas-liquid phase equilibria during periods of unsaturation.

The quantitative measurement of oxygen transfer and utilization in soil will have application in studies of: oxidation-reduction reactions in the lower soil profile, potential conditions for biological oxidation of soluble organic contaminants in soil water, and soil oxygen supply characteristics for subsurface oxidation of organic wastes such as those from small septic systems.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Connecticut

2.0249, FLOW OF A ROTATING FLUID OVER IRREGULAR SURFACE TOPOGRAPHIES

D.L. BOYER, Univ. of Delaware, School of Engineering, *Newark, Delaware* 19711

The objectives of this work are (1) to develop analytic solutions and (2) to conduct experimental investigations of the flow past arbitrarily shaped obstacles located on both the lower and the upper surfaces of two 'infinite' horizontal planes in a rapidly rotating system.

The necessary flow conditions can be realized experimentally by pumping fluid through a rapidly rotating rectangular channel whose horizontal dimension is large compared to the obstacle dimensions. A series of experiments will be conducted to establish a critical range of Reynolds and Rossby Numbers for which Taylor Columns are formed. An effort also will be made to determine the flow pattern for the various regimes of Reynolds and Rossby Numbers for which the phenomenon does not occur.

The physical systems will be investigated under two regimes, Ro/Re is less than 1, where Ekman type boundary layers occur along the solid boundaries and (Ro Re)1/2 is less than 1 where inertia terms may be neglected everywhere.

2. WATER CYCLE

SUPPORTED BY U.S. National Science Foundation

2.0250, FLUSHING PATTERN OF CERTAIN TIDAL STREAMS IN DELAWARE

F.C. DAIBER, Univ. of Delaware, Graduate School, *Newark, Delaware* 19711

Our various biological and hydrographic investigations within the tidal creeks adjoining Delaware Bay over the past years point up the need for a more thorough knowledge of the circulation patterns and other hydrographic features within these tidal creeks. This information will identify the location and volume of fresh water during various tidal and seasonal conditions. Such information is of value in selecting sites and times for withdrawal of water for irrigation, farm and industrial usage. It has implications in terms of domestic and industrial pollution and health, transport of plant nutrients from coastal marshes and survival of eggs and larvae of fish and shellfish. This study could serve as a model for study of creeks of other sizes and magnitude of tributaries. This work is to begin in fiscal year 1967 and terminate at the end of fiscal year 1969.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Delaware

2.0251, CLIMATE OF THE NORTHEAST - ANALYSES & RELATIONSHIP TO PLANT RESPONSE (NE-35

D.J. FIELDHOUSE, Univ. of Delaware, Agricultural Experiment Sta., *Newark, Delaware* 19711

To analyze available meterological data to determine frequency distributions of climatological variables and probabilities of occurrence of certain weather patterns likely to influence plant culture. Determine relationships between macro and micro climatic variables influential in crop production. Analyze records on crop response, spread of plant diseases, and severity of insect infestations and determine if relationships exist with available meterological data. Determine by field observations, climate measurements and detailed experimentation direct influence of climate on plant growth, diseases, insect pests and efficiency of crop treatments.

Description of Work: To analyze the Delaware weather records according to procedures developed in the Northeast to determine heating degree days, growing degree days, drought probabilities and other similar analyses important to agriculture.

To determine the response of snap beans to variations in soil and air temperature and to the cultural practices such as irrigation, foliar sprays and mulches which affect these radiation dependent climatic variables.

SUPPORTED BY U.S. Dept. of Agriculture
Delaware State Government

2.0252, WATER ABSORPTION BY ASPARAGUS

D.J. FIELDHOUSE, Univ. of Delaware, Agricultural Experiment Sta., *Newark, Delaware* 19711

This project will contribute toward objective 2 of the Regional project. 2. To determine the influence of plant and environmental variables upon water extraction from the soil profile.

The Delaware Station will determine the effects of spray mulches, stage of growth, growth retardants (which alter plant size and physiological age) and precision tillage on the water extraction patterns of vegetable crops. Precision tillage refers to the creation of a deep tillage zone in close proximity to the intended drill row.

SUPPORTED BY U.S. Dept. of Agriculture
Delaware State Government

2.0253, MORPHOLOGY AND HYDROLOGY OF PLEISTOCENE DEPOSITS, DELAWARE

J.J. GROOT, Univ. of Delaware, Graduate School, *Newark, Delaware* 19711

This project will: (1) attempt to determine ways by which Pleistocene buried channels can be detected and reconstructed in the Coastal Plain of Delaware, (2) determine the hydrologic characteristics of the channel sediments and the amount of ground-water pumping such channels will sustain.

Pleistocene stream channels are rather common in most areas of the country that bordered the former Pleistocene ice sheets. Where present, such channels are usually an excellent source of ground-water both from the standpoint of quantity and quality. Ordinary seismic and drilling techniques are generally quite successful in locating channel deposits in area of consolidated bedrock where the lithologic contrast between bedrock and channel sediments in great. However, in Coastal Plain areas, the channel deposits are similar in nature to the adjacent sediments and detection by any single means becomes quite difficult. Furthermore, no overall theory regarding channel formation and subsequent erosional modification guided previous attempts in locating channels. This study will use a combination of methods in locating channels based upon a theory of formation and erosional history recently worked out by one of the investigators.

A pilot area containing known Pleistocene channels will be studied in detail using drilling and resistivity techniques in the field. Extensive examination of core samples will be undertaken in the laboratory. Following field exploration, pump tests will be run to determine the potential ground-water yield of the channel system. The overall conclusions will be checked against the theory and the methods advised will finally be tested in other areas of the State.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Delaware

2.0254, THE GROUND-WATER FLOW SYSTEM IN THE DELMARVA PENINSULA

R.D. VARRIN, Univ. of Delaware, Water Resources Center, *Newark, Delaware* 19711

This study has as its prime objective a thorough understanding of the ground-water flow system in the Delmarva Peninsula. The geological data on the properties and distribution of aquifers and non-aquifers have been summarized in cross-section form. The basic data on the factors of the water balance-evapotranspiration, water surplus, runoff, soil moisture storage--have been calculated from the analyses of more than 60 years of temperature and precipitation records from three representative stations on the peninsula. The water balance calculations and geologic data have been used as input information in the design and operation of analog models.

Two viscous-flow analog models have been constructed: (1) a vertical model to determine the nature of ground-water discharge to Delaware Bay; and (2) a horizontal model to determine the effect of pumping from multiple-aquifer wells. Based on the results of the viscous-flow analog tests and numerous field studies in Delaware, an electric analog model of the northern portion of the Delmarva Peninsula has been designed and constructed.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Delaware

2.0255, STREAM VALLEY ASYMMETRY IN AN ARCTIC ENVIRONMENT-CONDITIONS GOVERNING GEOMORPHIC PROCESSES 7360

M.A. MELTON, Arctic Inst of North America, ***Washington**, District of Columbia*

The study is to investigate the geomorphology of the small west-trending valleys in high latitudes to establish (1) whether or not these valleys exhibit any consistant asymmetry in their valley-side slopes, and (2) whether any asymmetry is more the product of microclimatic differences across the valleys or is the result of the behavior of the stream. Field methods and sampling designs are expected to allow an objective estimate of the relative importance of the various controls on valley asymmetry, from which comparisons can be made with other climates in which stream valley asymmetry has been observed.

The investigation was conducted in a number of small east-west trending valleys in the Caribou Hills area, east of the MacKenzie River. Final analysis of data and synthesis has been accomplished at the University of British Columbia and the following final report has been submitted to the Army Research Office - Durham (Environmental Sciences Division), Box CM, Duke Station, Durham, N. C. 27706: 'Stream Valley Asymmetry in an Arctic-Subarctic Environment - Conditions Governing the Geomorphic Processes' by Barbara A. Kennedy and Mark A. Melton, 1 June 67 - 31 May 68.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0256, A STUDY OF TECHNOLOGIES FOR REDUCING WINTER WEATHER COSTS

A.G. RONHOVDE, Arctic Inst of North America, *Washington, District of Columbia*

The purpose of the study is to identify promising means to minimize and reduce the costs and negative effects of winter weather on economic growth and development.

The study will apply particularly to the New England area, the Upper Great Lakes Region, and to Alaska. However, the study will have application to the whole northern tier of states and to other areas which have severe winter weather.

The study will aim to identify and evaluate technological, engineering, scientific and economic techniques and programs whose application would give promise of reducing the costs of winter weather and thereby of economic benefit to affected regions.

It also will seek to identify and evaluate those research and development programs which can beneficially be applied in the near future, and to indicate subject areas where additional research and development would give promise of positive, short-term results.

An attempt will also be made to forecast for the next five to twenty years the major technological developments which may be expected to aid in achieving winter weather costs reductions.

In arriving at recommendations it will be necessary also to evaluate cultural, psychological and political impediments which may hamper application of identified technologies.

SUPPORTED BY U.S. Dept. of Commerce - Econ. Dev. Adm.

2.0257, RELICT COPEPODS FROM LAKE TUBORG, ELLESMERE ISLAND

T.E. BOWMAN, Smithsonian Institution, *Washington, District of Columbia* 20560

Identification and enumeration of 2 spp. of calanoid copepods collected in a plankton tow in partly brackish Lake Tuborg. Both species are not now known from coastal waters of the Canadian Arctic islands, and are believed to be relicts of a formerly more widespread brackish water fauna now restricted mainly to Siberian Arctic coastal waters. Suggestions concerning their origin in Lake Tuborg are given, using information on the age of the lake determined by C14 dating of the lake water carbonates.

SUPPORTED BY Smithsonian Institution

2.0258, MECHANICS OF WAVE ACTION IN DEEP AND SHALLOW WATER

T. SAVILLE, U.S. Army, Coastal Engin. Res. Center, *Washington, District of Columbia* 20016

Studies are made in both laboratory and field to determine the characteristics of all types of waves (tsunamis, standing waves, harbor surges, etc., as well as normal ocean gravity waves), and the change in these characteristics as the waves approach shore over a shoaling bottom of varied characteristics, and finally break. Study also involves such phenomena as wave set-up and longshore currents which are generated by wave action. The mechanics and kinematics of these waves are also studied. Breakers and surf, and the reforming of waves after breaking are included in this study.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0259, MECHANICS OF SAND MOVEMENT BY WAVES

T. SAVILLE, U.S. Army, Coastal Engin. Res. Center, *Washington, District of Columbia* 20016

Investigations will be made of the mechanics of sand movement by waves by studying experimental models in a laboratory, by making field measurements and observations, and by analytic theoretical work. Laboratory tests will involve the basic mechanics of sand grain movement under wave action, studying individual grain stresses and movement; data will be obtained in both the field and laboratory on the quantitative movement of sand by waves for different shore configurations, and attempts will be made to relate these to incident wave and current conditions; field measurements will be made of the basic mechanics of sediment transport, particularly by the use of labeled sand grains which can be followed and identified over some distance of movement; the effect of various types of structures on sediment movement will also be examined.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0260, CORRELATION OF BEACH PROPERTIES AND INCIDENT WAVES

T. SAVILLE, U.S. Army, Coastal Engin. Res. Center, *Washington, District of Columbia* 20016

Study is being made, in both field and laboratory, of the relationship between beach properties (including profile as well as sediment properties) with incident wave and water level conditions. Study also involves the effect of structures in affecting changes in these characteristics.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0261, HYDRAULICS AND DYNAMICS OF ESTUARIES

T. SAVILLE, U.S. Army, Coastal Engin. Res. Center, *Washington, District of Columbia* 20016

Hydraulics and dynamics of inlets and estuaries, including both flow and sedimentation and erosion processes will be studied in models and the field, with theoretical analysis. Estuarine erosion as a result of wave action and high water levels will be a specific part.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0262, WAVE RECORDING AND ANALYSIS

T. SAVILLE, U.S. Army, Coastal Engin. Res. Center, *Washington, District of Columbia* 20016

A cooperative surf observation program with U. S. Coast Guard collects visual data on surf height, period, direction, and type of breaker at 16 U. S. Coast Guard stations. Statistical compilation is planned.

Recorded wave data are also collected at a number of locations along U. S. Coasts, and an automated system is under development.

Work is on a wave direction gage using a rotating sonic current meter as the indicator and a damped Rayleigh disc is underway.

Pressure records are also planned for obtention at a station at 70' and 35' depths directly under the present relay type gage to obtain data on changes in pressure as related to the depth of the gage and period of the waves.

Standardized analytical methods for engineering use are being developed. New types of gages (such as radar, sonar, and laser) are being studied.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0263, STABILIZATION OF SHORES BY GROINS AND JETTIES

T. SAVILLE, U.S. Army, Coastal Engin. Res. Center, *Washington, District of Columbia* 20016

Groin fields of varying design will be tested in a model basin under varying conditions of wave attack and degrees of groin fullness. Amount of sediment passing the field will be trapped and measured. Initial tests involve measurement of material prior to groin installation to establish the littoral regime along an unencumbered beach.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0264, METHODS OF BYPASSING SAND PAST INLETS

G.M. WATTS, U.S. Army, Coastal Engin. Res. Center, *Washington, District of Columbia* 20016

Data are collected and compiled at all known places where by works of man, sand is passed across natural or improved inlets of the shoreline. Such works presently include:)a) offshore breakwater and lee sand-trap to be periodically emptied by floating hydraulic dredge plant; (b) fixed pumping plant and pipe line system at jettied inlet to provide continuous bypassing; (c) periodic dredging with floating hydraulic dredge plant in overly-widened channel in a jettied inlet; (d) weir-type jetty and retention basin to be periodically emptied by floating hydraulic dredge plant; and (e) mechanical removal and transport by truck haul from updrift accumulation to downdrift eroded area at a fixed littoral barrier. Quantitative and qualitative data, both physical and economic, are to be compiled and analyzed with the view toward development of relationships which will serve as guide lines or criteria in the design of sand transfer systems.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0265, GENERAL CIRCULATION - NUMERICAL MODELING OF PRECIPITATION

J. SMAGORINSKY, U.S. Dept. of Commerce, Geophysical Fluid Dynam. Lab., *Washington, District of Columbia* 20004

A long term numerical integration of a moist general circulation model utilizing the global grid system developed by Kurihara is in progress. Preliminary results show realistic features of the atmospheric circulation. For example, easterlies which predominate in the summer stratosphere, and the world-wide distribution of rainfall are in agreement with observations. A long-term integration of the same hemispheric moist model but with the horizontal resolution doubled produced values of the poleward transport of heat and momentum by large scale eddies which were closer to observed values.

Sophisticated primitive models of the atmosphere and oceans have been combined, creating a single interactive model of the atmosphere- ocean system. Interaction is through the exchange of momentum, heat, and the excess of evaporation over rainfall. This model will be used to study (a) the evolution of climate, (b) the possibility of very long range weather predictions, and (c) the climatic effects of artificial or inadvertent weather modification.

The large-scale hydrology of North America (east of the Rockies) covering a 5-year period was studied utilizing Travelers Research Center's analyses of some of the variables. Computations were made of mean monthly values of evapotranspiration, streamflow runoff, precipitation, atmospheric water vapor flux divergence, and surface and subsurface water storage changes. In progress is a study aimed at describing in detail the characteristics of the longitudinally averaged water vapor flux of the Northern Hemisphere, on a mean monthly basis.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.0266, NUMERICAL PREDICTION OF CLOUDINESS AND PRECIPITATION

J.D. STACKPOLE, U.S. Dept. of Commerce, Development Division, *Washington, District of Columbia* 20233

A study was initiated to incorporate a moisture parameter in the hydrodynamic forecast model presently in use at the National Meteorological Center. The study is a sub-project of a larger effort which deals with baroclinic modeling with the primitive equations of atmospheric motion. The experience gained with the present-NMC moisture prediction model will be utilized as much as possible, but some generalization is necessary to permit latent heat feed-back into the forecasts of motion and mass fields. The more exact approach to the problem is expected to yield improved forecasts of cloudiness and precipitation. The project continues in FY68 with corrections or modifications of the model controlled by feedback from operational runs.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.0267, CLOUD AND PRECIPITATION FORECAST MODEL

J.D. STACKPOLE, U.S. Dept. of Commerce, Natl. Meteorological Ctr., *Washington, District of Columbia* 20233

Objective - This project has as its principal aim the development of more accurate forecasts of cloudiness and precipitation. The study is a sub-project of a larger effort (baroclinic modeling with the primitive equations) devoted to improve forecasts of all parameters in the atmosphere; and thus, its applications and relevance to agency goals are consistent with the larger project. A subordinate goal of the project is to provide information on latent heat generation in the atmosphere. Such information is expected to improve the accuracy of the primitive equation model forecasts.

Approach - The experience gained with the present NMC precipitation model has been used in the development of the new approach. Moisture is considered in a single layer in the lower-half of the atmosphere. The criterion for condensation is based on a flexible bound of mean relative humidity in the layer. Problems in obtaining automatic analysis of moisture field could slow progress.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.0268, REMOTE SENSING OF ESTUARINE WATER AND VEGETATION, MARYLAND

R.R. ANDERSON, U.S. Dept. of Interior, Water Resources Division, *Washington, District of Columbia*

Purpose: To determine which film or film-filter combinations will provide the most information in aerial reconnaissance of estuaries ecosystems.

Methods: Correlate physical and chemical aspects of the estuarine environment with photographic and imaging characteristics on various types of films. The ultimate goal of the project is to be able to identify major plant communities associated with estuaries and evaluate water quality conditions both directly and indirectly using indicator plant species as a guideline.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0269, INVESTIGATION OF WATER RESOURCES IN ALASKA

V. BERWICK, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242

Additional crest stage gages are being installed as part of a program to define the hydrologic relations of the small streams of Alaska. The 20 new gages will bring the in place total to 80 out of an ultimate minimum of 150. Operation of the existing gages is included in the project.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Alaska State Government

2.0270, DRAINAGE AREA FLOW RESEARCH

F. BONER, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242

The magnitude and frequency of flows from small drainage courses is being investigated.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Montana State Government

2.0271, PERMEABILITY DISTRIBUTION AND SEDIMENTATIONAL FEATURES

J. BREDEHOEFT, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242

The research effort is directed toward studying what might be called 'petrophysics' in which the aim is to determine principles of the functional nature of permeability distribution as related to lithology, sedimentational processes, etc. Although the problem is complicated by the fact that the resulting sedimentational features (permeability distribution in an aquifer systems) were produced by countless hydraulic systems--no one of which can be measured now--the problem seems amenable to at least some understanding through statistical analysis and electronic computer techniques.

The major objective of the permeability research is to determine the factors and relationships that govern permeability distribution so that the physical characteristics of entire natural systems can be predicted by indirect evidence. It is proposed to develop geologic methods by which rock characteristics, as determined by sedimentational stratigraphic features, can be utilized to

predict permeability distribution and the geometric form of the components of natural water systems.

Two naturally occurring hydrologic systems have been used as 'field laboratories' in which to test the conceptual ideas. Much previous research has been carried out using the Tensleep sandstone aquifer system in the Big Horn Basin, Wyoming. Investigation of the Carrizo sandstone, a coastal plain aquifer of Texas, which will be used as a second field laboratory, is now beginning.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0272, BASIC RESEARCH IN GEOMORPHOLOGY AND HYDROLOGY

C.W. CARLSTON*, U.S. Dept. of Interior, Water Resources Division, *Washington, District of Columbia

'Underfit' streams occur where local valley widening permits the streams to develop unconstricted free meanders. The Driftless Area of Wisconsin contains extremely 'underfit' streams whose flood intensities and resultant meander wave lengths and belt widths have been greatly reduced by the high storage capacity of glaciofluvial and glaciocrustrine valley fills. This study started in the Driftless Area of Wisconsin on the Black Earth Creek, an 'underfit' stream, and has been expanded to include studies of incised meanders and free meanders (valley width greater than meander belt width) throughout the eastern United States. The purpose of the project is to determine the relation of the Q1.5 (bankfull discharge) to meander wave length, meander belt width, meander radius of curvature, stream width and slope. Such data will be used to determine whether the incised meanders are relics of earlier erosion cycles, to estimate the discharge required to produce the incised meanders, to reconstruct the original area-discharge relation of the incised meanders and, by comparing these with area-discharge curves for U. S. stream systems in varying climatic areas to estimate earlier precipitation regimes of the streams which now have incised meanders. In general to learn more about the hydraulic geometry of meandering streams and possibly to study the hydraulic geometry of free incised meanders in the laboratory.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0273, EXTREME HYDROLOGIC EVENTS & THEIR EFFECTS ON NUCLEAR FACILITIES

***H. CARRIGAN*, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242**

The program was initiated in FY'67. at nuclear facilities is necessary to determine whether such events could initiate radioactive material releases of an unacceptable degree. A study of this type will permit answers to questions related to the amount of ground water recharge that occurs in arid environments. The likelihood that an unusually high water table rise might occur in association with floods and humid environments leading to unacceptable leaching rates and transport of buried or sorbed radioactive wastes or to lowered bearing capacities of soils supporting waste tanks or that headward erosion into burial trenches might take place at a given site during extreme conditions of run-off intensity and duration.

SUPPORTED BY U.S. Atomic Energy Commission

2.0274, CORROSION AND ENCRUSTATION MECHANISMS IN WATER SUPPLIES

***F.E. CLARKE*, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242**

A variety of physical, chemical, and biological processes determine tendencies of water supplies to cause objectionable corrosion problems in wells and other water handling equipment. Knowledge of these mechanisms is necessary for proper prediction of effects and proper control. Quality characteristics of well water supplies are determined by field studies and the data are analyzed thermodynamically for evidence of potential encrustation and corrosion reactions. The work to date in deep well fields of Egypt, Nigeria, and West Pakistan has revealed that the oxidation reduction potential - pH relationship - is very important in determining magnitude of corrosion damage. Chemical equilibrium studies appear to indicate that degree of saturation with calcium carbonate and ferric hydroxide are major factors in determining the nature and intensity of corrosion. Encrustation with ferrous carbonate, a common problem, appears to be independent of the concentration of this mineral in the well water and to depend primarily on kinetic factors, such as flow rate. Effective control measures are being devised on the basis of these studies.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0275, INVESTIGATION AND ANALYSIS OF FLOODS FROM SMALL DRAINAGE AREAS IN OHIO

***W.P. CROSS*, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242**

The existing program of flood studies and analyses are being supplemented to obtain an adequate measure of flood characteristics for drainage areas of less than one square mile by using additional high stage indicators (pipes).

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Ohio State Government

2.0276, SAFFORD VALLEY, ARIZONA GEOPHYSICAL STUDIES

***G.P. EATON*, U.S. Dept. of Interior, Geologic Division, *Washington, District of Columbia* 20242**

To make geophysical surveys of the Safford Valley (Basin) in support of ground water investigations and to interpret these geophysical data to provide a greater understanding of ground water hydrology of the Basin.

To determine the geometric configuration of the underlying basement rocks, the thickness and character of basin-fill sediments, the areal extent and attitude of volcanic rocks and other factors that might influence the occurrence of ground water.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0277, WATERSHED SHAPE-FACTOR

***A. EYSKINE*, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242**

The objective of this project is to ascertain and establish a factor which could be used in design formulas for culvert box, culvert and minor structure capacities. The factor would take into account the effect of the shape of the watershed with respect to peak concentrations of discharge from the area. At present this is not taken into account as the practice is to design for maximum discharge capacities. It is estimated that the shape can have a variable effect up to 30% of the design capacity. Thus if this effect is known a savings of up to a similar percentage figure could result.

It is proposed to select control areas and test sites in three sections of the state.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
North Dakota State Government

2.0278, INVESTIGATION AND ANALYSIS OF FLOODS FROM SMALL WATERSHEDS IN OKLAHOMA

***A.A. FISHBACK*, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242**

The magnitude and frequency of flood peaks in one to fifty square mile watersheds were investigated. Ninty crest-stage and recorder gauges were installed and library research was conducted. During 1965 ten gauges will be installed, flood discharges will be computed by hydraulic principles and flood characteristics will be studied.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Oklahoma State Government

2.0279, CHEMISTRY OF ATMOSPHERIC PRECIPITATION

D.W. FISHER*, U.S. Dept. of Interior, Water Resources Division, *Washington, District of Columbia

The general objective is to obtain a better understanding of environmental factors that determine the chemical nature of

precipitation and to assess the role of precipitation in determining the quality of streams and of ground water.

Sampling networks are in operation in New York - New England, St. Thomas, V. I., and in North Carolina in three distinctly different environments. A specific watershed is being studied in North Carolina to relate precipitation chemistry to terrestrial water quality.

Specific attention is being given to the correlation of the sulfate and nitrate content of precipitation with atmospheric concentrations of sulphur and nitrogen to resolve basic problems on the sources of some important precipitation constituents.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0280, FLOOD-FREQUENCY AND BASIN PARAMETER RELATIONSHIPS IN SMALL DRAINAGE AREAS

H. GOLDEN, U.S. Dept. of Interior, Water Resources Division, *Washington, District of Columbia*

Purpose: To determine the factors and physical relationships that control the frequency and magnitude of floods on small drainage basins (generally less than 15 mi2, and many less than 2 mi2), and develop reliable methods for estimating peak discharges.

Methods: Depending on the climatic and other features of the particular region, various methods and combination of factors are analyzed and tested for reliability, based on past and current records of flood flow, or synthesized floods. These factors include basin shape, slope, geology, vegetative cover, land use, antecedent precipitation; runoff volumes, peak discharge, and rainfall intensity and duration.

Geographical scope: Work is being conducted in 35 states and Puerto Rico as part of the program of water resources investigations conducted by the Geological Survey in cooperation with the States.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0281, HYDROLOGY RESEARCH PROJECT

G.H. HAYES, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242

The objective of this investigation is to obtain hydrologic data on small watersheds and analyze the information so that it can be used for the hydraulic design of highway drainage structures.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Maine State Government

2.0282, DISTRIBUTION OF ELEMENTS IN FLUVIAL AND BRACKISH ENVIRONMENTS

V.C. KENNEDY, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242

To determine the distribution of major and minor elements in solution, adsorbed, or in solid form in streams, to study the variation in mineralogy and exchange capacity of stream sediments, and their importance in transporting various elements, to investigate methods, such as fluorescent tracers, for following sediment movement into the marine environment and to determine changes in adsorbed ions as sediment moves into the ocean.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0283, GEOMORPHIC ASPECTS (SISTERS AND WATTS BRANCHES, MARYLAND)

L.B. LEOPOLD, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242

The objective is the study of basic aspects of the hydrologic cycle relating to processes by which water and sediment are delivered to stream channels and transported by them.

At the Sisters Project, a 2.2-acre wooded watershed, a detailed study is being made of the distribution of rainfall on the watershed, the rains producing runoff, the characteristics and routing of hydrographs for an ephemeral channel, the disposition of water at or beneath the ground surface during rains, and the mass movement of soil.

At Watts Branch, a small meandering channel that is mapped and permanently monumented in detail, measurements of the rate of channel movement in relation to the flow and climatic conditions are being made.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0284, LONG TERM CHANNEL CHANGES

L.B. LEOPOLD, U.S. Dept. of Interior, Water Resources Division, *Washington, District of Columbia*

A number of drainage basins ranging in size from several acres to several square miles are being selected across the United States. It is hoped that these will eventually include sites in all physiographic and climatic regions. Beginning in 1962 and to present sixty sites have been selected and measurements have been recorded. In general, the study will consist of the following measurements or installations at each site: (1) topographic and geologic mapping, (2) channel profile and crosssections, (3) soil and vegetation description, (4) crest-stage gage and rain gage, (5) measurements of erosion and mass movement, and (6) channel scour. Repetitive surveys, yearly or as needed, compared to previous surveys will provide an indication of the long-term changes occurring. Over a period of time, it is anticipated that a delineation may be made between those changes which are man-caused and those due to climatic changes.

The sites are similar in type to those that will be established as part of the Vigil Network System. It is hoped that other countries will begin such investigations and data will be collected on a worldwide basis. Techniques developed in the present study will serve as a guide for future studies.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0285, INVESTIGATION OF SCOUR AT BRIDGES IN ALASKA

L.S. LEVEEN, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242

Scour at bridges in Alaska is being studied at selected sites in the field. Initially only reaches where a bridge crosses a relatively straight section of the stream channel are being studied. The stream channel is surveyed upstream and downstream of the bridge. Cross sections and longitudinal profiles of the stream bed are taken with an echo sounder for key discharges. Hydraulic and transport variable studies include sediment size analysis, current relationships, measurements of suspended load, size analysis of suspended load, velocity distribution at various stages, measurement of scour depth, and determination of the discharge-frequency relation. It is believed that analysis of the data will lead to a means of predicting scour at bridges.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Alaska State Government

2.0286, UNSATURATED FLOW STUDIES

W.O. SMITH, U.S. Dept. of Interior, Water Resources Division, *Washington, District of Columbia*

Work is continuing on developing the theory for describing flow in the unsaturated zone, with special reference to conditions of constant temperature and to unsaturated flow under thermal and under electrical gradients.

Further analysis will be made of theoretical developments relating porosity and moisture content, as well as grain size and sorting, to the dielectric properties of certain types of water-bearing sands, and of the effects of structure, exchange ion, and water content on dielectric properties of clays. Laboratory experimental work will include measurement of dielectric constants and the associated loss factors.

The water content of the unsaturated zone, and the mechanism of water movement during infiltration are only poorly known. An understanding of the infiltration mechanism is particularly applicable to the design of artificial recharge projects. Present methods of determining water content in the zone tend to disturb the sediments, and thereby make measurements inaccurate. The determination of the dielectric behavior and water content is well known, dielectric behavior will provide an accurate means of determining water content.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0287, HYDROGEOLOGY OF ARTESIAN SYSTEMS AND LIMESTONE TERRANES

V.T. STRINGFIELD, U.S. Dept. of Interior, Water Resources Division, *Washington, District of Columbia*

Water in artesian aquifers consisting chiefly of (1) limestone, and (2) sands and gravel is one of the principal sources of water supplies in the Coastal Plain province in the southeastern States. Artesian water in Tertiary limestone in Florida and southeastern Georgia is the principal source of water for municipal, industrial, and irrigation supplies. Outside the Coastal Plain in the southeastern States, the artesian systems are less extensive and less productive, but are important sources of water.

Although the aquifers are known in a general way and much detailed information has been obtained and published on local areas, regional studies are being made to obtain a better understanding of such characteristics as (1) circulation, recharge, and discharge of water in the artesian systems, (2) the relation of occurrence and circulation of the water to recharge and discharge areas and to geologic structures, (3) geologic conditions affecting permeability and waterbearing capacity of aquifers, (4) solution cavities in the linestone, (5) geochemistry of the artesian water, and (6) relation of fresh artesian water to salty water in the aquifer.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0288, THE HYDRAULICS OF GROUND WATER TESTS

R.J. SUN, U.S. Dept. of Interior. Geological Survey, *Washington, District of Columbia* 20242

The project was initiated in FY 67 and proposes to investigate the following aspects. The applicability of the several currently available dispersion equations to aquifers of differing geologic characteristics; justification of the use of simplifying assumptions that must be made; modification of basic equations to account for change in hydraulic head due to pumping of a sampling well. Development of a computer program to simulate ground water movement between tracer test wells and develop methods for determining aquifer characteristics on the basis of comparison of simulated and actual tracer flow tests. The results of these studies will be utilized to develop an improved mathematical model for description of the time concentration curve obtained in a two-well tracer test which has operational advantages over other field methods wherein there is a need for more sophisticated methods of applying ground water tracer techniques to waste transport by ground water through anisotrophic inhomogeneous media.

SUPPORTED BY U.S. Atomic Energy Commission

2.0289, SMALL DRAINAGE AREA STUDY

UNKNOWN, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242

The investigation and analysis of floods from small drainage areas in Arizona are being continued: selection of areas and the installation of 100 crest-stage gages, on a state-wide basis: computation of peak flow and drainage area when gages and flood hydrograph recorders indicate a flow or flood has occurred.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Arizona State Government

2.0290, RUNOFF STUDIES ON SMALL DRAINAGE AREAS

UNKNOWN, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242

Objective: Emphasis on small drainage areas, down to about one square mile, and primary phases of the program will be: definition of discharge frequency relations on a regional basis and collection of peak discharge data where existing coverage is inadequate. Conducted in West Virginia.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
West Virginia State Government

2.0291, FLOOD FREQUENCY FOR SMALL DRAINAGE AREAS

UNKNOWN, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242

The objective is to determine the flood-discharge frequency relations for streams draining five square miles or less in the State of Mississippi.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Mississippi State Government

2.0292, HYDROLOGY STUDY

UNKNOWN, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242

Floods from small drainage areas are being investigated. Obtaining and analyzing information on stream-flow characteristics will lead to a more efficient design of bridges and culverts.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Vermont State Government

2.0293, SMALL STREAMS INVESTIGATIONS IN OREGON

UNKNOWN, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242

The work on this previously approved continuing project will consist of analyzing previously collected data on discharge from crest- stage stream gages, flood hydrograph recorders and indirect measurement of unusual floods.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Oregon State Government

2.0294, INVESTIGATION AND ANALYSIS OF FLOOD HYDROGRAPHS FROM SMALL DRAINAGE BASINS IN SOUTH DAKOTA

UNKNOWN, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242

Data are being collected on rainfall, basin characteristics and flood flow, and the data are being analyzed to develop relationships suitable for prediction of the magnitude and frequency of floods from any small watershed in South Dakota. The method derived will be used for design of highway culverts and small bridges.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
South Dakota State Government

2.0295, PROGRAM FOR INVESTIGATION AND ANALYSIS OF FLOODS FROM SMALL DRAINAGE AREAS IN DELAWARE

UNKNOWN, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242

Objective: To obtain an adequate measure of streamflow characteristics which will provide, within prescribed limits of accuracy, an estimate of the magnitude and frequency of floods which might be expected from small drainage areas in Delaware.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Delaware State Government

2.0296, PROGRAM FOR HYDROLOGIC INVESTIGATION OF SMALL DRAINAGE AREAS IN TEXAS

UNKNOWN, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242

Hydrologic data to be used in the hydrologic design of highway drainage structures are being obtained and analyzed for determining the magnitude and frequency of floods for drainage areas ranging from 1 to 20 square miles.

2. WATER CYCLE

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Texas State Government

2.0297, SMALL WATERSHED STUDY

UNKNOWN, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242

Hydrologic data on small drainage basins which can be used in the hydraulic design of highway drainage structures are obtained and then analyzed.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Georgia State Government

2.0298, INVESTIGATION OF WATER RESOURCES. FLOODS IN SMALL STREAMS IN TENNESSEE

UNKNOWN, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242

Objective: To obtain and analyze hydrologic data on small drainage basins which can be used in the hydraulic design of highway drainage structures.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Tennessee State Government

2.0299, HYDROLOGIC STUDIES

UNKNOWN, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242

Objective: Prepare a statewide flood-frequency report for streams with drainage areas of 50 square miles or more, greatly expand the collection of flood-flow information from small streams, and analyze these data and prepare a flood-frequency report for small drainage areas.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Virginia State Government

2.0300, GEOLOGIC ASPECTS OF SEA-WATER ENCROACHMENT - RECOGNITION OF LATE GLACIAL SUBSTAGES IN NEW YORK AND NEW ENGLAND

J.E. UPSON, U.S. Dept. of Interior, Water Resources Division, *Washington, District of Columbia*

Continuation of field mapping of Pleistocene deposits as indicators of fluctuations of sea level. Current work pertains to identify, stratigraphic position; and extent of the Gardiners Clay as an indicator of former position of shore line, and as a confining stratum for ground water. Field studies earlier included Fishers Island, Connecticut, New York, now shifted to eastern Long Island, New York.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0301, INVESTIGATION AND ANALYSIS OF FLOODS FROM SMALL DRAINAGE AREAS IN SOUTH CAROLINA

B.H. WHETSTONE, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242

Data on flood flow, drainage basin characteristics, and rainfall are being collected and analyzed. Relationships will be developed for predicting the magnitude and frequency of floods from any small watershed in South Carolina. The method will be used in highway culvert and small bridge design.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
South Carolina State Government

2.0302, INFLOW HYDROGRAPH STUDY

L. WIARD, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242

The magnitude and frequency of flood volumes to be expected from small drainage areas in Wyoming are to be defined, and also, the characteristic shape of flood hydrographs in relation to the physical characteristics of the basins. A rational method of accounting for the effect of embankment storage which will be useful in culvert design is to be developed. Hydrologic data (stream flow and precipitation) will be obtained for about 50 different basins.

Data on stream length, slope, stream density, size of drainage basin, soil type, basin shape, and other factors will be compiled for each basin. Aerial photographs were adequate, or standard surveying methods, if necessary, on small drainage basins will be utilized.

The feasibility of using climatic data to extend in time flood records for a basin will be investigated, and also, the relation between rainfall frequency and runoff-volume frequency.

Assuming that rainfall frequency is defined by long term records and that general rainfall-runoff volume relations can be defined by the data obtained in this investigation, the frequency of flood peaks can be approached through time lag characteristics. The chosen approach to definition of the effect of embankment storage in reducing flood peaks requires definition of the time lag characteristics of the basic and the relation between outflow and storage at the culvert site. Time lag characteristics are being defined for each of the 50 basins as both rainfall and the flood hydrograph are being measured. Time lags are then related to the physical characteristics of the basin such as length and slope to provide a general method to be used in design. Data on stream length, slope, stream density, size of drainage basin, soil type, basin shape, and other factors are being compiled for each basin.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Wyoming State Government

2.0303, DISSIPATION AND DIFFUSION OF HEAT IN STREAMS AND LAKES

N. YOTSUKURA, U.S. Dept. of Interior, Water Resources Division, *Washington, District of Columbia*

Purpose: To develop a method for prediction of the temperature variation in streams and lakes which are subjected to thermal loading.

Methods: The energy budget method of temperature prediction assumes uniform distribution of heat within a cross section of a flowing water and accounts for heat exchanges at the boundaries of the water body. It has been indicated theoretically that inclusion of longitudinal dispersion coefficients in a heat balance equation would materially affect the distribution of temperature along the length of a stream. This project will initially emphasize a basic study of the effect of heat diffusion or of non-uniform distribution of heat within the body of water on the ultimate dissipation of heat. The effect of stratification of flows, especially in estuaries, on heat dissipation will also be investigated.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0304, DEVELOPMENT OF HYDRAULIC DESIGN PROCEDURES FOR CONCRETE BOX CULVERTS WITH STANDARD, IMPROVED AND SIDE-TAPERED INLETS

H.G. BOSSY, U.S. Dept. of Transportation, Bureau of Public Roads, *Washington, District of Columbia*

Design aids are being developed and made available to highway engineers for rapid selection of an economic type and size of box culvert for a given site and design flood peak, by means of monographs for inlet control operation of box culverts of present types, new designs for improved capacity by use of inlet edge levels, and greater capacity side-tapered inlets.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.

2.0305, DYNAMIC PROPERTIES OF GRANULAR BASE MATERIALS IN SATURATED AND PARTIALLY SATURATED CONDITIONS

UNKNOWN, U.S. Dept. of Transportation, Bureau of Public Roads, *Washington, District of Columbia*

The effect of the degree of moisture saturation on the mechanical properties of granular base materials under high rates of strain is being studied. These stress rates correspond to those produced by traffic loadings on flexible pavements.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.

2.0306, INVESTIGATION OF RAINFALL DISTRIBUTION ON URBAN RUNOFF FOR IMPERVIOUS AREAS

D.C. WOO, U.S. Dept. of Transportation, Bureau of Public Roads, *Washington, District of Columbia*

The effect of rainfall distribution (with time and area) on the urban runoff hydrography for impervious areas is being studied using a mathematical model.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.

2.0307, STORM WATER INFLOW

N.G. SMITH, U.S. District of Columbia, Highways & Traffic Dept., *Washington, District of Columbia*

Objective: To provide a better prediction of inflow to pumping stations in the Washington area.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
District of Columbia Government

2.0308, RADIOACTIVE FOOD-CHAINS IN THE SUBARCTIC ENVIRONMENT

J.K. MIETTINEN, Helsingin Yli Helsing. Univ., *Helsinki, Finland*
(AT-(30-1)3446)

Investigation of Lapps and Eskomos revealed in them increased body burdens of several artificial (90Sr, 137Cs, 55Fe) and natural (210Po, 210Pb) radionuclides resulting from fallout and enrichment through food-chains. Although the main features of this phenomenon are already known, many problems still exist. The above nuclides will be analyzed in ruminants (reindeer, elk) and predators feeding on reindeer (wolf, wolverine) as well as related animals (lynx, bear) by sample analysis, and in Lapps and southern Finns by whole body counting. The maximal body burdens of 137Cs in Finnish reindeer breeders (aver. 1.5 uCi in the whole body; ICRP MPC is 3.0 uCi) were measured in April 1965. Since then the levels have decreased by about 15 per cent per year except in 1966/67 when the decrease was 27 per cent due to exceptional grass growth. The body burden of 210Po and 55Fe is about 10 to 15 times, of 90Sr and 210 Pb about 3 times higher in reindeer meat consuming Lapps than in southern Finns having a more usual 'western' diet. 210 Po and 210Pb in the hydrosphere will also be investigated, as well as the specific activity concept of lead, strontium and caesium in the environment.

SUPPORTED BY U.S. Atomic Energy Commission

2.0309, BIOLOGICAL (ENRICHMENT) CHAINS OF RADIONUCLIDES IN FINNISH LAKES

J.K. MIETTINEN, Helsingin Yli Helsing. Univ., *Helsinki, Finland*

1. Food chains of Cs 137 from global fallout are studied in 12 lakes covering the whole range from oligotrophic to eutrophic ones. Cs 137 content in water, plankton, plants and fish are determined annually. 2. Tracer experiments in natural lakes are carried out to elucidate the limnological factors effecting accumulation in plankton, plants and fish of the elements (Cs, Sr, I, Ba, P, Ca) to which the radionuclides belong which constitute the greatest biological hazard in nuclear fission or neutron activation of soil by a nuclear explosion. 3. Excretion rates of the above elements in various fish species are determined using radioactive tracers.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

2.0310, WATER RELATIONS WITH CITRUS ON THE FLATWOODS AND MARSHES OF THE EAST COAST

D.V. CALVERT, Univ. of Florida, Agricultural Experiment Sta., *Gainesville, Florida* 32601

Project Objectives: 1. To determine the effect of irrigation on growth, yield, quality, and economic returns of citrus grown on soils of the flatwoods and marshes. 2. To determine the drainage requirement of citrus under shallow drainage conditions using the pumped well technique. 3. To evaluate factors that will minimize the detrimental effects to citrus of saline water applied through low rate sprinklers.

Description of Work Proposed: 1. Controlled irrigation experiment. Soil moisture will be maintained at various levels by means of supplemental irrigation in a block of 'Valencia' orange trees. Treatment effects will be measured by yield, fruit quality and tree size. 2. Pumped drainage experiment. Shallow wells will be installed in citrus groves and water table draw-down characteristics, citrus growth and yield responses to improved drainage will be studied. 3. Salinity Experiment. Water will be applied containing varying salt concentrations through low volume sprinklers under different humidity and temperature environments to both orange and grapefruit varieties. The effect of these irrigations will be assessed by leaf drop counts, visual ratings, and leaf analysis for sodium and chloride.

SUPPORTED BY Florida State Government

2.0311, HEAT BUDGET AND EVAPOTRANSPIRATION OF FRUIT TREES

J. GERBER, Univ. of Florida, School of Agriculture, *Gainesville, Florida* 32601

To conduct an investigation of the heat budget and evapotranspiration of fruit trees to provide basic information about the heat budget and water balance of the fruit tree as it contributes to the overall energy budget and water balance.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.0312, CONSERVATION OF WATER RESOURCES THROUGH MODIFICATION OF THE PHYSICAL AND CHEMICAL PROPERTIES OF SOIL

L.C. HAMMOND, Univ. of Florida, Agricultural Experiment Sta., *Gainesville, Florida* 32601

Objectives: (1) The effects of soil properties on soil wettability and on water entry, storage and movement in the soil profile. (2) The nature and effects of soil organic matter in soil-water relationships. (3) Creation of physical and chemical soil properties to contaminant attenuation in the soil.

Description of Work: Basic information on soil wettability, soil water evaporation and the nature of soil organic matter will be collected in laboratory studies of natural and treated soils. Meaningful soil property relationships which are found will be used to modify the soil for improvement of water entry and storage in the soil profile and reduction of evaporation. Leaching and incubation experiments will be used to obtain data on the mobility, adsorbability, and persistence of chemicals (surface-active agents, pesticides, evaporation retardants, and waterproofing materials) added to the soil.

SUPPORTED BY U.S. Dept. of Agriculture

2.0313, MOISTURE RETENTION, MOVEMENT, MEASUREMENT, AND AVAILABILITY TO PLANTS IN FLORIDA SOILS

L.C. HAMMOND, Univ. of Florida, Agricultural Experiment Sta., *Gainesville, Florida* 32601

Objective - To evaluate soil moisture in relation to plant growth and in relation to the physical properties of Florida soils.

Abstract - Experiments include comparison of neutron, suction, and gravimetric methods of measuring soil moisture in relation to timing irrigation. Moisture retaining and transmitting properties of Florida soils will be measured in the laboratory for comparison with certain field measurements. Crop growth under different controlled water tables on flatwoods soils and water use rates by various plants on well-drained soils will be a part of the study.

SUPPORTED BY Florida State Government

2.0314, WATER CONTROL FOR FOREST PRODUCTION

C.M. KAUFMAN, Univ. of Florida, Agricultural Experiment Sta., *Gainesville, Florida* 32601

OBJECTIVES: 1. To ascertain effects of non tree vegetation particularly saw palmetto (Sarona repens Bartr.), on availability of soil moisture. 2. To evaluate methods of reducing water loss by controlling non tree crop vegetation. 3. To determine effective means of controlling water table levels by drainage or by irrigation.

The water loss attributable to forest vegetation other than trees particularly saw palmetto, will be determined in order that justifiable control measures may be evaluated. Means of producing more favorable soil moisture conditions, such as site preparation, drainage and irrigation to a limited degree, will be investigated, leading to outlining of forest production procedures.

SUPPORTED BY Florida State Government

2.0315, EVAPOTRANSPIRATION AND SOIL MOISTURE DETERMINATION AS GUIDES TO CITRUS IRRIGATION

R.C. KOO, Univ. of Florida, Agricultural Experiment Sta. , *Gainesville, Florida* 32601

Work Proposed: A. Controlled experiment. Soil moisture will be maintained at various levels by means of supplemental irrigation in a block of three orange (Hamlin, Pineapple, and Valencia) and one grapefruit (Marsh) varieties. Treatment effects will be measured by yield, fruit quality and tree size. B. Develop a set of evapotranspiration curves for citrus based on moisture loss as a function of temperature by means of systematic soil moisture measurement. C. Test the practical application of evapotranspiration curves by calculating the soil moisture content in several groves with the aid of current weather records. Soil moisture measurements will be used to check the accuracy of the calculations.

SUPPORTED BY Florida State Government

2.0316, RELATIONSHIP BETWEEN EXCESSIVE SOIL MOISTURE AND CITRUS ROOT DAMAGE

H.W. FORD, Univ. of Florida, Agricultural Experiment Sta. , *Lake Alfred, Florida*

The project will evaluate the factors that influence the growth and survival of citrus roots in relation to depth and spacing of drainage tile and ditches. The effect of flooding on citrus root survival as influenced by rootstock, anaerobiosis of site, and anaerobic bacterial metabolites will also be studied.

Data will be collected from commercial groves that contain different soil types, rootstocks, and drainage procedures by utilizing water level recorders, recording rain gauges, and piezometers. Root distribution will be measured by collecting roots with a soil sugar. Effect of flooding on citrus root survival will involve measuring bacterial metabolites chemically and by gas chromatography evaluating certain indexes as an indication of the anaerobic state, and establish the minimum rate of water movement necessary to delay anaerobiosis.

SUPPORTED BY Florida State Government

2.0317, BIOLOGICAL PRODUCTIVITY RELATED TO HYDROLOGIC CONDITIONS

M.C. KILIPINSKI, U.S. Dept. of Interior, Water Resources Division, *Miami, Florida*

In progress is an investigation of seasonal and annual changes in aquatic biological populations as affected by changes in water levels and water quality in Everglades National Park. The populations include fishes, aquatic invertebrates, sedges and grasses, plankton, and periphyton. The aquatic habitats selected for study are the fresh- water glade, the aligator hole, and the ecotone between fresh and marine waters. The ecotone involves areas where the shallow water of the open glades meets tidally influenced tributary streams. Research stations are concentrated in the Shark River Slough and the headwaters of the Shark River that extend over 200 square miles or nearly 10 percent of the entire park. New techniques have been developed for periodic quantitative sampling of the aquatic fauna while in situ quadrats have been established for quantitative study of the flora. Changes in the biomass and species composition of the biological populations will be related to salinity, water temperature, dissolved oxygen, free carbon dioxide, light, and nature of substrate.

Aquarium studies with fresh-water animals are in progress to determine their ability to survive in the water of about 3 parts per thousand chloride.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0318, EVALUATION OF RECENT VEGETATIVE CHANGES IN EVERGLADES NATIONAL PARK

M.C. KILIPINSKI, U.S. Dept. of Interior, Water Resources Division, *Miami, Florida*

A study, based on aerial photographs of Everglades National Park taken between 1927 and 1965, is underway to relate changes in species composition and density of plant communities to Changes in fresh-water supply, fluctuations in water level, and fire.

Features on randomly selected photographs of the Everglades will be identified by reconnaissance observations in the field. A Fairchild contour finder is used for delineation of planimetric details. The resulting stereoscopic models from aerial photographs of identical areas in different years are brought to the same scale for comparison by use of vertical light projector.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0319, SUBMARINE SPRINGS

F.A. KOHOUT, U.S. Dept. of Interior, Geological Survey, *Miami, Florida*

The objective is to investigate the occurrence of submarine springs as a neglected phenomenon of coastal hydrology and to appraise the tools of remote sensing for these studies. The difficulty and expense of direct observations of submarine springs hinders their investigation. Remote sensing tools are being evaluated for application to the problem.

Overflights of known submarine springs along the Florida coastline were made by NASA Remote-Sensing aircraft. Submarine springs 12 miles offshore from Naples, Fla., and 2 1/2 miles offshore from Crescent Beach, Fla. were recognized in varying degrees by color photography, multispectral photography, and infrared imagery. Analysis of results is continuing.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0320, (U) INSTABILITY PATTERNS IN THE TROPICS

H.W. HISER, Univ. of Miami, Graduate School, *Miami - Coral Gables, Florida* 33124 (DA-28-043-AMC-00443)

BY DELINEATING AREAS OF INSTABILITY THAT MAY BE POTENTIAL HAZARDS TO ARMY OPERATIONS.

THE CARIBBEAN AREA THAT PRODUCE BAD WEATHER, AND DEVELOP TECHNIQUES FOR MAPPING AND ANALYZING THEM, 2) DETERMINE THE OPTIUM PROCEDURE FOR USING WEATHER RADAR IN THE TROPICS TO OBTAIN QUANTITATIVE PRECIPITATION MEASUREMENTS.

SPONSORED WITH ASL THE ANNUAL TROPICAL METEOROLOGICAL RESEARCH CONFERENCE WHICH BROUGHT TOGETHER LEADING TROPICAL RESEARCHERS FROM U. S. AND ABROAD FOR INCISIVE DISCUSSIONS ON CURRENT STATUS OF TROPICAL METEOROLOGICAL RESEARCH. THE CONTRACTOR COMPLETED A CLIMATOLOGY OF TORNADOES AND WATERSPOUTS AND DEMONSTRATED THAT UNIQUE RADAR SIGNATURES ARE ASSOCIATED WITH THOSE PHENOMENA. CHARACTERISTIC DIFFERENCES IN AIR MASS AND EASTERLY WAVE RAINFALL WERE REPORTED. COMPREHENSIVE RADAR ANALYSES OF SEVERE STORMS THAT PRODUCED INORDINATELY HEAVY RAINFALLS WERE PREPARED. BOTH CONTOURED AND NON-CONTOURED RADAR DATA WERE OBTAINED AND THE ENHANCED ANALYSES AND FORECAST CAPABILITY THAT RESULTED FROM THE FORMER, CLEARLY DEMONSTRATED ITS SUPERIORITY. SEMI-ANNUAL AND FINAL REPORTS ON CONTRACT DA28-043 AMC-00443/E/ WERE COMPLETED AND DISTRIBUTED. THE WORLD METEOROLOGICAL ORGANIZATION CONFERENCE IN VENEZUELA.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0321, RESEARCH INTO RECENT CLIMATIC CHANGES

E.B. KRAUS, Univ. of Miami, Graduate School, *Miami - Coral Gables, Florida* 33124

Suitable record series will be collected in the first instance. They will then be tested statistically for internal coherence and meteorologically for existence of local peculiarities.

Computational schemes will be devised to test on different time scales the coherence and correlation of large numbers of records. The possibility of different effects and relations in different seasons may have to be considered. The correlations between the hemispheres becomes evident only on a time scale of at least several years. The development of special filter functions and cross-spectra may be desirable.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.0322, INVENTORY OF THE GULF ESTUARY SYSTEM

N.G. VICK, U.S. Dept. of Interior, Bureau of Sport Fish. & Wlfe., *Panama City, Florida* 32401

The objectives of this study unit are to procure and document environmental and ecological data on the St. Andrew Bay System, Panama City, Florida. These data will include (1) area descriptions (2) hydrology of the bay system (3) sedimentology, and (4) samples of the biological materials available seasonally with emphasis on the sporting species of marine fishes.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

2.0323, BEHAVIOR OF ESTUARINE ANIMALS

D.J. HANSEN, U.S. Dept. of Interior, Biological Laboratory, *Sabine Island - Gulf Breeze, Florida*

Objective: Determine the effects of pesticides on the behavior and physiological tolerances of estuarine animals.

Procedures: A. Using apparatus in which a gradient of pesticide concentrations can be established the ability of selected mollusks, crustaceans and fish to sense and avoid pesticides will be tested. B. Animals will be exposed to pesticide concentrations that they cannot sense and avoid, and the alteration of behavior and physiological tolerances will be determined.

1. Alteration of preferences will be studied in salinity and temperature gradients. 2. After exposure to pesticides, the selected animals will be subjected to extremes of salinity, temperature and other stresses to determine if sensitivity has been changed. 3. Schooling fish will be exposed to pesticides to determine if there are changes in schooling patterns.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

2.0324, ESTUARINE ECOSYSTEMS

G.E. WALSH, U.S. Dept. of Interior, Biological Laboratory, *Sabine Island - Gulf Breeze, Florida*

The purpose of this research is to determine effects of sublethal concentrations of pesticides upon estuarine ecosystems. At present, physical, chemical and biological characteristics of four very similar coastal ponds are being analyzed to learn normal seasonal variations. When these are known, three of the ponds will be treated with pesticide and one will be utilized as a control. Effects of pesticide upon population dynamics and community structures will be studied after contamination.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

2.0325, ESTUARINE INVENTORY (FORMERLY CHEMICAL ENVIRONMENT)

J.E. SYKES, U.S. Dept. of Interior, Biological Laboratory, *Saint Petersburg - St. Pt. Bc., Florida* 33706

The purpose of this project is to prepare a description of physical characters, hydrology, sediments and biota in Florida estuaries of the Gulf through field study and consolidation of existing data; to work with other Gulf States through the Gulf States Marine Fisheries Commission in standardizing techniques and data assimilation in similar state projects; and to contribute jointly toward the formation of a Gulf of Mexico estuarine atlas. Hydrochemical analysis will continue on allied Laboratory projects as shown for the former Chemical Environ Project.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

2.0326, URANIUM AND HYDROGEN RADIONUCLIDES AS NATURAL TRACERS IN THE FLORIDAN AQUIFER

J.K. OSMOND, Florida State University, Graduate School, *Tallahassee, Florida* 32306

The proposed research involves the study of the distribution of H-3, U-234, and U-238 in waters of the Floridan Aquifer to see if variations in these radionuclides can add to our understanding of the hydrology of the aquifer. Water samples will be collected from wells, springs, and surface water in Northern Florida and the tritum and uranium content determined, as well as the U-234/U-238 ratio. Preliminary findings have shown that theses values vary widely in a pattern largely determined by the extent of local recharge of the aquifer.

Of particular significance is the variation of U-234 relative to U-238 because these isotopes do not fractionate by normal chemical processes (and thus the variation is due to the factors of mixing and time only), and the one (U-234) is the radiogenic daughter of the other (U-238) with a half-life of 250,000 years. This means that this ratio is a function not only only of present hydrologic conditions but of those existing in the past (Pleistocene Epoch) as well.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Florida State University

2.0327, REMOTE SENSING, GULF COASTAL AREA, CENTRAL FLORIDA

R.N. CHERRY, U.S. Dept. of Interior, Water Resources Division, *Tallahassee, Florida*

Purpose - To develop criteria utilizing remote sensing techniques to identify areas where fresh water is likely to occur in an aquifer in near-shore areas.

Methods - An aerial survey will be conducted to sense the thermal contrasts of aquifer and sea water under at least four conditions- during high and low tides in a period when fresh water stages are high and during high and low tides when fresh water stages are low.

Water temperatures, water velocity, and specific conductance of water from submarine springs previously located will be determined. The water stages of fresh water and sea water will be recorded. These determinations will be compared with remote sensing data which indicate submarine discharge and the relative position of the zero piezometric contour.

SUPPORTED BY U.S. Dept. of interior - Geological Survey

2.0328, LAKE HYDROLOGY STUDIES

G.H. HUGHES, U.S. Dept. of Interior, Geological Survey, *Tallahassee, Florida*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Florida.

Available water-level records for fresh-water lakes in Florida show appreciable variation among differences between the highest and lowest observed water levels of individual lakes. The differences range from 2 to 6 feet for about one-half of the total number of lakes and from 6 to 12 or more feet for the remainder. The objective of the initial phase of a general study of lakes is to relate the magnitude of the water-level fluctuations to the type of inflow that predominates and to the physical characteristics of the lake and its drainage basin. The concepts developed for the study will lead to a better understanding of lake-level fluctuations and to more meaningful interpretation of lake-level records.

Subsequent phases of the study will deal with lake evaporation and variations of chemical quality and temperature of the lake water.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Florida State Government

2.0329, REMOTE SENSING, EVERGLADES AREA, FLORIDA

M.C. KOLIPINSKI, U.S. Dept. of Interior, Water Resources Division, *Tallahassee, Florida*

Purpose: To determine the relations between water conditions and biological populations in the Everglades by interpretation of airborne data and to develop new applications in natural resources research for data from remote sensors.

Methods: Spectral reflectance measurements of floral communities and water will be obtained using an airborne 18-channel optical- mechanical scanner. The data will be accumulated in a form that will allow use of a computer to identify and map the distribution and amount of selected communities. Remote sensing data will be examined for potential in: detecting plankton blooms, locating alligator holes, and estimating populations of large animals.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0330, WATER RESOURCES STUDY, DUVAL COUNTY, FLORIDA

G.W. LEVE, U.S. Dept. of Interior, Water Resources Division, *Tallahassee, Florida*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Florida.

Purpose: To determine the surface- and ground-water resources of Duval County.

Methods: The investigations of the geologic and general hydrologic characteristics of the Floridan aquifer which began in 1960 will be expanded to provide quantitative and qualitative hydrologic characteristics of the aquifer. Geologic and hydrologic data will be obtained for the surficial sand and shallow limestone aquifers. Water use data will be obtained to determine trends in water use. The flow characteristics dispersion patterns and salinity of the St. Johns River and tributary streams will be determined.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Florida State Government

2.0331, HYDROLOGY OF UPPER OLD TAMPA BAY, FLORIDA

J.A. MANN, U.S. Dept. of Interior, Water Resources Division, *Tallahassee, Florida*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Florida.

Purpose: To provide data for evaluating the hydrological effects of conversion of the bay into a fresh water lake and information by which to judge the feasibility of similar plans in other areas of the State.

Methods: The study will include the area of the proposed lake and an additional 25 to 35 square miles of land adjacent to the lake in Hillsborough and Pinellas Counties. The quantity and quality of surface and ground-water inflow into the bay will be determined. Continuous conductivity and stage gages will be installed on the lake and the bay, and on selected wells in the area to determine the degree of interconnection between the aquifers and the fresh water lake. Conductivity traverses will be made of the upper part of the bay, supplemented by sampling sites, to determine ground-water discharge into the bay. An evaluation will be made of existing geologic and hydrologic data to determine the relation between changes in water quality and ground-water storage. The areal extent, thickness, and permeability of clay beds underlying much of the area will be determined. The fresh water-salt water intergace will be monitored continuously.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Florida State Government

2.0332, DEVELOPMENT OF WATER SUPPLIES FOR IRRIGATION IN THE SOUTH

J.R. CARREKER, U.S. Dept. of Agriculture, *Athens, Georgia*

Object: To investigate conditions and methods under which shallow groundwater, sand and limestone aquifers, ponds, and other surface and subsurface water supplies and storage facilities can be developed as sources of water for irrigation. Also to develop design criteria.

Plan of Work: Based on information on shallow and deep ground water sources acquired from surveys of State and Federal groundwater agencies, etc., test installations are made. Borings, test wells, pits, and other methods of exploration are used to determine the nature of the aquifers and their potential productive capacities. Water quality is determined and special attention given to possibilities of using water supplies having higher acid or salt contents than normally considered desirable. Special problems in design, construction, and management of surface storage structures are considered. Available water supplies from surface sources are determined. Measurements include rate and amount of runoff and streamflow from small watersheds in relation to size, soil, ground cover and land management.

Cooperation: Georgia and South Carolina Agricultural Experiment Stations; SCS.

SUPPORTED BY U.S. Dept. of Agriculture

2.0333, RELATION OF CLIMATIC AND WATERSHED FACTORS TO RUNOFF RATES AND VOLUME YIELDS

J.C. STEPHENS, U.S. Dept. of Agriculture, *Athens, Georgia*

Object: To identify the climatic and watershed factors influencing the size, frequency, and duration of storm flows, and seasonal and annual water yields, including surface and subsurface components, from agricultural watersheds. To evaluate these factors quantitatively and to develop procedures by which the magnitude and frequency of storm runoff, and seasonal and annual net water yields may be estimated for ungaged watersheds in the southern states.

Plan of work: The work is conducted on the Pigeon Roost Creek experimental watershed near Holly Springs, Mississippi, the Little River experimental watershed, Tifton, Georgia, on a complex of agricultural watersheds in Southern and Central Florida, on Ahoskie Creek watershed in Northeastern North Carolina, and at Watkinsville, Georgia. Some of the factors required for the analyses and which are measured or otherwise documented for the study are: Rates and duration of streamflow; precipitation patterns, antecedent moisture; season; soils; land use; conservation and watershed management practices; ground-water evelations; riparian vegetation; geology; gradients and hydraulic roughness of stream channels; and the size, shape, and other geomorphic attributes of the watersheds. On Little River experimental watershed, digital instruments are being installed to give a synoptic picture of hydrologic conditions over the entire watershed at 5-minute intervals.

SUPPORTED BY U.S. Dept. of Agriculture

2.0334, PRECIPITATION CHARACTERISTICS INFLUENCING RUNOFF FROM AGRICULTURAL WATERSHEDS

J.C. STEPHENS, U.S. Dept. of Agriculture, *Athens, Georgia*

Object: To develop an understanding of the amounts, duration, areal and seasonal distribution, storm paths, and other characteristics of rainfall as affected by geographic location, topographic location, and other factors, to the extent that the characteristics influence runoff from agricultural watersheds in the southern part of the United States.

Plan of Work: Objectives of the studies are currently being sought through networks of recording raingages on the Pigeon Roost Creek experimental watershed near Holly Springs, Mississippi; and through networks of gages on agricultural watersheds in Southern and Central Florida, and Northeastern North Carolina. A dense network of digital recording gages is operated on the

155-square-mile Little River experimental watershed, Tifton, Georgia.

SUPPORTED BY U.S. Dept. of Agriculture

2.0335, RUNOFF PRODUCTION BY UNIT SOURCE AREA FOR AGRICULTURAL WATERSHEDS IN THE SOUTH

J.C. STEPHENS, U.S. Dept. of Agriculture, *Athens, Georgia*

Object: To evaluate quantitatively, as one of the important factors in predicting runoff from ungaged watersheds, the runoff producing potential of the major individual soil-cover complexes in the South under typical conditions of use and treatment.

Plan of Work: The study is currently underway on unit-source watersheds at Holly Springs, Mississippi, and Watkinsville, Georgia. Correlations are made between such factors as runoff, precipitation, land use and conservation practices, and the physical and chemical characteristics of soils.

SUPPORTED BY U.S. Dept. of Agriculture

2.0336, SUBSURFACE AND GROUND WATER ACCRETION, DEPLETION, MOVEMENT AND CONTRIBUTION TO STREAMFLOW

J.C. STEPHENS, U.S. Dept. of Agriculture, *Athens, Georgia*

Object: To develop methods for predicting ground water accretion and movement, subsurface and ground water contribution to streamflow, and basin recharge in relation to watershed geology, soil and climatic factors, storm runoff, land use and treatment, and watershed protection programs; to evaluate the hydrological factors governing transmission gains and losses in stream channels in the southern states; and to identify and measure geologic components associated with water yields from ponds, pits, and irrigation wells in the southern coastal plains.

Plan of Work: The work is currently in progress on the Pigeon Roost Creek experimental watershed at Holly Springs, Mississippi, on agricultural watersheds in Southern and Central Florida, in Northern North Carolina, and on the Little River experimental watershed near Tifton, Georgia. Among other factors, the investigations include: Geologic mapping; ground water observations; soil moisture determinations; transmission capacities of soils and aquifers; the consideration of influent and effluent streamflow; and the development and improvement of geological interpretations to predict ground water yields from dug ponds and pits, and the characterization of surface landforms associated with ground water yields.

SUPPORTED BY U.S. Dept. of Agriculture

2.0337, EFFECTS OF SOIL, TOPOGRAPHY, CLIMATE, CROPPING AND MANAGEMENT PROCEDURES ON RUNOFF AND EROSION, AND ON THE PREDICTION OF SOIL LOSSES

J.R. CARREKER, Univ. of Georgia, U.S.D.A. Se. Watersh. Res. Ct., *Athens, Georgia* 30601

Object: To evaluate (1) the effects of slope steepness and length, rainfall amount, intensity and duration, cropping practices, tillage methods, and other procedures on field runoff and soil losses; and (2) the relationship of factors affecting runoff and soil loss in the prediction of these losses.

Plan of Work: The collection of runoff and soil loss data from soil and water management and cropping practice plots under natural rainfall will continue on several land resource areas. New practices such as interseeding of row crops, plow-plant, and mulch tillage will be evaluated under different soil and slope conditions, and their effectiveness compared with selected conventional practices. The loss of farm chemicals in washoff will be studied on small plot and field areas. Other studies will be concerned with slope effects and with the relation of soil characteristics to soil erodibility. The data collected will be applied in the soil loss prediction formula to fill in the gaps for data needed in the application of this formula in conservation planning. Wind erosion control measures will be adapted to southeastern conditions.

SUPPORTED BY U.S. Dept. of Agriculture

2.0338, SPRING AND SUMMER HORTICULTURAL CROPS

S.A. HARMON, Univ. of Georgia, Agricultural Experiment Sta., *Athens, Georgia* 30602

1. To determine the effect of irrigation and hormone sprays when used singly and in combination in the production of fall grown tomatoes. 2. To determine the effect of irrigation and soil fumigation when used singly and in combination on yield of tomatoes, sweet potatoes, and strawberries. 3. To measure the effect of frequency and amount of irrigation water applied and the inter-relationship of these to rate of fertilization on yields of tomatoes and sweet potatoes.

Description of Work: The use of hormone sprays has been completed and the use of plastic mulches with and without stakes on fall tomatoes is now being studied. Tomatoes are set in August, staked vs. unstaked, and replicated treatments of black and clear plastic with check are used. Irrigation vs. no irrigation using an overhead Skinner System will be compared also.

The interaction of fertilization and irrigation on yields of Irish potatoes and beans is being studied. Two rates of fertilization and four irrigation treatments are used. Otherwise normal culture and harvesting methods used.

SUPPORTED BY U.S. Dept. of Agriculture
Georgia State Government

2.0339, TRACING STORM AND BASE FLOW TO VARIABLE SOURCE AREAS ON FORESTED HEADWATERS

J.D. HEWLETT, Univ. of Georgia, Graduate School, *Athens, Georgia* 30602

Many important hydrologic decisions about the source of floods, the need for structures and the control of water pollution depend on detailed knowledge of the path and timing of flow from upland areas. Neither standard nor experimental methods are presently adequate to classify or describe the source and timing of water flowing past a measuring station. For example, classical hydrograph separation methods and associated terminology are particularly inapplicable to forested headwaters. The Principal Investigator has initiated a new concept of forest runoff produced chiefly by subsurface flow from variable source areas.

No adequate records of rainfall and streamflow from fully forested Piedmont areas exist. A 60-acre forested catchment near Athens, Georgia, will be operated for about 3 years, long enough to apply the variable source area concept to description and prediction of the source and paths of flow, the relative magnitude of the different types of flow, and the rate of turnover in water stored in various portions of the basin. Methods will include rainfall and streamflow measurement, soil mantle surveys by drilling, seismic and electric resistivity methods, soil water measurement by nuclear methods, and eventually a radioactive tracer to determine turnover rates.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Georgia

2.0340, A STUDY OF SUBSURFACE FLOW INTO MOUNTAIN STREAMS AS RELATED TO TOPOGRAPHY AND PARTIAL SOURCE AREAS

J.D. HEWLETT, Univ. of Georgia, Graduate School, *Athens, Georgia* 30602

The purpose of this work is to demonstrate the extent and importance of partial source areas for subsurface flow from two mountain forest areas, one in the Appalachians and one in Japan. Records from the two areas will be analyzed by a common method which will include common terminology and hydrograph techniques. Antecedent moisture conditions over the catchments will be estimated by a universal soil moisture prediction equation and checked in the field. Delivery of water under different antecedent conditions along the slope from stream to water divide will be derived from rainfall and streamflow records and a model for such flow will be offered as a contribution to existing hydrograph simulation programs which assume runoff to be essentially a linear process. This study proposes to show just why the runoff process in mountain areas is not linear.

2. WATER CYCLE

The work will be done chiefly at the University of Georgia and the Coweeta Hydrologic Laboratory, Dillard, Georgia. In addition the records and some staff help will be available at the experimental watersheds of the Tokyo University forests.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Georgia

2.0341, TRACING STORM AND BASE FLOW TO VARIABLE SOURCE AREAS ON FORESTED HEADWATERS

J.D. HEWLETT, Univ. of Georgia, Agricultural Experiment Sta., *Athens, Georgia* 30602

To determine the source and path of travel of storm and base flows from a forested basin.

A 60-acre forested catchment at Whitehall, Georgia will be gauged and operated as an observation watershed for about three years in order to describe the behavior of water on and in the soil. Primary measurements will be streamflow, rainfall, soil moisture, ground water and soil physical properties. Flow will be calculated and expressed in various ways in order to relate volumes of water to source areas and also to rate the response of this catchment to others in the Piedmont province. The organic and inorganic solutes and sediments will be measured in detail by personnel of the Southeast Water Laboratory and an attempt will be made to relate these to the source of water flows. Results will be used to support and clarify some new concepts of streamflow as generated by variable source areas and unsaturated flow, rather than by surface runoff and groundwater only.

SUPPORTED BY Georgia State Government

2.0342, ECOLOGICAL SIGNIFICANCE OF ORGANIC RELEASE PRODUCTS OF MARINE AND FRESHWATER ANIMALS

R.E. JOHANNES, Univ. of Georgia, Graduate School, *Athens, Georgia* 30602

The term 'release products' refers here to mucus, molts and dissolved organic matter released by aquatic animals. Recent work indicates that these materials play a variety of quantitatively significant roles in the flux of energy and nutrients in aquatic ecosystems. Here, we will make measurements of the release rates of free amino acids and total dissolved organic matter by a wide variety of benthic and planktonic freshwater animals. Mucus release rates will be determined for a variety of corals, jellyfish, and other mucus producers. Molting rates of the benthic estuarine shrimp, Palaemonetes pugio, will be determined along with the organic content of these molts. Loss of organic matter by the above routes will be compared with the rate of oxidation of organic matter during respiration, and attempts will be made to estimate rates of energy flow via these pathways in natural marine and freshwater communities. The utilization of these release products by other organisms will also be investigated.

SUPPORTED BY U.S. National Science Foundation

2.0343, THE PERSISTENCE IN AN ERODED SOIL OF TILTH IMPROVEMENT ENGENDERED BY A SOD-BASED ROTATION

L.S. JONES, Univ. of Georgia, Agricultural Experiment Sta., *Athens, Georgia* 30602

(1) To determine the changes that occur in soil aggregate distribution, water stability of soil aggregates and the organic matter and nitrogen level when the soil management practice is changed from sod-based rotation to continuous cropping. (2) To determine the changes that occur in water infiltration on the above described soils. (3) To determine the effects of continuing cropping on the optimum moisture for tillage of soils previously in sod-based rotations.

Soils on which sod based rotations have been in progress for 8 and 12 years will be plowed and row cropped for a minimum of three years. Corn, at a plant population of 15,000 will be used as the row crop. Nitrogen will be applied at a 150 pound per acre rate. Limestone, phosphorous, and potassium will be applied at rates sufficient to assure the maintenance of adequate levels of those materials. (1) Soil samples will be collected from both the surface and subsoil prior to the initiation of the experiment and for three succeeding years. Water stability and size distribution of aggregates, organic matter, and nitrogen will be determined in the laboratory. (2) Infiltration rate will be determined in the field on selected plots. (3) Using suitable laboratory or field methods, an attempt will be made to relate the effects of cropping systems to the optimum soil moisture content for tillage.

SUPPORTED BY U.S. Dept. of Agriculture
Georgia State Government

2.0344, RELATION OF PHYSICAL CONDITIONS OF SOILS AND RESULTS OBTAINED FROM IRRIGATION

R.A. MCCREERY, Univ. of Georgia, Agricultural Experiment Sta., *Athens, Georgia* 30602

A. To determine the effects of irrigation on: (1) Moisture intake and transmission characteristics of the soil. (2) Aeration characteristics of soil. (3) Morphological and physiological characteristics of crop plants. (4) Ion uptake under field conditions. B. To evaluate the accuracy and reliability of existing moisture measuring devices.

Description of Work: Additional sites of the 11 soil series already under study will be characterized fully to learn the magnitude of variations in properties. It seems possible that other criteria than those presently in use for some series separations may have to be developed by soil surveyors if the series concept is to be useful in crop management on the Piedmont. The slate belt series, 4 Herndon and Georgeville will be included in the current years investigations.

Effects of bed configuration on yield of mechanically planted peanuts under irrigation will be studied. These effects may have been masked in the past when hand planting was used because of excessive traffic by personnel doing the planting.

SUPPORTED BY U.S. Dept. of Agriculture
Georgia State Government

2.0345, FIELD EXPERIMENTS ON THE FLUX OF RADIONUCLIDES THROUGH A SALT MARSH ECOSYSTEM, RENEWAL

L.R. POMEROY, Univ. of Georgia, Graduate School, *Athens, Georgia* 30602 (AT(40-1)-3238)

After some 12 years of work on the salt marshes of Georgia by a number of investigators, it is now possible to begin building models of the flux of materials through the system. A compartmental-diagram model, showing standing stock and flux of phosphorus has been constructed. This is now being transformed into a mathematical model suitable for computer simulation of events in the salt-marsh ecosystem. The model will be tested and refined by computer techniques. Deficiencies in our data shown by computer analysis will be remedied by additional, small-scale field and labortory work. Manipulation of the model simulating changes in flux and storage of phosphorus by various populations (compartments) will help us predict the effect of various natural and man-made changes on the ecology of salt marshes.

In its present primitive state our model tells us that the marsh grass, Spartina alterniflora, which is the dominant primary producer, is unusually important in the biogeochemistry of phosphorus in marshy estuaries. Spartina appears to be taking all its phosphorus requirements from subsurface, reduced sediments that would otherwise be a sink. This phosphorus is released into the water when the Spartina dies and decays, as most of it does. This process undoubtedly has great significance in maintaining high productivity in the estuary.

SUPPORTED BY U.S. Atomic Energy Commission

2.0346, A GEOGRAPHIC ANALYSIS OF THE HYDROLOGIC RESPONSE IN THE SOUTHEASTERN UNITED STATES

J.F. WOODRUFF, Univ. of Georgia, Graduate School, *Athens, Georgia* 30602

The proposed research is directed towards establishing the broad regional patterns of hydrologic response in the Southeastern United States. Maps will be drawn based on the hydrologic response computed: as an average for the 30-year study period; as a 30-year average for the cool and warm seasons; as a 'running average' over the 30-year period; and for precipitation events of varying magnitudes. It is expected that these maps will show regional variations in how watersheds handle their precipitation; how this varies with season; with magnitude of precipitation event; and how it has changed in the last 30 years as the result of man's activities.

In all cases, hydrologic response will be determined by dividing the runoff by total precipitation for the periods or events being studied. Runoff will be separated from discharge by Hewlett's method. The response factor will be computed for 300 stations with 'good' records and spaced as evenly as possible across the study area. Isolines of hydrologic response will be interpolated using these point values.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Georgia

2.0347, AN ANALYTICAL AND EXPERIMENTAL STUDY OF BED FORMS UNDER WATER WAVES

M.R. CARSTENS, Georgia Inst. of Technology, School of Engineering, *Atlanta, Georgia* 30332

The development of, the geometry of, and the drag exerted by bed forms (dunes) which occur on the sea bed under first-order Stokian waves has been studied experimentally in an oscillatory-flow water tunnel. Three series of runs were performed with a different bed material in each series--0.297 mm glass beads, 0.585 mm Ottawa sand, and 0.185 mm Ottawa sand. Total amplitude of the oscillating water was constant during each run and was varied throughout the range from 0.25 ft. to 3.0 ft. for each series of runs. A final report for Contract DA-49-055-CIVENG-65-1 (Georgia Institute of Technology) was issued in September 1967. Publication as a Technical Memorandum of the Coastal Engineering Research Center, U. S. Army Corps of Engineers is pending.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0348, HYDRAULICS OF FLOOD MOVEMENTS

M.R. CARSTENS, Georgia Inst. of Technology, School of Engineering, *Atlanta, Georgia* 30332

Numerical methods for the solution of the non-linear partial differential equations (continuity and linear momentum) for unsteady, gradually varied, open-channel flow are to be thoroughly examined. The thesis is to achieve the following: (a) a theoretical development of the mathematical analog and definitions of the boundary conditions emphasizing the physics of flood routing; (b) a critical review of the literature; (c) a suggested method (or methods) of solution culminating in a flow chart for digital computation.

This research is being used as the basis for a graduate thesis.

SUPPORTED BY Georgia Institute of Technology

2.0349, ADSORPTION OF IONS IN TRACE CONCENTRATIONS ON SOIL AND SILT PARTICLES

G.G. EICHHOLZ, Georgia Inst. of Technology, Water Resources Center, *Atlanta, Georgia* 30332

Study of movement of dissolved ions in very low concentration through compacted porous sand and soil volumes on submicron size silt particles, as a function of relative particle size, mineral and physical characteristics of the particles, water flow, porosity of a synthetic bad, and concentration of suspended matter.

The present project involves primarily the mechanism of movement of those ions that travel by adsorption on very fine silt particles through the porous bed as contrasted with the movement of ions by dynamic ion exchange on the exposed particle surfaces. Radioactive tracers are employed where appropriate.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Georgia Institute of Technology

2.0350, STUDIES OF SAPROLITE AND ITS RELATION TO THE MIGRATION AND OCCURRENCE OF GROUND-WATER IN CRYSTALLINE ROCKS

V.J. HURST, Georgia Inst. of Technology, Water Resources Center, *Atlanta, Georgia* 30332

In the southeastern United States saprolite, weathered rock in which the original textures and structures are preserved, occurs between rock and soil. Near the soil-saprolite boundary develops a low permeability layer which retards infiltration and increases run-off during times of heavy rainfall. This proposal is concerned with the mineralogical, chemical, and textural character of this low-permeability zone, and the correlation of its occurrence and severity with rock type, rock structure, and topography. In order to determine the nature of this zone, the complete profile from soil through saprolite to parent rock must be studied for comparison. Special attention will be directed to determining whether traces of faults, shear zones, and joints act as preferential channelways through the low-permeability layer.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Georgia

2.0351, PILOT STUDY OF THE PROBABILITY OF OCCURRENCE OF CLIMATOLOGICAL PHENOMENA IN THE ATLANTA AREA

C.G. JOHNSON, Georgia Inst. of Technology, School of Engineering, *Atlanta, Georgia* 30332

The purpose of this research is to examine in progressive steps the relationship between present recorded climatological data and its effect upon specific systems of industry. Historical climatological data will be arranged by statistical methods and used to build probability predictive models. These models will then be used to compare and verify their reliability and validity with current local climatological occurrences. These developed models will then be studied with respect to their specific influence on local systems of industry for degrees of predictable relationships. The basic research strategy is planned on a series of progressively larger pilot studies. Phase I of the research is complete and the initial pilot model gave positive results. The research at this stage is nonsponsored and is primarily used as a subject for student development at the graduate level in the School of Industrial Engineering at the Georgia Institute of Technology.

SUPPORTED BY No Formal Support Reported

2.0352, ESTUARINE HYDROGRAPHY AND ITS ROLE IN TRANSPORT OF NATURALLY PRODUCED FOODS AND POLLUTANTS

T.L. LINTON, Georgia Inst. of Technology, Water Resources Center, *Atlanta, Georgia* 30332

The major objective of the program is to conduct a hydrographic study of the three representative types of estuaries that are found in Georgia. The estuaries of Georgia, as well as those of the entire United States, are being destroyed at an accelerated rate. Research is needed to provide basic information concerning estuaries to serve as a guide in formulation of The National Estuary Policy. Through studies of; (1) water mass movements, (2) seasonal temperature, salinity and oxygen patterns, (4) seasonal import of organic/inorganic materials, and (5) seasonal current patterns, a better understanding of the role of hydrographic factors in the distribution of nutrients and pollutants into and throughout the estuaries.

The estuaries of Georgia exist in a relatively undisturbed condition. This study will provide basic information concerning the conditions that are fairly close to the natural state before man-made manipulations occur, and may thus explain some of the causes of the high productive capacity of estuaries. With increases in population and industry the estuaries will be subject to greater pollution pressure. The hydrographic characteristics of estuaries must be known and understood in order to predict the amounts and kinds of effluents that estuaries can receive and their ultimate distribution after entry.

2. WATER CYCLE

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Georgia

2.0353, THE EFFECT OF A PERMEABLE BED ON SEDIMENT MOTION

C.S. MARTIN, Georgia Inst. of Technology, Water Resources Center, *Atlanta, Georgia* 30332

The proposed study is a continuation of an investigation that originally was comprised of three phases. In the completed first phase of the study the magnitude of the seepage force on the top layer of sediment particles on a plane slope was determined. This was accomplished by subjecting the plane slope to seepage flow and then measuring the apparent angle of repose and the piezemetric-head gradient within the bed at foilure. From the experimental results the seepage force on the top layer of bed particles was computed to vary from 1/3 to 1/2 times the corresponding seepage force on sediment particles well within the bed.

The purpose of the proposed second phase of the study will be to determine the criterion governing incipient sediment motion when a plane bed is subject to not only seepage through it but boundary-layer flow over it, as is present in a stream channel. Experiments will be conducted with sand comprising the bottom of a rectangular water channel.

The third phase of the study will be a continuation of the second phase in that the same experimental setup will be utilized. In this case the effect of the seepage force on sediment transport will be ascertained. The sand bed will be allowed to move as the flow through the channel and the seepage flow into or out of the bed are varied.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Georgia Institute of Technology

2.0354, TURBULENT FLOW THROUGH POROUS MEDIA

P.G. MAYER, Georgia Inst. of Technology, School of Engineering, *Atlanta, Georgia* 30332

Turbulent flow through porous media is not treatable by Darcy's law since the inertial effects may not be neglected.

In the proposed study, a mathematical solution will be attempted using finite element techniques as applicable to computer solutions.

A laboratory investigation is proposed to elucidate the physical constants pertaining to turbulent flows through homogeneous and non- homogeneous media.

The results of the study will be useful in predicting flow patterns in coarsely porous media and to determine pressure distributions in earth and rock fill structures.

SUPPORTED BY Georgia Institute of Technology

2.0355, FLOW THROUGH ANISOTROPIC LAYERED MEDIA

P.G. MAYER, Georgia Inst. of Technology, School of Engineering, *Atlanta, Georgia* 30332

Darcy's law of flow through porous media establishes a linear relationship between seepage velocity and hydraulic gradient. When applied to a general three-dimensional flow field, the 'seepage coefficient' is represented by a 3-by-3 matrix defined by nine numerical constants.

Under anisotropic conditions the permeability matrix is symmetrical and three principal axes exist in the direction of which the seepage velocity components are colinear with the pressure gradients.

The determination of equipotential lines and of streamlines is possible for anisotropic layered media by the mathematical method of Finite Elements.

The labroatory study and possible field investigation will include efforts to establish physical constants for natural porous media.

The mathematical study and the laboratory investigations will be correlated to provide tools for solutions of problems involving ground water recharge and subsurface disposal of liquid wastes.

SUPPORTED BY Georgia Institute of Technology

2.0356, FLOW THROUGH UNSATURATED POROUS MEDIA

G.M. SLAUGHTER, Georgia Inst. of Technology, School of Engineering, *Atlanta, Georgia* 30332

The first phase of this investigation will consist of a library search. It is felt that a collection of abstracts of studies made to date of fluid flow in the zone of aeration would be beneficial.

It is anticipated that the investigation will be extended to a laboratory study of flow in an unsaturated porous media. It is felt that more basic knowledge of this subject is required in order to completely solve the hydrologic equation.

SUPPORTED BY Georgia Institute of Technology

2.0357, STATISTICAL ANALYSIS OF FLOOD PEAKS OF GEORGIA RIVERS

G.M. SLAUGHTER, Georgia Inst. of Technology, School of Engineering, *Atlanta, Georgia* 30332

A statistical study, using the annual flood series of the 198 rivers/streams of Georgia, which are measured by the U. S. Geological Survey, will be made. The statistics to be computed include the following: mean, variance, standard deviation, coefficient of variation, coefficient of skewness, and coefficient of kurtosis. The computations will be performed on a Burroughs B-5500 digital computer by the use of an ALGOL 60 program.

On six of the rivers, which have 70 or more years of record, the statistics will be investigated in a number of different chronological subsets in an effort to correlate the findings from the rivers of shorter record.

The purpose of the study is to provide a better method of establishing the design discharge for a given frequency (recurrence interval) for a given hydraulic structure.

SUPPORTED BY Georgia Institute of Technology

2.0358, AIR INJECTION INTO AN AQUIFER

G.M. SLAUGHTER, Georgia Inst. of Technology, School of Engineering, *Atlanta, Georgia* 30332

The proposed research plan involves a laboratory investigation of injecting air into a permeameter. It is anticipated that the injected air will reduce the flow through the porous media. The injected air thus becomes a barrier to the flow which could prove quite beneficial in the case of a salt water intrusion problem.

A preliminary study has been conducted in which the results were not encouraging. That is, the injection of air into two different uniform sand test sections only decreased the discharge by approximately 10 per cent. It is felt that this small reduction is due in part to the scale effect of the permeameter and therefore, additional investigations with a different type of permeameter are planned.

SUPPORTED BY Georgia Institute of Technology

2.0359, THE EXTRACTION OF POTASSIUM FROM FRESH AND SALINE WATERS BY CLAY MINERALS

C.E. WEAVER, Georgia Inst. of Technology, Water Resources Center, *Atlanta, Georgia* 30332

The general objective is to determine how and to what extent the chemistry (particularly potassium) of fresh and saline waters is controlled by clay minerals and gels, both in the laboratory and in natural environments.

Using waters of various compositions, the ability of a variety of clay minerals to extract specific cations will be determined and the mean free bonding energies of the cations calculated. The release of interlayer clay water to the fluid will be measured and the factors controlling the return of adsorbed cations to the fluid phase as the chemistry of the water changes will be determined.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Georgia Institute of Technology

2.0360, THE EFFECT OF CLAY MINERALS ON THE CHEMICAL COMPOSITION OF FRESH AND SALINE WATERS

C.E. WEAVER, Georgia Inst. of Technology, Water Resources Center, *Atlanta, Georgia* 30332

The general objective is to determine how and to what extent the chemistry (Ca,Na, K, Mg, Al, Si, Mn, Fe) of fresh and saline waters is controlled by clay minerals and associated organic matter, both in the laboratory and in natural environments (rivers, estuaries, ground water).

The exchange of cations between the clay and the water can be a major factor in controlling the chemical composition of natural waters. Much of the ground water in sediments is present in muds and shales or has been squeezed from them during burial. Efforts will be made to determine how the clay minerals change the chemistry of pore water during deep burial (down to 20,000 feet).

Laboratory experiments will be conducted to determine quantitatively, the nature of the exchange of cations between the various clay minerals and organic materials and various natural waters. It will be determined how the nature of the clay-organic-water interaction varies as the solid material moves from one water environment to another. Mechanisms effecting ion exchange will be studied and attempts will be made to determine how strongly some of the cations are bonded to the solids.

A series of clay cores extending to a depth of 16,450 feet will be studied. Chemical, mineralogic and isotope studies of these cores will be made to determine how the clays modify the interstitial waters during burial.

Field experiments will be carried out in one or more river systems to determine quantitatively what effect the suspended clay and organic material has on the annual load of cations carried by the rivers.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Georgia Institute of Technology

2.0361, TROUT STREAM - SURVEY OF STREAMS AND THEIR WATERSHEDS

C. HASTINGS, State Game & Fish Commission, *Atlanta, Georgia*

To collect additional pre-development biological and physical data regarding Walnut Fork and Hood Creeks.

To measure biological and physical changes in Walnut Fork and Hood Creeks as erosion control methods and devices are employed.

Procedures: Both biological and physical data will continue to be taken on Walnut Fork and Hood Creeks this fiscal year to augment data taken previously and to measure biological and physical changes as erosion control methods and devices are employed.

Data which will continue to be taken on these two streams include amounts of fishing pressure (creel census), water temperatures, air temperatures, stream widths, stream depths, volumes of flow, water velocities, species of fish taken, numbers of fish taken, lengths of fish, weights of fish, types of stream bottom, amounts of cover, amounts of bottom organisms, classifications of bottom organisms, use of spawning sites--both natural and constructed, pictures, movements of trout, turbidities, dissolved oxygen content, carbon dioxide content, hydrogen-ion concentration, total hardness, and silt deposition.

Fish population studies (500 feet in length) will be continued on these streams at the rate of three sample areas per mile. Cresol and/or shocking equipment will be used in collecting fish.

The bottom samples will be collected by the use of a surber sampler which takes a sample of one square foot. Bottom samples will be qualitative and quanitative. Organisms will be identified to order and samples will be determined in quantity by volumetric means.

The survey findings and any additional recommendations will be reported.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Georgia State Government

2.0362, MECHANICS OF FLUID RESISTANCE

H.J. TRACY, U.S. Dept. of Interior, Water Resources Division, *Atlanta, Georgia*

The one problem that is perhaps the most characteristically hydraulic in nature is the problem concerned with fluid resistance at a boundary. The expenditure of energy throughout the flow is dependent upon the boundary resistance. Adopting a basic viewpoint, the problem is one dealing with the transport of energy and momentum by turbulent motion and the effect of these transport processes in determining the mean flow fluid. In other words the problem is vitally dependent upon the mechanism by which turbulent fluid motion receives, transports, and expends energy.

The objective of this study is to attempt to describe the fluid resistance in terms of dimensionless ratios characterizing the physical dimensions of the roughness projections. The descriptive measurement of these effects, however, can contribute to the development of any ultimate theory only if they are relevant to the mechanisms which determine the flow field, in other words, relevant to the aforementioned transport processes.

Because suitable instrumentation needed to investigate and measure point velocity, turbulence, and energy spectra in water is not yet available, the experimental work will be performed in an artificially roughened, closed, circular, air tunnel using a hot-wire anemometer. This work will consist of tests in which roughness resulting turbulence and energy spectra will be used to determine what geometric ratios representative of the boundary roughness are significant as well as their influence upon choice of friction coefficient.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0363, IRRIGATION AND FERTILITY PRACTICES FOR FLUE CURED-TOBACCO

G.N. SPARROW, Univ. of Georgia, Agricultural Experiment Sta. , *Tifton, Georgia*

Objectives: 1. To determine a favorable balance of soil moisture and plant nutrients for high yields of good quality tobacco. 2. To evaluate the hazard of excessive rains following immediately after an irrigation. 3. To express these determinations in standard terms in order to permit wide application of results.

Description of work: 16 treatments, consisting of 4 levels of nitrogen under 4 levels of soil moisture, are arranged in a randomized block design with 3 replications. Data obtained includes soil physical characteristics, soil moistures, irrigation amounts and frequency, yield, grade, acre value and chemical and physical analysis of leaf samples.

SUPPORTED BY Georgia State Government

2.0364, THE RESPONSE OF PEANUTS TO SUPPLEMENTAL IRRIGATION

J.R. STANSELL, Univ. of Georgia, Agricultural Experiment Sta. , *Tifton, Georgia*

Objectives: 1. To determine the amount and frequency of supplemental irrigation required for optimum production of runner peanuts. 2. To determine the limits of soil moisture within which runner peanuts will produce satisfactory yields of high quality. 3. In cooperation with interested specialists, to study and control if practical, the undesirable side effects of irrigation on peanuts, particularly excessive pod shedding. 4. To ascertain the comparative responses of selected varieties of peanuts to high levels of soil moisture.

Description of work: A replicated study will be initiated for each of the four objectives above. (1) Runner peanuts will be grown under 4 levels of soil moisture. (2) An automatic cover will prevent rain from falling on plots. Four irrigation treatments will be studied. (3) Chemical treatments of soil will be tested for effectiveness in preventing pod shedding under two levels of soil moisture. (4) Four varieties of peanuts will be grown under two levels of soil moisture.

SUPPORTED BY Georgia State Government

2.0365, HYDROLOGIC RELATIONS IN HAWAII

R.R. PULFREY, U.S. Army, Engineer District, *Fort Armstrong - Honolulu, Hawaii* 96813

1. Purpose: To establish criteria for hydrologic design of flood control projects and for plain information studies.

2. Procedure: The investigation involves data collected from a dense network of rainfall and streamflow gages located in three small drainage basins ranging from 4.3 to 6.2 square miles in area. The three areas are: Kalihi Stream - island of Oahu, Wailua Stream - island of Kauai and Kohakohau Stream - island of Hawaii. Continuous record of flow at the three drainage area outlets and two upstream points in two areas is being obtained. Rainfall instrumentation includes 17 recording and 12 non-recording rain gages. The basic data are analyzed to derive general rainfall-runoff relationships which are incorporated into hydrologic design criteria.

3. Progress. Project Bulletin No. 1, printed 30 November 1964, shows the preliminary results of studies in the Kalihi Basin. Collection of data in the Kalihi Basin will be completed at the end of FY-67. The scheduled activity for fiscal year 1968 is the continued collection and analysis of rainfall and streamflow data for the remaining two basins, correlation of physical characteristics of the drainage areas and their effects on runoff, and development of unit hydrographs.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0366, HYDROLOGIC STUDIES (STORM STUDIES) HAWAIIAN ISLANDS

R.R. PULFREY, U.S. Army, Engineer District, *Fort Armstrong - Honolulu, Hawaii* 96813

1. Purpose: To conduct a detailed analysis of selected past Hawaiian Island storms for use in various meteorological investigations including determination of design rainfall for studies or construction involving streamflow.

2. Procedure: a. Part IA consists of compilation of basic rainfall data, construction of mass rainfall curves and preparation of preliminary isohyetal maps by use of isopercentile maps. b. Part IB includes the tabulation of mass curve data, computation of maximum accumulated rainfall amounts at each station by selected time intervals, and the determination of time of occurrence of maximum rainfall for selected durations. A detailed meteorological analysis is prepared by the U. S. Weather Bureau.

3. Progress: Parts IA and IB for storm of 14-16 Apr 63, Island of Oahu; Part IA, 24-27 Jan 56, Island of Kauai; and Part IA, 2-3 Apr 61, Island of Hawaii are complete. Investigation of assigned storms will continue in FY-1968.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0367, TIMBER AND WATERSHED RESOURCES DEVELOPMENT RESEARCH IN HAWAII

R.E. NELSON, U.S. Dept. of Agriculture, *Honolulu, Hawaii*

Object: To select the best adapted and most productive tree species and determine management for timber and other purposes; to determine the hydrologic relations among climate, soils, and wildland vegetation, and develop watershed management methods for improved water yield, and flood and erosion prevention; and to determine quality, properties, and related characteristics and requirements for processing and marketing woods.

Plan of work: Timber management research is underway on: evaluation of tree species and provenances for adaptability to various environmental conditions; the silviculture of Acacia koa and other selected species; and determining the growth of selected exotic and native species. Current watershed management research includes studies of evapotranspiration, soil erodibility, and rainfall-streamflow relations. Forest products utilization research includes studies of mechanical and physical properties, durability, seasoning of wood, and wood quality. The project includes other studies to be undertaken during the next five years.

Cooperation: Hawaii Dept. of Land & Natural Resources; University of Hawaii, Soil Conservation Service; Hawaii Dept. of Social Services; Bishop Estate and C. Brewer & Co., Ltd.; Campbell Estate; Hawaiian Fern-Wood, Ltd.; Honolulu Wood Treating Company; and others.

SUPPORTED BY U.S. Dept. of Agriculture

2.0368, TRANSPORT PROCESSES IN FLUID FLOWS

A. OGATA, U.S. Dept. of Interior, Water Resources Division, *Honolulu, Hawaii*

Techniques for constructing artificial sandstone models simulating aquifer systems, and using dyes or radioactive tracers to detail dispersion effects in the fluid flow therein, are well advanced. The development of methodology is now pointed toward the determination of those physical parameters of the medium which control the pattern of flow. Because the description requires a knowledge of the path of the fluid particles, the use of tracer methods seems to be the most promising approach. Theoretical study of presently available flow equations will involve the study of the matrix parameters by means of dimensional and inspectional analysis. Laboratory analysis based on theoretical findings and various tracer characteristics is planned. Projected studies will involve progressively more complex media characteristics.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0369, GEOPHYSICAL EXPLORATION FOR HAWAIIAN GROUND WATER - PHASE III

W.M. ADAMS, Univ. of Hawaii, Water Resources Research Ctr. , *Honolulu, Hawaii* 96822

The adaptation of geophysical exploration procedures and instrumentation to volcanological hydrology, and application of the methods developed to exploiting ground water resources in Hawaii: A. A novel seismic correlation technique using transparent sonograms; B. Seismic holography; C. High voltage (5000 volts) electrical restivity system for restivity profiling to delineate ground water sectors and for restivity sounding to estimate the water table depth in a sector; D. Photometric reflectivity and multispectral photography for surveillance of coastal springs.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Hawaii

2.0370, STUDY OF THE ENERGY BUDGET ON THE HAWAIIAN ISLANDS

J. CHANG, Univ. of Hawaii, Graduate School, *Honolulu, Hawaii* 96822

Incoming radiation, reflectivity of the ground surface, and also its re-radiation will be studied in relation with evapotranspiration.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.0371, GEOPHYSICAL EXPLORATION FOR HAWAIIAN GROUND WATER - PHASE II

D.C. COX, Univ. of Hawaii, Water Resources Research Ctr. , *Honolulu, Hawaii* 96822

The applicability and further development of several geophysical techniques to ground water exploration problems in Hawaii will be investigated: a) Seismic techniques in relation to detailing lava structure at and below the water table, using signal averaging techniques and vibration inputs and multiple impulses; b) Resistivity surveys in relation to mapping of water-tables and salt fresh water interfaces and location discontinuities between high-head and low-head ground-water bodies; c) Thermal and light sensing in relation to detection and evaluation of coastal spring discharge; d) Electromagnetic sounding in relation to determination of water-table depths in arid areas.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Hawaii

2.0372, PILOT EVAPOTRANSPIRATION STUDY WITH LYSIMETERS OF WATER USE BY SUGAR CANE, PINEAPPLE AND TROPICAL TRUCK CROPS

P.C. EKERN, Univ. of Hawaii, Agricultural Experiment Sta. , *Honolulu, Hawaii* 96822

Objectives: 1. Develop a hydraulically counter balanced lysimeter. 2. Develop lysimeters stable against tipping by very tall crops. 3. Develop lysimeters for use in very heavy rainfall and with low-transpiring crops.

It is proposed in this project to initiate an investigation of the effect of water on crop yield and quality of sugar cane, pineapple, and tropical truck crops, extending earlier research on the magnitude of consumptive use of sugar cane and pineapple. Specifically in this pilot phase it is proposed to investigate modifications of semi contained hydraulic lysimeters required to make such lysimeters suitable for use with Hawaiian crops, taking into account, for example, the great height of sugar cane, the occasional periods of very heavy rainfall and the low level of consumptive use by pineapple.

SUPPORTED BY Hawaii State Government

2.0373, EVALUATION OF THE SULFUR SUPPLYING CAPACITY OF HAWAIIAN SOILS

R.L. FOX, Univ. of Hawaii, Agricultural Experiment Sta. , *Honolulu, Hawaii* 96822

1. To determine the sulfur status of Hawaiian soils and estimate sulfur added in rainfall and irrigation waters. 2. To determine the sulfur requirement of important crops. 3. To study factors which influence the availability of soil and fertilizer sulfur.

Soil profile samples will be examined for various sulfur factions. Crops will be grown on the soils in field and pot culture to determine the availability of the various forms of soil sulfur. The sulfur content of rain and air will be determined in relation to distance and elevation from the sea. Factors which influence the availability of fertilizer sulfur will be studied.

SUPPORTED BY Hawaii State Government

2.0374, SOIL-WATER RELATIONS OF HAWAIIAN SOILS

R.E. GREEN, Univ. of Hawaii, Agricultural Experiment Sta. , *Honolulu, Hawaii* 96822

1. Determine the soil water retention and conducting properties of the important agricultural and watershed soils of Hawaii. 2. Relate soil water retention and conductivity to the structural and mineralogical properties of soils. 3. Determine the magnitude of hysteresis in both water retention and capillary conductivity, and evaluate its importance in soil moisture measurements by suction techniques for irrigation control purposes.

Soil-water relations of several important Hawaiian soils will be studied in the laboratory using conventional pressure-membrane equipment to measure soil water retention and a steady-state flow system to measure capillary conductivity. These studies will provide (1) necessary data for application of moisture flow theory to complex infiltration and evapotranspiration problems, (2) moisture retention information needed for precise soil moisture control under irrigation, and (3) an evaluation of the dependence of soil-water relations on soil structure and mineralogical composition.

SUPPORTED BY Hawaii State Government

2.0375, WATER TRACING AND DATING IN HAWAII HYDROLOGIC CYCLE

L.S. LAU, Univ. of Hawaii, Water Resources Research Ctr. , *Honolulu, Hawaii* 96822

It is proposed to investigate the applications of tracer techniques, principally tritium and radiocarbon, to aid in determining the age, circulation and movement of water in the Hawaii hydrologic cycle and particularly that part pertaining to ground water. This project is to extend and expand a current project headed by L. S. Lau and L. Barnes, entitled Ground Water Tracing, and jointly supported heretofore by the Water Resources Research Center, University of Hawaii and Board of Water Supply, City and County of Honolulu.

Tritium content will be assayed with a liquid scintillation system with enrichment of samples. Radiocarbon will be likewise assayed but with benzene conversion. Water sampling will include ground water, rain water and surface water mostly on Oahu. Interpretations of field data will be complemented with considerations of theoretical models.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Hawaii

2.0376, PREDICTION OF WATER MOVEMENT IN UNSATURATED SOILS

G. UEHARA, Univ. of Hawaii, Agricultural Experiment Sta. , *Honolulu, Hawaii* 96822

1. To investigate the nature of the particle coatings of certain slowly wetted Hawaiian soils. 2. To investigate the influence of ionic environment, pH, and moisture content on the wettability of these soils. 3. To evaluate the factors associated with the development of slowly wettable soils.

Description of Work: Investigations on the cause leading to slow wettability of certain soils and the correction of the property are the primary objectives of this project. Measurements of such soil properties as particle size distribution, soil aggregation, ionic environment, compaction, moisture content and mineralogy by standard methods and the correlation of those factors with wettability summarize the nature of this work. In the event wetting properties of these soils can be improved in the laboratory application of the same technique in the field is anticipated.

SUPPORTED BY U.S. Dept. of Agriculture
Hawaii State Government

2.0377, MACADAMIA CULTURE

R.M. WARNER, Univ. of Hawaii, Agricultural Experiment Sta. , *Honolulu, Hawaii* 96822

The project objectives are to: a. Determine the best method for establishment of macadamia orchards on bauxitic soils, using heavy lime and fertilizer applications. b. Establish small clonal orchards of the three principal macadamia varities on Kauai for future investigations on cultural practices, including mechanical harvesting, where none now exist. c. Study the value of supplemental irrigation on the establishment of young orchards in a high but erratically distributed rainfall area. d. Determine the value and effectiveness of grafting to eliminate bitter nut seedlings from orchards by means of reciprocal stock and scion grafts. e. Study on an existing ten- year old clonal orchard at the Waimanalo Farm, on Oahu, the effects of three levels of supplemental irrigation, heavy, light and unirrigated, on premature nut drop, size, quality and total yield of macadamia nuts. The three moisture regimes will be maintained April to October during the critical period when the main portion of the crop is developing.

SUPPORTED BY U.S. Dept. of Agriculture
Hawaii State Government

2.0378, TIDAL EFFECTS ON GROUND WATER HYDRAULICS IN HAWAII

J.A. WILLIMS, Univ. of Hawaii, Water Resources Research Ctr. , *Honolulu, Hawaii* 96822

It is proposed to study the response of basal ground water aquifers to tidal fluctuations. Investigation will be limited to several representative types of aquifer which may be found in the Hawaiian Islands. The purpose of the study is to verify and possibly extend existing analytical results through laboratory experiment, to relate laboratory results with field observations, and finally to determine the relationships between tidal response and aquifer characteristics (i.e. storage, transmissibility, thickness) for the aquifers tested.

The basic study will be conducted with hydraulic models in the laboratory, with analytic or analog techniques used to supplement the model study. A pilot model of simple boundary geometry for which analytical results are available will be used to verify the modeling technique.

2. WATER CYCLE

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Hawaii

2.0379, PILOT-STUDY OF SMALL WATERSHED HYDROLOGY

I. WU, Univ. of Hawaii, Agricultural Experiment Sta. , *Honolulu, Hawaii* 96822

Objectives: (1) To study the existing rainfall and streamflow data and the instrumentation schemes for obtaining such data. (2) To study the flood damage from small watersheds to agricultural land and urban areas. (3) To review the current design criteria for runoff and flood determination. (4) Design a long term project for determining the rainfall runoff relationships.

Description of Work Proposed: (1) Review, collate, and analyze the existing collections of rainfall, streamflow, and other data pertaining to runoff determination and floods in Hawaii. (2) Study the present instrumentation schemes for obtaining such data. (3) Study and appraise the applicability of formulae and review the current design criteria for runoff determination and flood prevention construction. (4) Develop mathematic equations for flood hydrographs which fit the hydrological situation of the Hawaii Islands.

SUPPORTED BY Hawaii State Government

2.0380, STUDY OF IRRIGATION SYSTEM DESIGN CRITERIA FOR HAWAIIAN VEGETABLE CROPS

I. WU, Univ. of Hawaii, Agricultural Experiment Sta. , *Honolulu, Hawaii* 96822

Objectives: 1. To determine the soil water relations of Lalamilo soils. 2. To determine the soil-water-plant relations. 3. To determine an adequate irrigation practice. 4. Economic analysis of the yield and water use.

Description of Work Proposed: (1st year) 1. Collecting data from pan evaporation. 2. Collecting evaporation data from bare soil surface. 3. Determination of the soil water relations. 4. Study the irrigation pattern, the uniformity of its application. 5. Correlation of pan, soil evaporation to weather variables.

SUPPORTED BY Hawaii State Government

2.0381, PILOT STUDY OF SMALL WATERSHED FLOOD HYDROLOGY IN HAWAII, PHASE II

I.P. WU, Univ. of Hawaii, Water Resources Research Ctr. , *Honolulu, Hawaii* 96822

The proposed research plan is a continuation of the original project. This is designated as phase II.

The primary objectives and scope of the project are 1) to provide fundamental understanding on flood hydrology in Hawaii through analysis and study of existing available precipitation and streamflow data and with limited supplemental studies designed primarily to characterize physiography and land use, and 2) to evaluate the effects on urbanization on flood discharge, and 3) to prepare a research program designed to study rainfall-runoff relationship and design criteria for flood drainage.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Hawaii

2.0382, HORTICULTURAL CROP RESPONSE TO IRRIGATION PRACTICES

D.F. WILLIAMS, Univ. of Hawaii, Agricultural Experiment Sta. , *Waiakoa - Maui, Hawaii*

Project objectives 1) Determine the relative advantages of different methods of irrigation for, and the effect of irrigation at different soil moisture tensions on the growth of some major island crops. 2) Relate laboratory measurements of moisture characteristics of the major island soils (Project 133S) to crop growth in the field under different irrigation practices.

Description of work proposed - Replicated plantings of several vegetables and flowers will be overhead irrigated with perforain pipe and surface irrigated with gated pipe (furrow and basin) and canvas trickle hose. Soil moisture and root growth patterns will be followed by, and irrigation based on, measurements from moisture blocks and tensionmeters placed at different depths and distances from the crop row. Crop growth and disease incidence recordings will be related to irrigation treatment and daily pan evaporation and net radiation readings. Experiments will be repeat planted at different seasons of the year to determine season (day-length, net radiation) - crop response interactions; and on different soil types to determine soil type-crop response interactions, and the relationship of soil moisture characteristics to crop response on different soils. Varietal, plant population and fertility variables will be included wherever experimental design permits.

SUPPORTED BY Hawaii State Government

2.0383, INVESTIGATION OF NEW METHODS (NUCLEAR EQUIPMENT) FOR DETERMINING MOISTURE CONTENTS, AND COMPACTION DENSITIES OF SOILS AND AGGREGATES

H.L. DAY, State Dept. of Highways, *Boise, Idaho*

This study includes investigating new methods of determining moisture contents and compacted densities of soils and aggregates including the use of nuclear equipment for this purpose.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Idaho State Government

2.0384, EVAPOTRANSPIRATION UNDER NATURAL CONDITIONS

L.M. COX, U.S. Dept. of Agriculture, *Boise, Idaho*

Object: To study the loss of water by the evaporative process from ponds, irrigated alfalfa and sagebrush rangelands in a semiarid environment; to determine the actual loss of water from representative sites, including the microclimate and soil moisture status; and for predictive purposes to develop a procedure for proportioning the available energy, including advective energy, into sensible heat and latent heat fluxes for wide ranges of soil, vegetation and moisture conditions; and to develop coefficients for estimating actual water loss in terms of the potential evaporative demand.

SUPPORTED BY U.S. Dept. of Agriculture

2.0385, INFILTRATION AS INFLUENCED BY SOIL-VEGETATION COMPLEXES

L.M. COX, U.S. Dept. of Agriculture, *Boise, Idaho*

To determine the infiltration capacity of the various soil vegetation complexes occurring on a semiarid mountainous watershed under different antecedent moisture conditions and for various levels of intensity and duration; and to develop predictive relationships associating expected infiltration to soil and vegetation properties, soil temperature and moisture status; and meteorological factors.

Plan of Work: This work is in progress on the Reynolds Creek Experimental Watershed southwest of Boise, Idaho. A rainfall will be used to evaluate site infiltration on the various soil-vegetation complexes that have already been delineated.

SUPPORTED BY U.S. Dept. of Agriculture

2.0386, PRECIPITATION CHARACTERISTICS INFLUENCING HYDROLOGIC PERFORMANCE OF AGRICULTURAL WATERSHEDS IN THE PACIFIC NORTHWEST

W.R. HAMON, U.S. Dept. of Agriculture, *Boise, Idaho*

Object: To develop methods for evaluating precipitation for an area, both with respect to rates and amounts; to determine seasonal variations in precipitation types and amounts, storm duration, intensity and areal extent expectancies; to determine pertinent characteristics of precipitation with respect to runoff and sediment movement; and to evaluate the characteristics of the snowpack producing storms.

Plan of Work: The work is carried on principally in the Reynolds Creek Experimental Watershed southwest of Boise, Idaho, by means of a network of recording raingages and snow courses for precipitation measurements. Some aspects of the studies are in progress from headquarters in Moscow, Idaho.

SUPPORTED BY U.S. Dept. of Agriculture

2.0387, RUNOFF AND SEDIMENT MOVEMENT ON UNIT SOURCE WATERSHEDS OF THE PACIFIC INFLUENCED BY CLIMATE, SOILS, VEGETATION AND TOPOGRAPHY

W.R. HAMON, **U.S. Dept. of Agriculture, *Boise, Idaho***

Object: To develop methodology and criteria for characterizing soil-vegetation-geologic complexes; to evaluate the effects of these complexes on storm runoff, water yield and sediment movement; to determine the effects of these complexes on deposition and melt of snow and evaluate the interrelations of climatic factors with these complexes; and to develop criteria for judging areas of high water yield, storm runoff, and sediment production from known parameters.

Plan of work: This work is in progress on the Reynolds Creek Experimental Watershed southwest of Boise, Idaho. Various soil vegetation-geologic complexes have been delineated and instrumented intensively to measure precipitation; sediment yield; temperature, radiation; wind; slope; watershed shape, size, and exposure; amount and kind of vegetation; kind of soil and rock; snow density and depth; height and distance of obstacles to wind and snow, and other factors which may be pertinent.

SUPPORTED BY U.S. Dept. of Agriculture

2.0388, SNOW ACCUMULATION AND MELT ON STUDY AREAS

F.M. SMITH, **U.S. Dept. of Agriculture, *Boise, Idaho***

To determine the physical and meteorological factors contributing to nonuniformity of snow accumulation in shrub-covered study basins on mountainous terrane; to determine the influence of the controlling physical and meteorological factors on snowmelt from the above areas.

Plan of Work: This work is in progress on the Reynolds Creek Experimental Watershed southwest of Boise, Idaho. A photogrammetric technique is being used to describe the basic land and snow surfaces with such precision that it is possible to analyze accumulation and melt patterns over the entire study area. An energy balance at the snow-surface is also used to evaluate the melt rate.

SUPPORTED BY U.S. Dept. of Agriculture

2.0389, FUNDAMENTAL ASPECTS OF WATER EROSION IN THE PACIFIC NORTHWEST

M.E. JENSEN, **U.S. Dept. of Agriculture, *Kimberly, Idaho***

Object: To determine the causative factors of water erosion and the processes by which soil materials are removed and transported by water; to develop suitable methodology and devices for studying water erosion phenomena; and to determine effects of various soil, crop, land surface, topography, and climatic factors on infiltration and water erosion in the Pacific Northwest.

Plan of Work: Work under this project employs devices such as rainfall towers, portable field rainulators, and extensive field and laboratory plot control equipment for application of rainfall under specified conditions. Development of such research tools is a part of this activity. Control of climate including freezing and thawing of experimental plots, both prior to and during water application tests, as well as fixed control of soil variables by controlled tillage, crop residues, and other management factors permit development of basic relationships between various soil, cover, and climatic factors and the phenomena of soil loss by water erosion. The infiltration and water transmission in frozen or partially thawed soil is under investigation.

Cooperation: Washington Agricultural Experiment Station; SCS; and others.

SUPPORTED BY U.S. Dept. of Agriculture

2.0390, SIMULATION MODEL FOR EVALUATION OF INTERCEPTION FROM FOREST TREES

G.H. BELT, **Univ. of Idaho, Graduate School, *Moscow, Idaho* 83843**

Digital simulation models expressing the mechanisms controlling accumulation and depletion of intercepted snow from single trees will be developed. The models will reflect both meteorological and vegetational parameters influencing the interception process. The validity of the models will be tested using experimental data gathered by the Principal Investigator and obtained from the literature.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Idaho

2.0391, EFFECT OF PHYSICAL PROPERTIES OF POROUS MEDIA ON WATER MOVEMENT

G.L. BLOOMSBURG, **Univ. of Idaho, School of Engineering, *Moscow, Idaho* 83843**

The work will involve a numerical solution of the Navier Stokes equations for flow around arrays of particles. The numerical solution for the velocity and pressure distributions will be compared to experimental results. Another portion of the project will consist of relating the permeability of porous media directly to physical properties of the media -- such as porosity and particles size -- with no undefined shape or orientation factors. This portion of the project will consist largely of review of existing theories and experimental work.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Idaho

2.0392, EFFECT OF EXTERNAL AIR PRESSURE ON LIQUID FLOW THROUGH A POROUS MEDIUM

G.L. BLOOMSBURG, **Univ. of Idaho, Agricultural Experiment Sta. , *Moscow, Idaho* 83843**

Objectives: (1) To determine the effect of external pressure on th liquid permeability of a porous medium containing trapped air. (2) To determine the effect of external pressure on the amount of trapped air.

There is evidence from several field studies of canal seepage that there is a relationship between atmospheric pressure and permeability due to trapped air in the soil. In this laboratory study the relationship will be studied as well as the effect of pore size and atmospheric pressure on the amount of trapped air. The porous media used will be glass beads packed into a plastic column approximately 1 1/4 inches in diameter and 2 feet long. A hydrocarbon liquid or water will be used as the flowing liquid.

SUPPORTED BY U.S. Dept. of Agriculture
Idaho State Government

2.0393, DISTRIBUTION AND ECOLOGY OF AQUATIC INSECTS OF IDAHO

M.A. BRUSVEN, **Univ. of Idaho, Agricultural Experiment Sta. , *Moscow, Idaho* 83843**

Objectives: (1) Inventory the aquatic insects of Idaho to determine their distribution and abundance. (2) Study the biology of the aquatic insects of Idaho for the purpose of determining their life histories, ecological habitats, inter-and intra-specific relationships with other animals, parasites and predators, food habits, and importance to man and domestic animals. (3) Study the population dynamics of insects in selected aquatic habitats in order to determine and evaluate the biological and physical effects of the environment on the population.

The purpose of this study will be to determine the fauna, distribution, biology and ecology of aquatic insects in streams, lakes, ponds, reservoirs, drainage and irrigation ditches in Idaho. Various techniques for collecting in different habitats will be employed such as bottom scrapers, Surber bottom samplers, aquatic seines, nets and dredges in order to ascertain both qualitatively and quantitatively the insect fauna. An evaluation will be made of water chemistry, substrate, depth of water, turbidity, temperature, food and inter- and intraspecific relationships in order to determine their effects on the distribution an population dynamics of aquatic insects. Laboratory rearing studies in aquaria and tanks will supplement field data in delineating the bionomics, life histories, and role of insects in the aquatic ecosystem.

2. WATER CYCLE

SUPPORTED BY U.S. Dept. of Agriculture
Idaho State Government

2.0394, NON-STEADY 2 AND 3-DIMENSIONAL FLOW OF FLUID INTO POROUS MATERIAL

G.L. COREY, Univ. of Idaho, Agricultural Experiment Sta. , *Moscow*, *Idaho* 83843

Objectives: (1) To investigate possible approximate solutions for the differential equation describing non-steady 2 and 3-dimensional flow of a fluid into a porous material. (2) To determine experimentally the relationships between discharge, advance of the wetted front, and time when a fluid enters a porous material at a capillary pressure sufficiently high to eliminate complete saturation near the source. (3) To determine the effect of initial moisture content on the above relationships.

The diffusion approach toward flow into porous media has been thoroughly investigated for one-dimensional flow, however information is very limited concerning the more important 2 and 3-dimensional flow cases. Relationships between discharge, rate of advance and time will be experimentally determined. The fluid will be forced to enter the material at a tension so that the diffusion equation will be truly tested. The effect of initial moisture content on imbibition will be determined. An attempt will be made to solve with analog techniques the differential equation describing this flow so that the analytical solution can be compared with the experimental data.

SUPPORTED BY U.S. Dept. of Agriculture
Idaho State Government

2.0395, INTERACTION OF TEMPERATURE WITH OTHER FACTORS ON THE RESPONSE OF CANADA THISTLE TO HERBICIDES

L.C. ERICKSON, Univ. of Idaho, Agricultural Experiment Sta. , *Moscow*, *Idaho* 83843

Objectives: (1) To determine the influence of two nitrogen, phosphorus, moisture and temperature regimes on the growth and reproduction of Canada thistle Cirsium aruense L. (2) To determine the influences of these factors on the efficiency of moisture utilization of thistle growth (weight). (3) To determine the influences of these factors on the response of this species to herbicides.

This study will be conducted primarily in the greenhouse using individual plant containers. The growth media will be a N and P deficient sandy loam soil. Nitrogen and P2O5 will be added at O and 100 lbs equivalent/A. Moisture will be maintained at 1/3, and 1 atmosphere. A temperature difference of 10o F. will be maintained for 14 days before and following the herbicide application.

Prior to the herbicide applications two harvests will be made to determine the influences of fertility, and moisture on subsequent growth. Final phytotoxic effects will be determined by survival, date and vigor of re-growth, and finally plant weight.

SUPPORTED BY U.S. Dept. of Agriculture
Idaho State Government

2.0396, EVALUATION OF CLIMATIC PATTERNS AFFECTING IDAHO AGRICULTURE

D.O. EVERSON, Univ. of Idaho, Agricultural Experiment Sta. , *Moscow*, *Idaho* 83843

Objectives: (1) To complete the recording on punch cards of weather data from selected locations within Idaho. (2) To analyze precipitation data to determine the probabilities of receiving specified amounts of precipitation for weekly periods and three-week moving averages of these periods for each of the selected locations. (3) To determine whether there exist any detectable changes in precipitation and temperature normals over years when such data are available. (4) To analyze evaporation data during the growing season to establish its variation and range.

The limiting climatic factors influencing production in the agricultural regions of Idaho should be more clearly defined by statistical evaluation of weather records. Data spanning a thirty year period for about 15 weather stations are sufficient for this description. Precipitation data are not normally distributed, however use of the gamma distribution permits calculation of the probabilities of receiving given anounts of rainfall. Means and standard deviations of weekly temperatures, growing degree days and evaporation will adequately describe these climatic factors for use in making intelligent agricultural decisions.

SUPPORTED BY U.S. Dept. of Agriculture
Idaho State Government

2.0397, NORTHERN IDAHO ALFALFA PROBLEM

R.W. HARDER, Univ. of Idaho, Agricultural Experiment Sta. , *Moscow*, *Idaho* 83843

Objectives: A. Determine if root growth is being limited by soil conditions to the degree that they do not function properly in assimilating available nutrients and moisture from the soil. B. Determine if the soil conditions influence nutrient availability by effecting the chemistry of the soils. C. Determine the soil moisture movement pattern to find out if soil conditions are impeding water movement in such a way that the roots are unable to get an adequate supply of water or oxygen. D. Determine if physical conditions of the soil are effecting microbial activity. This study will be made on undisturbed soil cores, disturbed samples and on field plots on soils under virgin forest, and in areas where both normal and 'sick' alfalfa is growing. Detailed morphological, moisture movement pattern, nutrient uptake, and root growth studies will be made on both normal and 'sick' alfalfa sites in situ. Physical analysis of soil structure will be made in the laboratory. Various physical and chemical treatments will be made on core and disturbed soils and alfalfa growth habits will be studied. Chemical characterization of 'sick' and normal soils and alfalfa plants from these soils will be made. Microbial response to modification of physical and chemical properties of the soil in the field and greenhouse will be studied.

SUPPORTED BY Idaho State Government

2.0398, LIMNOLOGICAL STUDIES OF LENTIC WATERS IN IDAHO

F.W. RABE, Univ. of Idaho, Water Resources Research Inst. , *Moscow*, *Idaho* 83843

Four alpine lakes in the Five Lakes Butte Area in northeastern Idaho will be studied together with a reservoir located outside of McCall, Idaho which is scheduled for filling during the fall of 1966. Objectives are to determine the physical and chemical characteristics of the waters during the summer and limited samples during the winter, to measure primary production of the phytoplankton in the reservoir waters, to measure secondary production in both high lakes and reservoirs as pertains to zooplankton and macro-invertebrates, and to relate fish production with the biotic parameters measured in the high lakes. Limnological measurements of the newly impounded reservoir water over the years will help make it possible to compare production over a period of time. These observations will be related to the growth and condition of the fish populations,.

At least three graduate students will help conduct these studies. Such limnological measurements will enable us to learn more about lentic water production and carrying capacity of the waters and thus help establish a reliable fish stocking program.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Idaho

2.0399, HYDROLOGY OF FROZEN GROUND FLOODS

A.C. ROBERTSON, Univ. of Idaho, Water Resources Research Inst. , *Moscow*, *Idaho* 83843

The objectives of this project are to relate infiltration rates of frozen ground to parameters of moisture content of soil, temperature of surface water, and time, to apply these relationships to hydrograph studies of surface runoff under frozen ground conditions. Infiltration rates into frozen soil columns under various temperature and moisture conditions will be measured in the laboratory. Relationships developed from the data will be tested in hydrograph studies from a small watershed and in examination of past major frozen ground floods in the region.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Idaho

2.0400, TEMPORAL, HORIZONTAL AND VERTICAL VARIABILITY OF WATER CHEMISTRY IN THE UNSATURATED ZONE OF FINE-GRAINED SOILS

R.E. WILLIAMS, Univ. of Idaho, Water Resources Research Inst. , *Moscow*, *Idaho* 83843

The first phase of the project consists of the development of a method whereby many samples of soil water can be obtained from a given point in the zone of aeration. A sampling point will not be destroyed during the sampling process, thus temporal variation of water quality at any given point in the soil can be determined by analysis of samples collected over an extended period of time. In the second phase, the horizontal and vertical variability of water quality at several different times will be determined by analysis of samples collected from a network of points in the unsaturated zone in fine grained soils. Determination of temporal, horizontal and vertical variability of water quality should provide insight into rate and direction of movement of water in the unsaturated zone as well as information on the quality of the water recharging ground-water aquifers.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Idaho

2.0401, SOIL-PLANT-ATMOSPHERE COMPONENTS IN IRRIGATION STUDIES OF BLACK WALNUT TREES IN SOUTHERN ILLINOIS

W.C. ASHBY, Southern Illinois University, Graduate School, *Carbondale*, *Illinois* 62903

The overall objective is to identify soil, plant, and atmospheric factors influencing irrigation requirements and resulting growth of black walnut on a small watershed in southern Illinois.

Individual investigators' research objectives include: 1. Study of the relations between leaf water potential, stomatal conditions, leaf temperature, and soil moisture conditions. 2. Determination of a suitable empirical basis for enabling future walnut irrigators to estimate carefully the need for irrigation. 3. Ascertainment of the influence of varying soil moisture tensions on measured transpiration rates of black walnut.

SUPPORTED BY Southern Illinois University

2.0402, SORPTION ISOTHERMS OF PHENOL ON ION EXCHANGE RESINS

J.W. CHEN, Southern Illinois University, School of Engineering, *Carbondale*, *Illinois* 62903

Phenol is a troublesome pollutant from industrial wastes, it cannot be removed by biological treatment easily. Ion Exchange Resins are proposed as potential adsorbents to remove phenol because their selectivity and capacity.

Five different resins were screened. It was found that both IR 45 and IR 401 resins are excellent adsorbents for phenol. Sorption isotherms of these two resins at different pH and temperatures are investigated.

SUPPORTED BY Southern Illinois University

2.0403, THE EFFECTS OF PLANT TRANSPIRATION RETARDANTS ON TRANSPIRATION, LEAF TEMPERATURE, STOMATAL BEHAVIOR AND OSMOTIC PRESSURE

N.A. MILLER, Southern Illinois University, Graduate School, *Carbondale*, *Illinois* 62903

The objective of this research is the study of the effects of plant transpiration retardants on leaf temperature, stomatal behavior, osmotic pressure, water potential, turgor pressure and transpiration on field corn (Zea mays) grown under field conditions and greenhouse conditions.

In the field, measurements and collections will be made every four hours starting at 6 AM until 10 AM the following day. Leaf temperatures will be recorded using a copper-constantan thermocouple with a DC rustrak amplifier-recorder system. Stomatal behavior will be noted with General Electric RTV-11 silicone impressions and a microprojector. The osmotic pressure of the leaves will be determined with a Fiske Osmometer and water potential (DPD) with the Schardakou method. The turgor pressure will then be determined from this data (OP-DPD0TP). Similar collections will be carried out in the greenhouse including the gravimetric determination of transpiration rates.

Control and treated plants will be studied simultaneously. Retardants to be used include phenylmercuric acetate (different concentrations), chlorogenic acid, n-decenylsuccinic acid, and hexadecyl and octadecyl alcohols.

SUPPORTED BY Amer. Assn. For The Advancement of Sci.

2.0404, EFFECT OF SOIL MOISTURE AND POTASSIUM FERTILIZATION ON THE TRANSPIRATION RATE OF SOYBEANS (GLYCINE MAX)

J.P. VAVRA, Southern Illinois University, School of Agriculture, *Carbondale*, *Illinois* 62903

The objective of this project is to study the effects of varying concentrations of potassium and different soil moisture levels on soybean growth and transpiration. The experiment will be conducted in the greenhouse and in the field.

SUPPORTED BY Southern Illinois University

2.0405, DAILY HEAT BUDGETS IN ENVIRONMENTAL FLUIDS

J. VERDUIN, Southern Illinois University, Graduate School, *Carbondale*, *Illinois* 62903

The diurnal heat gain and nocturnal heat loss in aquatic environments and in the atmosphere is under investigation. Heat budgets are expressed in terms of calories per cm2 per day and the distribution at different levels in water and air is being determined. The aquatic investigations are confined to habitats in Illinois and Ohio, but atmospheric data extend from tropical to polar stations.

SUPPORTED BY Southern Illinois University

2.0406, SCAVENGING STUDY OF SNOW AND ICE CRYSTALS

A. LIEBERMAN, I I T Research Institute, *Chicago*, *Illinois*

A research program is described to study the important factors for defining scavenging effectiveness of snow and ice crystals. Two factors of concern are the aerodynamic and the electrostatic forces between the falling crystal and the particles or droplets in its path. The differences between the forces associated with the crystal and those associated with an equivalent droplet are to be considered.

The forces should be investigated first independently, and then in combination. Both analytical and experimental studies are planned, with the ultimate objective of better defining the parameters controlling scavenging by snow and ice crystals. During the first year efforts will be directed primarily toward study of aerodynamic effects.

SUPPORTED BY U.S. Atomic Energy Commission

2.0407, DYNAMICS OF THE CIRCULATION IN THE GREAT LAKES

G.E. BIRCHFIELD, Northwestern University, School of Engineering, *Evanston*, *Illinois* 60201

The overall objective of this work is to make a study of the dynamics of the circulation in the Great Lakes. The circulation of the Lakes may be caused by several factors. Certainly one of the primary forcing functions is the wind and temperature fields of the atmosphere overlying the lakes. The proposed research is subdivided into two major tasks.

The first task is to consider a numerical model of the combined Lake Huron, Lake Michigan basins as a single basin connected by the Straits of Mackinac. Horizontal transport will be calculated for a field of constant stress, a field of constant curl stress and a field of constant divergence stress. It is anticipated that bounds can be established on the exchange of mass between the lakes as a function of wind stress.

The second task concerns the distribution of wave energy in a lake. It is proposed to investigate the normal energy modes for a two-layer circular lake with a parabolic depth profile. Some information will be obtained as to the distribution of energy among the normal modes in response to a simple stress field. Such a study will assist in determining the relative importance of the modes as a function of the forcing period. It is planned to estimate the normal modes numerically for a Lake Michigan model.

SUPPORTED BY U.S. National Science Foundation

2.0408, A STUDY OF A POLLUTED RIVER, THE ILLINOIS

W.C. STARRETT, State Dept. of Conserv. , *Springfield, Illinois*

Objective: The Illinois River, originating below Chicago and flowing southwestward to enter the Mississippi River at Grafton, has a long history of pollution, much of which has been documented (since 1900) by Survey aquatic biologists. At present there is a move on by the State and Federal Governments to clean up the pollution. Our investigation will measure the progress that is being made and suggest the sources of the more severe types of pollution based on the reactions of the fishes and aquatic invertebrates.

Procedures: Biological collections are made at specific stations with trap nets, a boat shocker, and using minnow seines for small fishes. These collections are paralleled by limited chemical sampling and dissolved oxygen profiles. Dredges are used to collect deep water specimens and molluscs. Collections of invertebrates and small fishes are preserved and returned to the laboratory for identification. These procedures will be followed each summer and fall for three additional years.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Illinois State Government

2.0409, INVESTIGATION OF PERMEABILITY OF FINE GRAINED GLACIAL SEDIMENTS IN RELATION TO WASTE DISPOSAL IN ILLINOIS

R.E. BERGSTROM, State Geol. Survey, *Urbana, Illinois*

The objective of the research is to evalute current methods and to develop practical procedures for determining the field permeability of fine grained glacial sediments. These sediments -- mainly tills -- are too tight to be analyzed for permeability on the basis of conventional pumping tests. Field measurements will be made using several methods of injection -- and possibly pumping -- in shallow bore holes. Laboratory tests will be made on cores by standard permeameter methods.

The permeability data will be obtained from representative glacial deposits of known character and extent, so that results may be extrapolated, and will be evaluated for such practical applications as selecting sites for surface waste disposal, protecting shallow aquifers from pollution, and appraising drainage and ground-water recharge conditions.

SUPPORTED BY Illinois State Government
University of Illinois

2.0410, THEORETICAL ANALYSIS OF REGIONAL GROUND-WATER FLOW IN THE HAVANA AREA

P.C. HEIGOLD, State Geol. Survey, *Urbana, Illinois*

A study of the flow system of the Havana Area, a broad sand plain adjacent to the Illinois River, ahs been undertaken, using numerical methods adapted for computer solution. A mathematical model representing three dimensional, non-homogeneous, isotropic, steady state flow has been developed. Input data, such as water tables, bedrock elevations, and hydraulic conductivity values, have been taken from a hydrogeologic report of the area and additional data sources of the Illinois State Geological Survey and the Illinois State Water Survey. Output includes the regional potential distribution in the glacial deposits between the water table surface and the Pennsylvanian and Mississippian bedrock which is assumed to be impermeable. The mathematical model is general enough to be applied in other areas where the basic conditions are met.

SUPPORTED BY Illinois State Government

2.0411, RELATION OF FLOODPLAIN POOLS TO THE BIOLOGICAL PRODUCTION OF THE KASKASKIA RIVER AND ITS MAINSTEM RESERVOIRS

R.W. LARIMORE, State Natural History Survey, *Urbana, Illinois*

Floodplain pools produce fish and fish foods that are flushed into the river or reservoir during periods of high water. The limnology and biological communities of these pools will be studied and related to the fishery and recreational values of the river and mainstem impoundment. Possibilities will be investigation of manipulating the biological communities and their habitats to produce kinds and quantities of fish and fish foods of value in the river or reservoir.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Illinois State Government

2.0412, TOPOGRAPHIC EFFECTS ON PRECIPITATION

S.A. CHANGNON, State Water Survey, *Urbana, Illinois*

An extensive study of the increased precipitation in the Shawnee Hills area of southern Illinois is underway. Data from the raingage installations will be used to identify the specific areas of the hills where the topographic effects maximize. This will allow further instrumental studies of the changes produced in the low-level atmosphere by the relatively small hills.

Data collection for the first five-year phase of project began January 1, 1965; analyses will be continuous throughout the program.

SUPPORTED BY Illinois State Government

2.0413, INTERRELATIONSHIP OF FACTORS AFFECTING QUALITY OF IMPOUNDED WATERS

R.L. EVANS, State Water Survey, *Urbana, Illinois*

A study of water quality in lakes is being made in an effort to obtain knowledge concerning the interrelationship of physical, chemical, and biological processes occurring in an impounded water. Initial study on Lake Bloomington include comparison of quality characteristics in tributaries with those of water withdrawn from the lake to measure changes occurring in the impoundment. Chemical analyses are performed on waters of the lake, its tributaries, muds and squeeze water and interface liquor. Phytoplankton and bottom fauna are collected and identified, temperatures and dissolved oxygen measured, and secchi disc readings are recorded.

SUPPORTED BY Illinois State Government

2.0414, HYDROMETEOROLOGICAL ANALYSIS OF SEVERE RAINSTORMS

F.A. HUFF, State Water Survey, *Urbana, Illinois*

A continuing program of field surveys and detailed analyses of severe rainstorms in Illinois has been conducted since 1950; analyses are based on radar, synoptic weather, and field survey data, and include area-depth-duration relations, antecedent rainfall evaluation, isohyetal maps for peak periods of storm.

SUPPORTED BY Illinois State Government

2.0415, RADIOACTIVITY IN RAINFALL

F.A. HUFF, State Water Survey, *Urbana, Illinois*

Investigation is being made of the space and time distribution of radioactivity in rainfall and its relationship to various meteorological factors such as the amount, duration, and intensity of rainfall, cloud depth and type, and synoptic weather features. Sampling area includes broad portion of central Illinois.

(Supported in part by research grant by Atomic Energy Commission under Contract AEC 1199).

SUPPORTED BY Illinois State Government
U.S. Atomic Energy Commission

2.0416, RAINFALL EVALUATION STUDIES

F.A. HUFF, State Water Survey, *Urbana, Illinois*

With support from an NSF grant, an extensive study of the time and space characteristics of storm, monthly, seasonal, and annual precipitation has been undertaken. The primary purpose is to provide knowledge needed in evaluating weather modification potential and in developing design and verification criteria for precipitation modification experiments. Major data source is the Water Survey raingage networks. Efforts are being made to combine statistical analyses with meteorological knowledge to define better the physical properties and distribution characteristics of natural precipitation and how storm rainfall distributions are affected by such factors as precipitation type, synoptic storm type, rainfall intensity, and storm duration.

SUPPORTED BY Illinois State Government
U.S. National Science Foundation

2.0417, GEOHYDROLOGIC SYSTEM ANALYSIS WITH AN ELECTRIC ANALOG COMPUTER

T.A. PRICKETT, State Water Survey, *Urbana, Illinois*

Electric analog techniques have now been devised and tested for simulating nearly all active and passive boundary conditions which are common to all groundwater systems. Within the last year, emphasis was placed on final design of the necessary circuits needed to simulate the nonlinear properties of evapotranspiration, induced infiltration from rivers, aquifer storage, groundwater runoff, recharge from precipitation, and underflow.

Also, a report is currently being written which describes various finite-difference networks for both electric analog and digital simulation of aquifer systems. Methods are outlined for designing several types of equivalent discretized aquifer systems which result in a minimum number of simultaneous equations that need to be solved for a given problem solution. Special network designs are given that allow a great reduction in the size of an analog model and in programming or data input in the case of digital simulation. Error analysis has been included to guide the investigator in design of such networks.

SUPPORTED BY Illinois State Government

2.0418, GROUND-WATER STUDIES - PILOT DRAINAGE BASIN STUDY

R.J. SCHICHT, State Water Survey, *Urbana, Illinois*

All factors of the hydrologic cycle (especially precipitation, temperature, streamflow, soil moisture, changes in surface and sub surface storage, and evaporation) are being measured and examined to obtain quantitative knowledge of movement and storage of ground water under natural conditions in 22-square mile basin (East Branch, DuPage River, in Chicago Region).

The annual rate of recharge to, and evapotranspiration from, the ground-water reservoir is to be determined. Stream discharge hydrograph is being separated into its two components, surface runoff and ground- water runoff. Gravity yields of glacial deposits and underlying dolomite aquifer to be estimated.

First phase completed October 1966; to be renewed in future to study effect of land-use changes (rural to suburban); skeleton observation network being maintained in interim.

SUPPORTED BY Illinois State Government

2.0419, GROUND-WATER STUDIES - DEEP SANDSTONE AQUIFER IN CHICAGO REGION

R.J. SCHICHT, State Water Survey, *Urbana, Illinois*

Investigations cover extensive artesian well field with wells 1200 to 2200 feet deep, locally heavily pumped (pumpage in 1961 was 96.5 million gallons per day, and has exceeded practical sustained yield of aquifer since 1958); includes study of groundwater level recession, interferences, transmissibilities, effect of additional demands; water-level and pumpage data are analyzed annually.

SUPPORTED BY Illinois State Government

2.0420, STREAMFLOW HYDROGRAPH SEPARATION

R.J. SCHICHT, State Water Survey, *Urbana, Illinois*

In this study, separation of the streamflow hydrograph into its components of surface runoff and groundwater runoff is based on differences in the total dissolved minerals in groundwater and in surface water as measured by the conductivity method. An earlier study was conducted on the Pilot Drainage Basin (East Branch DuPage River, in Chicago Region); however, sewage effluent in this river during parts of the year affected the results. A second study has been started on the 95-square-mile Panther Creek watershed (central Illinois). Here, separation of the streamflow hydrograph by the conductivity method will be compared with the rating curve method of relating mean groundwater stage to groundwater runoff, since a rating curve for Panther Creek was previously establsihed.

SUPPORTED BY Illinois State Government

2.0421, STREAMFLOW VARIABILITY

K.P. SINGH, State Water Survey, *Urbana, Illinois*

Basic research into the inherent variability of streamflow is being pursued. This study is currently oriented toward improving knowledge of the actual yield of an impounding reservoir during critical drought conditions.

Understanding the variability of streamflow provides fundamental knowledge which will be useful in processing Illinois streamflow to provide answers to many questions in areas of: water supply direct from streams, drainage, duration of low flows and high flows, zoning of flood plain land, and to some extent floods.

SUPPORTED BY Illinois State Government

2.0422, SEDIMENTATION IN LAKES AND RESERVOIRS

J.B. STALL, State Water Survey, *Urbana, Illinois*

To aid designers of water-supply reservoirs, sediment accumulations are measured and sediment samples taken for laboratory analysis in a continuing program. Cooperating agencies survey watershed soil types, slopes, land uses, and conservation practices. Data are analyzed for correlation with watershed factors, rate of sediment deposition, and expected life of reservoir.

(Cooperative with Agricultural Research Service, Soil Conservation Service, and Illinois Agricultural Experiment Station)

SUPPORTED BY Illinois State Government

2.0423, (U) RADAR MEAS REMENT OF RAINFALL

G. STOUT, State Water Survey, *Urbana, Illinois* (DA-28-043-AMC-00032E)

OF RADAR MEASUREMENT OF RAINFALL RATE THROUGH IMPROVED KNOWLEDGE OF

AND FROM THE RADARS AND RAIN GAGES INSTALLED AT THE UNIVERSITY OF ILLINOIS ARE BEING ANALYZED TO DETERMINE THE BEST RELATIONSHIP BETWEEN THE RADAR-REFLECTED SIGNAL AND THE RATE AND AMOUNT OF PRECIPITATION. RAINDROP-SIZE DATA, TAKEN AT MANY LOCATIONS IN THE WORLD, HAVE BEEN ANALYZED AND ARE TO BE USED IN DEVELOPINGZ/R RELATIONSHIPS (Z IS THE RADAR-REFLECTED SIGNAL AND R IS THE RAINFALL) APPLICABLE TO THE ARMY SYNOPTIC SITUATIONS AND CLIMATIC REGIMES IN THE WORLD.

CONTINUED HIS RESEARCH ON QUANTITATIVE DETERMINATION OF PRECIPITATION USING WEATHER RADAR. EVALUATION AND PUBLICATION OF ALL RAINFALL DISTRIBUTIONS OBTAINED WITH THE RAINDROP CAMERA AT VARIOUS GEOGRAPHICAL LOCATIONS WERE COMPLETED. THE DROP SIZE DISTRIBUTIONS ARE BEING USED TO COMPUTE COMMUNICATION ATTENUATION FOR SYNCOM FREQUENCIES. PROGRAMMING HAS BEEN COMPLETED TO PERMIT COMPUTATION OF REFLECTIVITY, RAINFALL RATE, LIQUID WATER CONTENT, AND ATTENUATION FOR SELECTED FREQUENCIES BETWEEN 3 AND 70 GHZ. REF A/ ECOM-02071-1, INVESTIGATION OF THE QUANTITATIVE DETERMINATION OF PRECIPITATION BY RADAR , JUN 67; B/ ECOM-02071-2, 'INVESTIGATION OF THE QUANTITATIVE DETERMINATION OF PRECIPITATION BY RADAR, DEC 67 C/ ECOM-02071-RRI, RAINDROP DISTRIBUTIONS AT MAJURO

ATOLL, MARSHALL ISLANDS, MAR 67 D/ ECOM-02071-RR2, RAINDROP DISTRIBUTIONS AT ISLAND BEACH, N. J. SEPT. 1967 E/ ECOM 02071-RR2, RAINDROP DISTRIBUTIONS AT FRANKLIN, N. CAROLINA SEPT 67 F/ ECOM-02071-4, RAINDROP DISTRIBUTIONS AT WOODY ISLAND, ALASKA, NOV 67 G/ ECOM-02071-RR5, RAINDROP DISTRIBUTIONS AT BOGOR, INDONESIA, JAN 68 H/ ECOM-02071-RR6, RAINDROP DISTRIBUTIONS AT CORVALLIS, OREGON, FEB 68 I/ STOUT, G., SURVEY OF RELATIONSHIPS BETWEEN RAINFALL RATE AND RADAR REFLECTIVITY IN THE MEASUREMENT OF PRECIPITATION, PAPER PRESENTED AT THE MEETING OF 28 SEPT 67, OF THE INTERNATIONAL ASSOCIATION OF METEOROLOGY AND ATMOSPHERIC PHYSICS OF THE GENERAL ASSEMBLY OF THE INTERNATIONAL UNION OF GEODESY AND GEOPHYSICS J/ STOUT, G., SEVERE STORMS OVER THE CENTRAL PLAIN STATES, PRESENTATION BEFORE THE N. J. CHAPTER OF THE AMM, NOVEMBER 1967.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0424, DENSE RAINGAGE NETWORK PROJECTS

G.E. STOUT, State Water Survey, *Urbana, Illinois*

A long-term project in which two dense raingage networks encompassing 1200 and 1600 mi2 are presently operated to provide basic data for various climatological, hydrometeorological, and severe storm studies. Data also provide useful information for evaluating the potential of weather modification and designing precipitation modification experiments. One network is located in the Shawnee Hills region of the southern part of the state and the other in the central Illinois flatlands to sample different climatic and topographic conditions.

SUPPORTED BY Illinois State Government

2.0425, MATHEMATICAL GEOMORPHOLOGY

A.E. SCHEIDEGGER, U.S. Dept. of Interior, Water Resources Division, *Urbana, Illinois*

The origin of land forms and the development of landscapes have been intriguing problems in geomorphology. Contributory agents, among others, are erosion, weathering, and accumulation. Most previous work has been concerned with the effects of weathering. This study is to analyze the processes of erosion and accumulation in landscape development, and to develop mathematical models of erosion and accumulation processes in geomorphology. Methods of analysis whereby erosion data may be applied to test the model will be studied.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0426, EFFECT OF WATER AVAILABILITY ON PHOTOSYNTHESIS OF PLANTS

J.S. BOYER, Univ. of Illinois, Graduate School, *Urbana, Illinois*

The proposed research deals with the effect of water availability on photosynthesis and its implications for increasing the efficiency of water use by crops. The investigations will center on means of measuring crop moisture status and the reasons for changes in photosynthesis at various plant moisture stresses. Three studies will be carried out: 1. A simple field method will be developed to measure the moisture status of corn and soybean crops. 2. The method will be used in conjunction with measurements of photosynthesis of corn and soybeans to determine the moisture status at which these crops require water. Measurements of moisture status and photosynthesis will also be made in plants recovering from water deficiencies to determine whether the method can be used to indicate when sufficient water has been applied during irrigation of corn and soybeans. 3. Experiments will be undertaken to elucidate mechanisms by which lack of moisture may reduce photosynthesis. Chloroplasts will be isolated from leaves which are subjected to water deficiencies and will be studied for evidence of structural damage as well as changes in enzymatic activity brought about by the deficiency conditions.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Illinois

2.0427, SYSTEM ANALYSIS OF RAINFALL-RUNOFF RELATIONSHIP

V.T. CHOW, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

The watershed is treated as a lumped hydrologic system. Assuming a general nonlinear equation for the basin storage and combining it with the equation of continuity, a differential equation for the system has been formulated. This equation has been quasi-linearized by assuming that the coefficients are functions of the average inflow and outflow of the system. Without resorting to the quasi-linear procedure, the nonlinear equations are now being solved on digital computers.

SUPPORTED BY University of Illinois

2.0428, STOCHASTIC ANALYSIS OF RAINFALL-RUNOFF RELATIONSHIP

V.T. CHOW, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

Stochastic behavior of rainfall-runoff relationship has been investigated by employing sequential generation and simulation techniques to the analysis of the data from 28 annual storms in the French Broad River Basin at Bent Creek, North Carolina. The stochastic process was formulated by Markov-chains and Monte Carlo methods, assuming deterministic watershed system. The watershed system itself, in addition to the stochastic input rainfall and stochastic output runoff, is now being considered as stochastic in the analysis.

SUPPORTED BY University of Illinois

2.0429, HYDROLOGIC ANALYSIS BY ANALOG COMPUTERS

V.T. GHOW, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

Direct and indirect analog computers are used for the analysis of hydrologic systems of surface and ground waters. For linear and nonlinear reservoirs, floods have been routed through them by simulation of EAI PACE computers. The results indicated that the initial storage in the reservoir affects only the very beginning portion of the outflow hydrograph. For investigating ground water potentials, resistance networks have been designed and analyzed for a number of ground water regions in Illinois.

SUPPORTED BY University of Illinois

2.0430, GROWTH AND DEVELOPMENT OF NATIVE HARDWOODS AND PINE

A.R. GILMORE, Univ. of Illinois, Agricultural Experiment Sta., *Urbana, Illinois*

(1) To work out site index curves for both hardwood and pine on the basis of site factors; (2) to establish timber productivity classes for the important soil types or series; (3) to study the growth or various species in relation to factors that effect the availability of soil moisture; (4) to investigate the relation between site and mineral content of the foliage of both pine and hardwood species.

Description of Work: Microdendrometer studies will be used to determine the influence of various site factors, soil moisture in particular, on the seasonal growth of pine plantations and native hardwood stands. They will be used also to study the effects of the release of trees from competition on diameter growth.

An intensive study of site-growth relationships in native hardwood stands will be made on soil types important to timber-growing in southern Illinois. The foliar analysis for N., P., K., Ca., and other elements will be made on leaf samples taken from hardwood trees growing on different site qualities. Nitrogen determination will be by micro- kjeldahl methods. Other elements will be determined with a flame photometer.

SUPPORTED BY U.S. Dept. of Agriculture
Illinois State Government

2.0431, EFFECTS OF SOIL MOISTURE STRESS

A.R. GILMORE, Univ. of Illinois, Agricultural Experiment Sta., *Urbana, Illinois*

Objectives: To investigate the effects of controlled soil moisture stress on (1) foliar nutrients, number of growth flushes, diameter growth, and height growth of loblolly pine trees. (2) The specific gravity; tracheid length; and percentage of summerwood, springwood, cellulose, extractives, and lignin of the wood of loblolly pine trees.

Procedure: Plots in an 18-year-old plantation of loblolly pine wil be subjected to six soil moisture stresses and replicated three times in a randomized block design. Soil moisture will be monitored with a d/M nuclear gauge. Micro-environment stations will be maintained. Radial growth will be recorded by dendrograph.

At the end of the experiment, wood will be analyzed for cellulose, lignin, nutrients (nitrogen, potassium, etc.) and any other chemical component by accepted A.O.A.C. procedures.

SUPPORTED BY U.S. Dept. of Agriculture

2.0432, A WATER TRANSPORT IN THE SYSTEM, SOIL-PLANT-ATMOSPHERE

A. KLUTE, Univ. of Illinois, School of Agriculture, *Urbana, Illinois*

This is to be an experimental study of the uptake of water by plant root systems under controlled conditions. Plants will be grown in soil columns with provision for temperature and humidity control of the top of the plant. Evaporation from the soil surface, and from the leaves of the plant will be measured separately. Data will be collected to supply the necessary parameters in a theory of water uptake based on the use of unsaturated flow theory including a sink- term in the flow equation.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Illinois

2.0433, INVESTIGATION OF WATER STORAGE AND MOVEMENT IN SOILS

A. KLUTE, Univ. of Illinois, Agricultural Experiment Sta., *Urbana, Illinois*

Objectives: (1) The development of new and improvement of old concepts of the behavior of water in soils, especially unsaturated soil. (2) The development and improvement of methods of measuring soil properties that are significant in water storage and movement. (3) Application of the theory of flow to analyze various soil water flow systems and obtain predictions of their behavior.

Work Proposed: Solutions of the flow equation for water in unsaturated soil will be obtained for various specific flow systems. Experimental observations on these flow systems will be compared with these solutions. Methods of measuring conductivity and water capacity will be developed and improved. Attempts to extend the flow theory to deformable soils will be made.

SUPPORTED BY U.S. Dept. of Agriculture
Illinois State Government

2.0434, HYDROLOGIC CHARACTERIZATION OF SMALL WATERSHEDS

A. KLUTE, Univ. of Illinois, Agricultural Experiment Sta., *Urbana, Illinois*

Regional Objective: To investigate the use of mathematical, electrical, and hydraulic models to study hydrologic phenomena of watersheds.

Specific Objectives: 1. To analyze the flow behavior of water in a soil with a sloping surface during three stages of flow: (1) wetting under rainfall, (2) steady flow under rainfall, (3) drainage after rainfall has ceased, and to determine the contribution of subsurface flow to the runoff from the land. 2. To predict the soil water content, hydraulic head and pressure head of the soil water as a function of time and position in the soil. 3. To predict the flow rate across the soil surface as a function of time and position on the slope during each of the three stages of flow.

Work Proposed: Numerical solutions of the flow equation for water in soil will be obtained for boundary and initial conditions that will represent wetting of a soil on a slope, the steady flow through the soil and the drainage of the soil after rainfall ceases. The contribution of the soil water flow to runoff will be evaluated, and the effect on the flow of various parameters, such as slope length, slope angle, and soil properties, will be evaluated.

SUPPORTED BY U.S. Dept. of Agriculture
Illinois State Government

2.0435, STUDY OF THE HYDROLOGY FOR MODELS OF THE GREAT LAKES

D.D. MEREDITH, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

Sophisticated quantitative analyses of precipitation, evaporation, and runoff for each of the Great Lakes and the Great Lakes as a system are proposed in order to provide a better understanding of these relationships for future management of the Great Lakes. Monthly estimates will be derived, based upon a thorough meteorologic and hydrologic evaluation of all existing data. These water movement data are necessary for a quantitative systems analysis of the Great Lakes for future managemant.

In order to perform these tasks it will be necessary to gather into one analysis site all of the existing runoff and precipitation data as well as other pertinent meteorological data from United States and Canadian sources. The accumulated data will be used to make monthly and annual estimates of runoff, precipitation, and evaporation for lakes on an individual basis for the period 1945-1965 with some consideration given to the drought period of the 1930's. The monthly estimates will be available for future use through publication in the appropriate journals.

SUPPORTED BY University of Illinois

2.0436, CLAY-WATER-ION INTERACTIONS

R.J. MILLER, Univ. of Illinois, Agricultural Experiment Sta., *Urbana, Illinois*

Objectives: (1) Evaluate the effect of clay adsorbed water on the water flow characteristics of a clay-water system. (2) Determine the influence of temperature on the physical nature of water in association with clays. (3) To investigate the effect of various treatments and ions on the surface characteristics of clays.

Work Proposed: Experiments will be conducted to elucidate the effect of clays and exchangeable cations on the structure of water adsorbed on clay surfaces. A combination of experimental observations and current ideas on water structure may lead to a better understanding of the mechanisms involved in clay adsorbed water.

SUPPORTED BY U.S. Dept. of Agriculture
Illinois State Government

2.0437, AN EXPERIMENTAL STUDY OF EDDY DIFFUSION COEFFICIENTS, EVAPOTRANSPIRATION AND WATER USE EFFICIENCY

R.J. MILLINGTON, Univ. of Illinois, School of Agriculture, *Urbana, Illinois*

Work at Porton has shown the utility of artificial line sources in measuring eddy diffusion coefficient profiles for mass transfer in the lower atmosphere. It is proposed to extend this approach to measurement of profiles of eddy diffusion coefficients within and above the leaf canopy of crop plant communities.

A line source of organic vapor will be introduced into both wind tunnel model systems and into field crops. Concentration distribution downwind will be estimated on gas samples, pumped from sample points to a collection site, where analysis will be made using a gas chromatograph flame ionization detector.

Measurement of wind speed at one height together with concentration distribution data, permits finite difference numerical analysis of the usual two-dimensional flow equation involving both convective and eddy diffusive terms. Alternatively, by using sources at different heights and measuring at short distances downwind, separate estimates of the eddy diffusivity can be made within 'layers' of the system, using a graphical solution of the flow equation.

The eddy diffusion coefficient profiles thus obtained, when augmented with measures of the profiles of water vapor pressure and carbon dioxide, allow calculation of evapotranspiration and net photosynthesis. These latter data are collected as source and sink strength terms for each 'layer' of the system permitting some separation of evaporation from transpiration.

Variation in evapotranspiration and the ratio of crop dry matter produced by photosynthesis per unit of water used, that is, water use efficiency, will be examined in relation to crop canopy geometry and meteorological factors.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Illinois

2.0438, SOIL-MOISTURE-PLANT GROWTH RELATIONSHIPS

D.B. PETERS, Univ. of Illinois, Agricultural Experiment Sta., *Urbana, Illinois*

Objective: To determine the effect of soil moisture content, soil moisture suction, hydraulic conductivity, and related soil physical properties on entry of water into plant roots.

Plan of Work: The separate and combined effects of soil moisture suction on moisture uptake by roots are evaluated under controlled environmental conditions. Seedlings are grown for short periods of time in soils with different moisture contents at a given suction level, and in soils with different suction levels at a constant moisture content. Changes in root weight and volume are used as indices of water transfer between soil and root. Radioactive tracers are used to simultaneously evaluate the relation between water uptake and ion uptake. Determination of the mechanisms of water movement through plants and ways that transpiration may be suppressed are underway. Mechanisms by which external factors influence transpiration are also under study. Determinations of the moisture retentivity and conductivity of soils for characterization purposes are included in this project.

SUPPORTED BY U.S. Dept. of Agriculture

2.0439, CLIMATIC INFLUENCE ON WATER USE AND CROP PERFORMANCE IN THE CORN BELT REGION

D.B. PETERS, Univ. of Illinois, Agricultural Experiment Sta., *Urbana, Illinois*

Object: To determine the plant-soil-meteorological interactions involved in the partition of energy at the earth's surface and to develop methods of beneficial alteration in energy dissipation in the Corn Belt region.

Plan of work: The soil-plant-atmosphere relationship and particularly crop geometry and the atmosphere will be evaluated. Possibilities for altering crop geometry to conserve moisture and create a more desirable soil-atmosphere enviornment for growing plants appear almost unlimitied. Research will be directed toward an understanding of the evaporation process as it relates to the soil water-atomosphere system so as to increase the efficiency of utilization of available precipitation. This will involve a systematic evaluation of the effects of elements of climate such as net humidity, temperature and wind velocity on evaporation of water from soils and other surfaces. Studies will be made of the interrelations of net radiation, humidity, temperature and wind velocity on evaporation of water from soils and other surfaces. Studies will be made of the interrelations of net water from the soil and through plants, and energy transformed into dry matter by common crops. Fundamentals of moisture transfer and storage in the soil-atomosphere system will be investigated.

SUPPORTED BY U.S. Dept. of Agriculture

2.0440, SOIL MOISTURE FLOW PROBLEMS AND SOLUTIONS IN THE CORN BELT REGION

D.B. PETERS, Univ. of Illinois, Agricultural Experiment Sta., *Urbana, Illinois*

Object: To develop (1) fundamental equations governing moisture transport, (2) means of solution of transport equations, and (3) method for evaluation of soil physical parameters essential to the solution of transport equations.

Plan of Work: The physical components of the environment are reduced to mathematical forms that can be utilized in transport equations. The solution of these equations through appropriate models, electrical resistance networks or electronic computers is developed and tested. Soil physical evaluative procedures are then developed to supply the data essential to the solution of the transport equations and the general utility of the solutions are translated into design features of water management systems. While the work in this investigation will be basic in nature, emphasis will be given to solution of flow problems in the Corn Belt region. (The design of a soil moisture management system is controlled by the soil-physical factors that govern the transport of water into and through soil.

SUPPORTED BY U.S. Dept. of Agriculture

2.0441, NUMERICAL ANALYSIS OF TIME-DEPENDENT FREE SURFACE FLOWS

W.D. ROSE, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

Finite difference algorithms are being developed to model in three dimensional space the unsteady-states of motion in water that is in part or in whole bounded by so-called free surface boundaries. Field equations of both the Navier-Stokes and Fourier diffusivity types are under consideration, where in the former case special attention is also given the action of capillary forces, and where in both cases attention is given to the hydrodynamic and body forces of gravity. Applications range from considering the shape of falling rain drops, wave motion, action of water in hydraulic structures, open channel flow, soil infiltration problems, aquifer performance, and individual well problems.

SUPPORTED BY University of Illinois

2.0442, SYSTEMATIC ANALYSIS OF THE MOISTURE-TEMPERATURE INTERACTIONS ON CORN YIELD

E.C. RUNGE, Univ. of Illinois, School of Agriculture, *Urbana, Illinois*

The proposed research plan involves field, laboratory and statistical investigations to determine the interaction between plant available stored soil moisture (PASSM), at various rainfall and temperature combinations during the growing season on corn yield. The approach is to analyze historical corn yields where PASSM, rainfall and temperature are known or can be estimated. Various mathematical models relating PASSM, rainfall and temperature to corn yield will be studied with particular attention given to the interactions involved.

Field investigations will include measuring PASSM, rainfall, temperature and corn yield at several locations wherer the PASSM varies within a location and rainfall and temperature vary between locations. This data will be analyzed to determine the interactions between PASSM, rainfall and temperature on corn yield.

SUPPORTED BY University of Illinois

2.0443, STOCHASTIC TREATMENT OF RIVER GEOMETRY

A.E. SCHEIDEGGER, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

Water is one of the important 'mines and minerals'. Because of this, the department has become involved in the study of river flow and drainage basin development. A test of meander formation showed that the latter can be regarded as a random walk process. An analysis of the structure of drainage basins showed that the configuration of the latter also can be regarded as the outcome of a stochastic process.

SUPPORTED BY U.S. National Science Foundation

2.0444, HYDRAULIC GEOMETRY OF STREAMS

J.B. STALL, Univ. of Illinois, State Water Survey Division, *Urbana, Illinois*

A completed project shows there to be, for the 18 river basins in Illinois, a consistent pattern in which the width, depth, and velocity of flow in a stream change along the course of the stream, with a constant frequency of discharge. These channel characteristics are termed hydraulic geometry and constitute an interdependent system which can be described by a series of graphs having simple form, or by equations.

The data from about 250 stream gaging stations will be assembled and used to develop the parameters to define the hydraulic geometry of stream systems for ten river basins selected to represent various physiographic and hydrologic regions of the humid part of the United States. These parameters are to be generalized for various physiographic divisions and used to help explain variability of other observed hydrologic phenomena such as low flow frequency, and flow duration. These parameters will also be used to predict the average depth and velocity of flow at problem locations on the stream where no measurements are available. This will allow computation of the re- oxygenation capacity of the stream at a problem location, and the time- of-travel of contaminants through the stream system.

The study will extend enormously the range of hydraulic geometry parameters derived for very flat stream systems in Illinois.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Illinois

2.0445, RAINOUT OF RADIOACTIVITY IN ILLINOIS

G.E. STOUT, Univ. of Illinois, State Water Survey Division, *Urbana, Illinois* (AT(11-1)1199)

Several studies are being pursued to acquire better understanding of the atmospheric processes controlling rainout and fallout, and, thereby, substantially improve our capability to predict the intensity of radioactivity under various meteorological conditions during periods of potential fallout hazard. A study of the relation between air motions and radioactive rainout in convective storms is being made to seek an explanation of the causes of various mesoscale rainout characteristics observed in past experiments. Another study is concerned with investigation of subsynoptic circulations in the upper and middle troposphere and their effect on the rate of diffusion of radioactive material. A laboratory investigation of sub-micron particle scavenging by rain is being initiated, since over 50 percent of tropespheric radioactive particulates are of this size.

SUPPORTED BY U.S. Atomic Energy Commission

2.0446, THE EFFECT OF VARYING SOIL MOISTURE REGIMES ON THE YIELD AND LEAF NITROGEN COMPOSITION OF CORN

E.H. TYNER, Univ. of Illinois, Agricultural Experiment Sta., *Urbana, Illinois*

Objectives: 1. To establish the effect of high plant populations on the critical N percentage of corn. 2. To determine the yield and leaf composition models relating population, N rate, and plant-available water levels when corn is planted on partially recharged soils and subsequently irrigated during the growing season. 3. On the basis of the results of the second objective, to develop N and population recommendations based on alternative decision models.

A 4 x 3 x 1 split plot field design field trial with 4 population rates varying from 16 to 18,000 plants per acre with 3N rates varying from no N to 150 lbs. and one water level will be carried out for objective 1.

A 2 x 2 x 3 x 3 split plot design field trial with 50 percent and 100 percent preseason rooting volume moisture recharge, with 2 growing season moisture levels maintained by irrigation, with 3 population rates and 3 N rates will be carried out under objective 3.

Leaf composition and yields will be calculated out as quadratic functions of the water, population and N rates. These will be employed under objective 3.

SUPPORTED BY U.S. Dept. of Agriculture
Illinois State Government

2.0447, EFFECT OF RAINDROP IMPACT AND SURFACE ROUGHNESS ON SHEET FLOW

H.G. WENZEL, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

The general objective of this research is to examine in detail both experimentally and theoretically the mechanics of sheet flow. This knowledge will be useful in improving the design of urban drainage facilities where this type of flow is common. More specifically the individual objectives are: (a) to investigate experimentally the effect of raindrop impact on sheet flow using carefully controlled laboratory rainfall, surface profile, and runoff measurements, (b) to study in detail the pressure fluctuations caused by raindrop impact using pressure transducers and to correlate this work with the results of the first objective, (c) to study the effect of roughness on sheet flow on a more thorough basis than has been previously attempted and (d) to review the existing theoretical relationships describing sheet flow in the light of the experimental results so that, if necessary, modified equations can be developed which will reflect the true physical phenomenon.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Illinois

2.0448, HYDRAULIC RESISTANCE IN ALLUVIAL CHANNELS

B.C. YEN, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

The proposed research involves an analytical investigation directed at the determination of the hydraulic resistance for sediment-bearing flow in channels. The approach is to reanalyze the available experimental and field data based on dimensional analysis and mechanics of fluid and sediment movement.

The effects of the geometry of the channel, the properties of the sediment particles, and the characteristics of the flow are to be studied. The results will be presented in dimensionless general forms for engineering purposes such as river training, flood control, and canal design.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Illinois

2.0449, DROUGHT RESISTANCE IN BARLEY VARIETIES

J.J. CHINOY, Gujarat University, *Ahmedabad, India*

Object: To investigate the resistance of barley to wilting at different growth and developmental stages and the role of sugars, phospholipids and protein in resistance; and to obtain a growth or developmental index for selecting varieties of barley for arid zones.

Plan of work: Indian and American varieties of barley will be treated with (1) normal watering during growth, (2) wilting at the tiller initiation stage, (3) wilting at the shooting stage, (4) wilting at the flowering stage, and (5) continuous moisture stress in the soil. Permanent wilting will be maintained for a fixed number of days, then normal watering resumed. Resistance of plants to drought will be estimated and varietal coefficients of plant parts determined. Coefficients of drought resistance for different plant parts will be determined, also different characteristics determining the yield of grain under the different treatments. Varieties of barley will be exposed to different photoperiodic cycles (24, 11 and 8-hour days). Drought intensity and related coefficients will be determined. Internal causes of drought resistance will be determined by water of dehydration and permeability of seedling; treatment of seeds with growth regulators and trace elements; and changes in carbohydrates, phospholipids and protein during growth.

2. WATER CYCLE

SUPPORTED BY U.S. Dept. of Agriculture

2.0450, COMPARISON OF EVAPORATION INSTRUMENTS

M. GANGOPADHYAYA, Indian Dept. of Meteorology, *New Delhi, India*

The objectives of this research, which is funded under the Special Foreign Currency Program of the United States Government, are a. To construct and install various types of evaporimeter tanks, including the U. S. Class A Pan, the U.S.S.R. 20 sq. meter and GGI-3000 tanks, and a 16-foot diameter sunken plastic tank (U.S. backyard swimming pool). b. To obtain correlation coefficients between measurements of evaporation as obtained by the various instruments.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.0451, NEW-TYPE GLYCOL MONO ALKYL ETHERS FOR THE CONTROL OF WATER EVAPORATION, TO EXTEND THE USE OF COTTONSEED OIL

A.B. BISWAS, Natl. Chemistry Lab. of India, *Poona, India*

Object: To determine the best method for introducing the ethenoxy group into alkyl alcohols, optimum number of such groups, and the physical properties of the product.

Plan of work: Alcohols will be prepared from saturated fatty acids of the cottonseed oil. A series of compounds of the type CH3(CH2)N (CCH2CH2) OH containing one thylene oxide group, will be prepared by such reactions as that of the bromides of the saturated fatty alcohols with monosodium glycolate, or by direct condensation of the fatty alcohols with one unit of ethylene oxide. The reaction products will be purified. Potential derivatives containing different functional groups also may be synthesized, and studies made of their relevant physico-chemical properties. The condensation of the alcohols with multiple units of ethylene oxide to give products of the type CH3(CH2)N(CCH2CH2)XOH will be studied also, to spreadibility on water surfaces, stability against chemical degradation, wind, wave, and dump action, ambient temperature, and the case of repair of the damaged surface. The products will be tested for emulsifying ability and attention given to possible flavor or toxicity effects in waters protected by these materials. The surface phenomena of the products will be studied. These compounds will be tested for evaporation properties, particularly for resistance to 'piling up' due to wind activity and for efficiency and rapidity of self repair to ruptures of film surfaces.

SUPPORTED BY U.S. Dept. of Agriculture

2.0452, THERMAL AND BIOLOGICAL CHARACTERISTICS OF LAKES

R.G. LIPSCOMB, U.S. Dept. of Interior, Water Resources Division, *Fort Wayne, Indiana*

The project is to evaluate methods of evaporation computation, study thermal-stratification processes, investigate biological influences on water quality, and study the process of lake aging. Where practical, new investigative techniques will be developed. Time and spacial distribution data from detailed counts of algal species in Pretty Lake, LaGrange County, Indiana, are being related to the distribution of water temperature and of chemicals known to be important in growth processes. Wind, temperatre, and radiation data are being used in the study of water temperatures and evaporation. Analyses of plant and animal remains in the lake sediments, along with other sediment analyses, will provide data for the study of the aging process in Pretty Lake.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0453, CHANNEL MEANDER STUDIES

J.F. DANIEL, U.S. Dept. of Interior, Water Resources Division, *Indianapolis, Indiana*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Indiana.

Purpose: To develop predictive criteria for movements of river channels.

Methods: Several channel meanders in different types of soil in different areas of the State have been selected for study. Variables such as peak discharges, average discharge, grain size of bed and bank materials, and suspended sediment loads will be correlated with measured changes in meanders to establish relations which may exist. If relations can be established, meander movements may be predicted at other locations.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Indiana State Government

2.0454, EVAPORATION LOSSES FROM LAKES IN INDIANA

C.H. TATE, U.S. Dept. of Interior, Water Resources Division, *Indianapolis, Indiana*

Purpose: To determine the evaporation losses from a lake in central Indiana by the energy-budget method and to develop a coefficient to be used with the mass-transfer method of computing evaporation elsewhere in the state.

Methods: Initially the energy-budget method will be used to determine evaporation from Morse Reservoir in central Indiana and a coefficient computed to be used with the mass-transfer method. Within 2 years enough data will have been collected to determine this coefficient for Morse Reservoir and the station will be discontinued as an energy-budget station but will be continued as a mass-transfer evaporation station. New sites for energy-budget studies will be selected through the state to define a curve of surface-area vs. mass- transfer coefficient so that the mass-transfer method of evaporation computation may be used anywhere in the state.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Indiana State Government

2.0455, LOW FLOW CHARACTERISTICS OF INDIANA STREAMS

C.H. TATE, U.S. Dept. of Interior, Water Resources Division, *Indianapolis, Indiana*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Indiana.

Purpose: To analyze stream flow data and determine low flow characteristics such as flow frequencies and duration.

Methods: Stream flow at continuous record gaging stations will be arrayed by computer at periodic intervals. A network of low-flow stations where base discharges will be measured periodically will be operated. Frequencies and durations will be determined at gaged sites and estimates of certain parameters will be made for ungaged sites through correlation techniques.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Indiana State Government

2.0456, WATER RESOURCES, COLUMBUS, INDIANA AREA

F.A. WATKINS, U.S. Dept. of Interior, Water Resources Division, *Indianapolis, Indiana*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Indiana.

Purpose - To investigate alternative methods of development of water supplies from surface and ground water sources.

Method - Data to construct an analog model of the outwash sand and gravel aquifer in Bartholomew County will be collected. The model will be used to demonstrate the relative merits of various methods of development of water resources to assure an adequate supply for the next 50 years.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Indiana State Government

2.0457, MECHANICS OF SOIL EROSION BY WATER

M.F. BAUMGARDNER, Purdue University, Agricultural Experiment Sta. , *Lafayette - West Lafayette, Indiana* 47907

(1) To determine the erodibility of soil as influenced by its particle characteristics; (2) to determine the effect of rainfall splash and overland runoff on soil erosion; (3) to determine the importance of rainfall characteristics on the erosion process; (4) to determine the effect of temperature on soil detachability and transport; (5) to investigate and evaluate the properties of soils which produce resistance to detachability and transport.

To better understand the mechanics by which water causes soil erosion, the phenomenon is to be studied under somewhat idealized but controlled, laboratory conditions. Simulated rainfall and soils will be initially utilized in experiments with shallow water flow over soil beds and through flumes. Concurrent experiments of the resistive mechanisms of natural soils will also be begun to give practical significance to findings with simulated soils.

SUPPORTED BY U.S. Dept. of Agriculture
Indiana State Government

2.0458, THE EFFECT OF URBANIZATION ON RUNOFF IN SMALL WATERSHEDS
J.W. DELLEUR, Purdue University, School of Engineering, *Lafayette - West Lafayette, Indiana* 47907

The objective of the research is to study the effect of varying degrees of urbanization on the rainfall - runoff relationship in pre-urban, early suburban and suburban watersheds principally in West Lafayette, Indiana. For this purpose the following watersheds will be used: a) the Ross Ade drain upper and lower watersheds having areas of 29 and 333 acres respectively, covering a fully developed suburban development and a portion of the Purdue campus respectively. b) The Purdue Swine Farm covers two watersheds having a total area of about 470 acres, the upper watershed is in the process of being developed, the lower watershed is a pre-urban stage. It is expected to evaluate the volume and peak rate of runoff, the shape of the hydrograph, the frequency of peak discharge, the infiltration rate, the base flow, the time of concentration and the time lag in terms of the land use intensity. The data obtained will be analyzed by means of conceptual and/or mathematical models simulating watersheds with varying degrees of urbanization.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Purdue University

2.0459, ASSEMBLY AND ANALYSIS OF HYDROLOGIC AND GEOMORPHOLOGIC DATA FOR SMALL WATERSHEDS IN INDIANA
J.W. DELLEUR, Purdue University, School of Engineering, *Lafayette - West Lafayette, Indiana* 47907

A computer oriented assembly and retrieval system will be developed for hydrologic and geomorphologic data for watersheds from 2 to 300 square miles in Indiana. This will include approximately 55 watersheds for which a large number of single peak hydrographs will be digitized at 15 or 30 minute intervals. A number of hydrograph and storm characteristics will be evaluated. The geomorphologic characteristics will be obtained from drainage and topograph maps. The data will be loaded on magnetic tape.

Upon completion of the data assembly, the hydrologic response of small Indiana watersheds will be evaluated under varying rainfall and climatic conditions. Attempts will be made to correlate the parameters describing the hydrologic system transfer functions to the basin hydrologic and geomorphologic characteristics. The final objective is the development of prediction methods for streamflow forecast for ungaged basins in Indiana.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Purdue University

2.0460, EXPERIMENTAL INVESTIGATION OF THE DEPENDENCE BETWEEN TURBULENCE EDDY VISCOSITY AND FLUID VISCOSITY
V.W. GOLDSCHMIDT, Purdue University, School of Engineering, *Lafayette - West Lafayette, Indiana* 47907

Momentum and mass are diffused by molecular effects through viscosity as well as by turbulence agitation of fluid elements. The diffusive effect of turbulence has been explained by defining an 'Apparent Eddy Viscosity' a convenient grouping of variables whose value up to now has only been deduced from measurements. Inasmuch as most reliable measurements of turbulent properties have been made in air (where the viscosity is especially constant) it has not been possible to conclude (except through similarity postulates) whether or not that this 'apparent' turbulent 'viscosity' is dependent on the fluid properties themselves.

Under the current research, the measurements of turbulence intensities and velocity distributions in a submerged liquid jet will be made and the dependence or lack of dependence between eddy and molecular viscosity will be investigated.

SUPPORTED BY Purdue University

2.0461, MATHEMATICAL SIMULATION OF HYDROLOGIC EVENTS ON UNGAGED WATERSHEDS
L.F. HUGGINS, Purdue University, Water Resources Research Ctr., *Lafayette - West Lafayette, Indiana* 47907

The basic approach of the proposed research project is to develop relationships describing the dynamics of the various components of the runoff process for small elemental areas within a watershed. Fundamental hydrodynamic equations will then be utilized in high speed computers to integrate the spatially varied, time dependent outputs from all of the many elements within the watershed to obtain a composite runoff hydrograph.

Then after a composite runoff hydrograph has been developed, the adequacy of the mathematical model will be tested by applying the model to several small gaged watersheds from which records are currently available and comparing the predicted and observed hydrographs. The sensitivity of the predicted hydrographs to variations in parameter values for the various hydrologic components will then be investigated. On the basis of this investigation, it is anticipated that a laboratory model will be constructed for investigating shallow flow over erodible surfaces where detention and retention are apt to be pronounced. Upon refining one or more of the sensitive parameters in the model, the model will then be applied to larger, more complex gaged watersheds for a comparison between the predicted and actual runoff.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Purdue University

2.0462, MATHEMATICAL SIMULATION OF HYDROLOGIC EVENTS ON UNGAGED WATERSHEDS
L.F. HUGGINS, Purdue University, Agricultural Experiment Sta. , *Lafayette - West Lafayette, Indiana* 47907

(1) To develop the fundamental mathematical relations describing the mechanics of surface runoff within a watershed and the digital computer programs required to perform the integration of the resulting equations to produce a complete runoff hydrograph; (2) To investigate the adequacy of the mathematical model by applying it to several gaged watersheds from which records are currently available and comparing predicted and observed runoff hydrographs; (3) To use the above mathematical model and currently available data to investigate the sensitivity of predicted hydrographs to variations in parameter values for the various hydrologic components of the model; (4) On the basis of the results of Objective 3, to initiate laboratory studies of the more important hydrologic components not currently being investigated elsewhere in suitable detail in order to obtain more precise quantifying information than is currently available.

The basic approach for this project is to develop relationships describing the dynamics of the various components of the runoff process for small elemental areas within a watershed. Fundamental hydrodynamic equations will then be utilized in high speed computers to integrate the spatially varied, time dependent outputs from all of the elements within the watershed to obtain a composite runoff hydrograph.

2. WATER CYCLE

SUPPORTED BY Indiana State Government

2.0463, RELATIONSHIP BETWEEN THE ERODIBILITY OF SOILS AND THE SEDIMENTATION RATE OF RESERVOIRS

H. KOHNKE, Purdue University, School of Agriculture, *Lafayette - West Lafayette, Indiana* 47907

Many studies exist that reveal the effects of climate, topography, vegetation, land use, and the relation of watershed size and reservoir size upon the rate of sedimentation of reservoirs. Surprisingly no specific studies exist that relate the properties of the soils of the contributing watershed to the sedimentation rates. It must be assumed these are related to the erodibility of the soils. However, the same amount of eroded soil material from two watersheds will contribute different amounts of sediment to a reservoir, depending on the mechanical composition. Much of the sand is frequently deposited in the flood plains above the reservoir while a big portion of the clay passes through the reservoir unless the electrolyte content of the water is quite high.

This project will determine the soil properties that can be expected to contribute to sedimentability in watersheds that drain into reservoirs for which the sedimentation rates are known. Considering also the other factors affecting sedimentation rates, an attempt will be made to correlate measurable soil properties to the sedimentability of the soils studied.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Purdue University

2.0464, DEVELOPMENT OF LAND USE EQUATIONS FOR THE SLOPING SOILS OF INDIANA

J.V. MANNERING, Purdue University, Agricultural Experiment Sta., *Lafayette - West Lafayette, Indiana* 47907

(1) To derive land use equations applicable to Indiana conditions; (2) To evaluate some of the newer practices such as mulch tillage, deep tillage, and minimum tillage.

DESCRIPTION OF WORK: A portable rainfall simulator that produces artificial storms of approximately the kinetic energy of high intensity natural rainfall will be used to test factors that affect soil erosion. Factors to be tested include soil erodibility, length of slope, percent of slope, past erosion, crop cover at various stages of growth, crop rotations, tillage practices, and residue management. Through the use of this equipment to evaluate these factors that affect runoff and erosion, it is hoped to complement existing natural rainfall data in arriving at realistic values for land use equations.

SUPPORTED BY U.S. Dept. of Agriculture
Indiana State Government

2.0465, AN INTEGRATED SYSTEM OF STREAM CLASSIFICATION

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A stream classification system which will quantitatively make comparisons of one stream to another has never been developed. It is the objective of this research to establish a system by finding some patterns of similarity between all streams. Geologic factors such as types of soil and rock, rock structure, and age; hydrologic factors as depth, load, and channel roughness: and geomorphic factors as topography and stream number will be considered as possible parameters in establishing such a classification system. The data will be taken from a wide range of streams, including all the major rivers of the world. Patterns of similarities will be revealed by parameter correlation, using the computer to determine the interrelationships of these parameters. Establishment of a unified, systematic terminology of stream classification will greatly improve the communication framework within which all water research is conducted, regardless of field of specialization.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Purdue University

2.0466, ELECTRICAL EFFECTS ON WATER INFILTRATION INTO SOILS

D. SCHWARTZENDRUB, Purdue University, Agricultural Experiment Sta., *Lafayette - West Lafayette, Indiana* 47907

(1) To determine experimentally the magnitude of the streaming potential developed under conditions of steady-and transient-state (infiltration) water flow in unsaturated soils; (2) To predict streaming potential theoretically by beginning with present unsaturated flow theory and making suitable modifications for the effect of unsaturation; (3) To compare theoretical predictions of streaming potential with the experimental determinations.

The experimental work will emphasize the simultaneous measurement of electrical streaming potential (using pH meter and strip-chart recorder), water content (using gamma-ray attenuation), and soil-water suction (using a transducer-recorder technique). These will be measured as functions of time and position in a uniformly packed column of horizontal soil to which water is added at one end. Use of the experimental findings to validate theoretical predictions should enable the development of more realistic and precise equations for describing water infiltration into soil.

SUPPORTED BY Indiana State Government

2.0467, ELECTRICAL EFFECTS ON WATER INFILTRATION INTO SOILS

D. SWARTZENDRUBER, Purdue University, School of Agriculture, *Lafayette - West Lafayette, Indiana* 47907

The hydraulic movement of water through porous membranes and porous materials saturated with water or water solution can produce an electrical streaming potential which opposes the hydraulically induced flow. This phenomenon should also be present in unsaturated water flow processes, such as the infiltration of water into soil. The objectives of the proposed research are: 1. To determine experimentally the magnitude of the streaming potential developed under conditions of steady-and transient-state (infiltration) water flow in unsaturated soils. 2. To predict streaming potential theoretically, by beginning with present saturated flow theory for membranes and making suitable modifications for the effect of unsaturation. 3. To compare theoretical predictions of streaming potential with the experimental determinations.

Studies realizing these objectives should provide a better understanding of the infiltration process, and should enable the development of more realistic and precise equations for describing the infiltration of water into soil. They may also point the way toward possible use of electrical energy to assist the entry of water into soil, either by neutralizing the streaming potential or in an electroosmotic sense.

Experimental work will emphasize the simultaneous measurement of electrical streaming potential (potentiometric strip-chart recorder), water content (gamma-ray attenuation), and soil-water suction (transducer-recorder technique). These will be measured as functions of time and position in a uniformly packed column of horizontal soil to which water is added at one end.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Purdue University

2.0468, QUANTIFICATION AND PREDICTION OF THE INFILTRATION PHASE OF THE HYDROLOGIC CYCLE

D. SWARTZENDRUBER, Purdue University, School of Agriculture, *Lafayette - West Lafayette, Indiana* 47907

The objectives of this project are: 1. To examine the validity of unsaturated soil-water flow theory for various facets of the infiltration process, and to obtain from the validated theory more realistic and workable mathematical descriptions of infiltration processes. 2. To analyze output hydrographs from simulated rainfall plots, with special emphasis on separating out from the instantaneous rainfall the portion which is infiltrated. 3. To predict infiltration rates from measured soil properties and soil-water content, and to validate these predictions with field measurements of infiltration rate.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Purdue University

2.0469, DYNAMICS OF WATER INFILTRATION INTO SOIL AS GOVERNED BY SURFACE CRUSTING AND SEALING

D. SWARTZENDRUBER, Purdue University, School of Agriculture, *Lafayette - West Lafayette, Indiana* 47907

The infiltration of water into soil can be strongly affected by the presence of crusts or seals at the soil surface. It is proposed to study the dynamics of water flow through crusts and seals, to provide a basis for characterizing them with respect to their water transmitting properties under flow conditions associated with infiltration. The specific objectives of the study are: 1. To obtain mathematical solutions for the entry of water into unsaturated soil when a thin layer of low intrinsic permeability is located at the inlet surface of the soil. 2. To test the experimental validity of the mathematical solutions on idealized crusted-sealed unsaturated flow columns. 3. To obtain experimental measurements of water infiltration into unsaturated soil columns containing an actual crust-seal produced by either natural or artificial rainfall.

The results of Objective 3 will be compared both with the mathematical solution of Objective 1 and the results of the idealized crusted-sealed system of Objective 2. On basis of these comparisons, quantitative characterization of the flow properties of the crust-seal will be sought. Experimental observations to be taken will include water content by gamma-ray attentuation at various times and positions in the soil columns, total volume of water absorbed by the columns, and possibly soil-water suction by means of transducer tensiometers.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Purdue University

2.0470, FLOW LAWS FOR THE MOVEMENT OF WATER IN SOILS

D. SWARTZENDRUBER, Purdue University, Agricultural Experiment Sta., *Lafayette - West Lafayette, Indiana* 47907

(1) To evaluate the nature and extent of deviations from Darcy's law in water saturated porous media; (2) To evaluate the nature and extent of deviations from Darcy's law in porous media partially saturated with water; (3) To study the flow behavior of non-Newtonian liquids in porous media.

Various mixtures of sand, silt, and clay will be placed in permeameter cyclinders and subjected to a range of different hydraulic gradients. The flow velocity through the samples will be plotted against the hydraulic gradient to determine the constants in a newly proposed basic flow law. An attempt will be made to correlate these constants with nature of the sand-silt-clay mixture. This will assist in determining limits of validity for Darcy's law, which is a special case of the newly proposed basic flow law. In systems where Darcy's law is expected to be valid, such as for sands, some non-Newtonian liquids will be passed through. This should give some indication as to whether deviations from Darcy's law when water is the liquid can be accounted for on a non-Newtonian basis.

SUPPORTED BY U.S. Dept. of Agriculture
Indiana State Government

2.0471, CHARACTERIZATION OF THE RATE OF WATER INFILTRATION INTO SOIL

D. SWARTZENDRUBER, Purdue University, Agricultural Experiment Sta., *Lafayette - West Lafayette, Indiana* 47907

1. To develop theoretical and experimental means of describing the water-transport properties of soil relevant to the infiltration phenomenon. 2. To predict the infiltration rate from the water transport depth function, the water content of the soil profile, and the crusting characteristics of the soil surface. 3. To measure infiltration rates with field-type instrumentation, to analyze and interpret these values, and to compare them with predicted values.

SUPPORTED BY Indiana State Government

2.0472, FLUID ELASTIC OPERATORS FOR UNDERSTREAMLINED STRUCTURES

G.H. TOEBES, Purdue University, School of Engineering, *Lafayette - West Lafayette, Indiana* 47907

This research has been concerned with the Hydroelastic loading of circular and triangular cylinders. The experimental investigation has been concerned with the deformation dependent 'Fluid Elastic Operator' for a circular cylinder, a triangular cylinder with the apex towards the flow, and a triangular cylinder with a blunt face towards the flow, all placed normal to the fluid flow. The cylinder was subjected to a simple harmonic motion with the lift force and displacement being measured. The amplitude and frequency of the cylinder motions were varied. The study resulted in the determination of the energy transfer between the cylinder and the fluid flow and the amplification of the lift force with frequency of oscillation close to the Stronhal frequency.

SUPPORTED BY U.S. National Science Foundation

2.0473, THE HYDRAULICS AND GEOMORPHOLOGY OF MEANDERING RIVERS WITH FLOOD PLAINS

G.H. TOEBES, Purdue University, School of Engineering, *Lafayette - West Lafayette, Indiana* 47907

It is proposed to study the flow field through meandering rivers during flood stages when also the flood plains are part of the conveyance. Except for a model study preparatory to the presently proposed work there is no systematic study of the title problem. The research will serve to improve river routing procedures and engineering designs involving flood-plain utilization. The study is also of considerable theoretical interest.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Purdue University

2.0474, ESTIMATING SOIL MOISTURE FROM METEOROLOGICAL MEASUREMENTS

D. WIERSMA, Purdue University, Agricultural Experiment Sta., *Lafayette - West Lafayette, Indiana* 47907

Objectives: (1) Determine the potential evapotranspiration rate under Indiana conditions. (2) Determine the effect of decreasing soil moisture on the evapotranspiration rate. (3) Develop a method for estimating soil moisture under different vegetative covers, soil types, and various geographic areas of Indiana. (4) Develop a method for estimating the daily, weekly, and seasonal soil moisture conditions for the several geographic areas of Indiana.

From routine meteorological measurements, it is proposed that an estimate of the soil moisture condition at a particular time and at a given location in Indiana be made. The relationship between the atmospheric energy gradient to the potential evapotranspiration rate and in turn this evapotranspiration rate to soil moisture changes makes this possible. The interaction of decreasing soil moisture unsaturated hydraulic conductivity and the atmospheric energy gradient on evapotranspiration will be studied in the laboratory. The effect of kind and amount of vegetative cover and soil typess will be studied in the field.

SUPPORTED BY U.S. Dept. of Agriculture
Indiana State Government

2.0475, BASIC PRINCIPLES AND MECHANICS OF RAINFALL, RUNOFF, SOIL MOVEMENT AND LOSS IN THE CORN BELT

W.H. WISCHMEIER, Purdue University, U.S.D.A Soil & Wat Cons. Lab., *Lafayette - West Lafayette, Indiana* 47907

Object: To develop basic information on the mechanics of runoff and soil erosion from rainfall, and establish fundamental principles to guide applied phases of the research.

Plan of Work: Laboratory studies of a fundamental nature will be conducted in Minnesota, on raindrop splash patterns and the relationships of drop size, shape, velocity, and energy of impact of waterdrops upon soil detachments, suspension and transport; in Indiana, the effects of overland flow, interaction of rainfall and overland flow and slope; and in Illinois on the relation of rainstorm drop size distribution, energy and intensity to runoff and erosion from field plots and subsurface movement of water under sloping topography. Periodic review and planning conferences will insure close integration of the different phases of the study, achievement of study objectives, and use of improved techniques and procedures.

SUPPORTED BY U.S. Dept. of Agriculture

2.0476, EVALUATION OF CLIMATIC, TOPOGRAPHIC, SOIL AND CROP MANAGEMENT FACTORS IN RELATION TO WATER MANAGEMENT AND EROSION CONTROL IN THE CORN BELT

W.H. WISCHMEIER, Purdue University, U.S.D.A Soil & Wat Cons. Lab., *Lafayette - West Lafayette, Indiana* 47907

Object: To evaluate under field conditions the primary and interaction effects of soil characteristics, rainfall, land slope, vegetative covers, and management practices upon runoff, water erosion and wind erosion.

Plan of Work: Measurements of the effectiveness of cropping systems and management plans and studies of the relationships of runoff and soil loss to length and degree of slope and to physical and chemical properties of the soil will be made under both natural and artificial rainfall. The studies will be designed to provide reliable information on the interaction effects as well as on the primary effects of the different variables which influence field runoff and soil loss. The runoff and erosion control effectiveness of new practices such as interseeding of row crops, plow-plant and mulch tillage will be evaluted under various soil and slope conditions using field plot rainfall simulators. Effects of soil characteristics will also be measured under small laboratory and field plot rainfall applicators. Runoff and soil loss data obtained under natural rainfall will be used as benchmark information to aid in analysis of qualitative data obtained with the simulators.

SUPPORTED BY U.S. Dept. of Agriculture

2.0477, DEVELOPMENT AND REFINEMENT OF METHODS FOR PREDICTING FIELD RUNOFF AND SOIL LOSS

W.H. WISCHMEIER, Purdue University, U.S.D.A Soil & Wat Cons. Lab., *Lafayette - West Lafayette, Indiana* 47907

Object: To develop tables, equations and graphs for preduction of field runoff and soil losses and to refine the soil loss prediction equation methods for applying conservation practices to farm fields and estimating sediment production rates.

Plan of work: All rainfall, runoff, soil loss and related data secured from small runoff plots of the Division are assembled at Lafayette, Indiana, for graphical analysis and transfer to punch cards for machine correlation and other analysis. Relationships established are immediately available for improving the accuracy of the soil loss prediction method. Selected research workers in major areas of the humid region will have the results of the analysis for study and adaptation to their local conditions. They will work directly with State and regional SCS personnel in the development and refinement of the method for use by SCS farm planners. U. S. Weather Bureau records on rainstorm duration and intensity will be used to supplement location records and extend the area of soil loss application. Periodic review and planning conferences insure achievement of study objectives and use of improved techniques of data handling and presentation of results.

SUPPORTED BY U.S. Dept. of Agriculture

2.0478, GROUND WATER SEEPAGE PATTERNS TO WELLS FOR UNCONFINED FLOW

D. KIRKHAM, Iowa State University, School of Agriculture, *Ames, Iowa* 50010

To derive exact theories for seepage of water to wells and cavities in semi-confined aquifers, to digitally computerize these theories, and from the computed values of the potential and stream functions to prepare flow nets, showing, in particular, the location of free surfaces. These exact theories would replace approximate theories obtained by Dupuit-Forchheimer procedures or other approximate methods. The theories will show how accurate electric and other type analogs may be relied on. The theories are needed to understand well dynamics accurately and to furnish coefficients needed to convert accurately measured rates of water rise in piezometer cavities to hydraulic conductivities. The exact theory for the buffered infiltrometer will be worked out. The problems considered here are three-dimensional and therefore not subject to (two-dimensional) conformed transformation procedures.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Iowa State University

2.049, SIMULTANEOUS FLOW OF WATER AND HEAT IN WATER-UNSATURATED IOWA SOILS DURING EVAPORATION

D. KIRKHAM, Iowa State University, School of Agriculture, *Ames, Iowa* 50010

Simultaneous flow of water and heat into one- and two-dimensional homogeneous, and layered soils with and without cracks, will be studied under controlled laboratory conditions. The soils will be packed in plastic containers and saturated with water. Soil temperature will be measured with thermocouples installed at various positions throughout the soil. The soil container will be placed below a bank of heat lamps in a wind tunnel where air velocities will be controlled. Changes in soil moisture content during evaporation will be followed by measuring the soil moisture at a series of times at various positions throughout the soil using the gamma ray-attenuation technique. The gamma ray attenuation technique will be used to measure the bulk density of the soil at various positions in the model. An attempt will be made to solve the differential equations describing the flow of heat and moisture in unsaturated soils either analytically or numerically, and the theoretical results will be compared with the experimental data.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Iowa State University

2.0480, MOVEMENT OF WATER AND GASES IN SOIL

D. KIRKHAM, Iowa State University, Agricultural Experiment Sta., *Ames, Iowa* 50010

Develop and test mathematical theory and formulae for relating soil water and gas movement to physical properties. Improve the neutron scattering device and attempt to combine with density measurement by gamma ray absorption. Develop theory for using tagged atoms to follow water movement in soil and plants.

DESCRIPTION OF WORK: The theory of ground water movement will be further developed for the saturated and unsaturated state. Emphasis for the saturated state will be on the mathematical solutions of drainage problems, and especially on the problem of the falling water table. Emphasis on the unsaturated state will be on evaporation. The isotopes deuterium and oxygen-18 will be used as tracers for studying problems of water and gas movement through soils and plants. Neutron and gamma ray equipment will be used for soil water and soil density measurements.

SUPPORTED BY U.S. Dept. of Agriculture
Iowa State Government

2.0481, INTERRELATIONSHIP OF SURFACE AND SUBSURFACE FLOW IN THE NISHNABOTNA DRAINAGE BASIN

L.V. SENDLEIN, Iowa State University, Graduate School, *Ames, Iowa* 50010

The Nishnabotna River basin drains a modified glacial terrain with Pleistocene deposits overlying bedrock. The Pleistocene deposits are composed of glacial drift with sand and gravel-filled channels associated with the buried bedrock valleys. The bedrock aquifers subcrop within the basin and where they intersect the modern alluvial or buried sand and gravel systems, they discharge into them. Discharge hydrography can be used to evaluate groundwater discharge at the point of measurement, however the source of the water and the amount moving into or out of the basin cannot be determined by this method. In order to determine the amount discharged to streams, the relationship of the subsurface geology to the modern alluvial system must be known.

This study is composed ot two phases: 1. evaluation of subsurface flow into and out of the Nishnobotna Basin, and 2. location and evaluation of discharge from the subsurface to the modern stream system.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Iowa State University

2.0482, EFFECTS OF WEATHER ON CROPS

R.H. SHAW, Iowa State University, School of Agriculture, *Ames, Iowa* 50010

A continuing study to examine meteorological techniques for estimating evapotranspiration and soil moisture and to test techniques for calculating evapotranspiration losses and improve usefulness in determining the available moisture in meadow crops. Test periods are April-June, June-August, and August-November. Estimated soil moisture is compared with measured soil moisture.

Evaluation of the effect of advected energy on the metal evaporation pan directly will be initiated in FY-68.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.0483, USE OF INFRARED AND OTHER RADIATION TECHNIQUES TO EVALUATE DROUGHT IN IOWA AND ADJACENT AREAS

R.H. SHAW, Iowa State University, School of Agriculture, *Ames, Iowa* 50010

A method is proposed to detect the onset and development of drought by the measurement and analysis of the spectral radiation characteristics of plants. Because the various factors producing water stress in plants reduce the quality and quantity of the harvested plants, it is important to detect drought intensity differences under a variety of different management practices.

Radiation theory indicates that the spectral 'signature' of plants could differ because of chemical composition, color, temperature, water content, etc. Experimental evidence has established that a reduction in near infrared reflectance occurs as a result of drought but could not be distinguished from nutritional and disease disorders by infrared photography alone. A spectrophometric analysis is proposed in the 0.4 to 1 micron wavelength region to investigate the possible separation of the causative factors. Infrared photography will also be used. The results will be correlated with the stress conditions of plants as evaluated by presently available techniques.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Iowa State University

2.0484, WEATHER INFORMATION FOR AGRICULTURE

R.H. SHAW, Iowa State University, Agricultural Experiment Sta., *Ames, Iowa* 50010

Objectives: 1. Iowa weather data will be analyzed and interpreted for problems in agriculture. 2. Iowa weather data analysis will be coordinated with similar information in the North Central Region. 3. Both state (The Climate of Iowa) and regional publications will be published as summaries are completed.

Work proposed - The work proposed involves the analysis of soil moisture - atmospheric stress conditions (stress day concept) for several experimental farms in Iowa. An analysis will be made of the climatology of stress days. The study of weather and oat yields over the region will be continued. Data will be furnished for any regional summaries undertaken by the regional committee.

SUPPORTED BY U.S. Dept. of Agriculture
Iowa State Government

2.0485, SOIL AND CLIMATE FACTORS AFFECTING THE EFFICIENT USE OF WATER BY CROPS

R.H. SHAW, Iowa State University, Agricultural Experiment Sta., *Ames, Iowa* 50010

Using soil moisture data collected over Iowa, a method has been developed by which daily soil moisture balances can be predicted. Precipitation and evaporation pan data are the weather data used. Procedures have been developed for corn, meadow and oats.

The climatology of soil moisture under corn at Ames, Iowa was estimated for 30 years, 1933-62 for the different available field capacities and for each 3 different 'starting' soil moisture profiles in the spring. An atmospheric - soil moisture variable was developed and used in the interpretation of the effects of weather, stand and fertilizer treatment on long term experimental plot corn yields. The climatology of water stress conditions for corn was also prepared. The methods are now being expanded to other climatic regimes.

The efficiency of water use with different row spacings of corn has been studied and the relative amounts of water lost by soil evaporation and transpiration evaluated.

SUPPORTED BY Iowa State Government

2.0486, FLOW OF WATER INTO TILE DRAINS ON STRATIFIED SOILS

S. TOKSOZ, Iowa State University, School of Agriculture, *Ames, Iowa* 50010

A solution for the Laplace's equation will be sought in connection with water flow into tile drains in a stratified soil having different permeabilities and with a curved water table between the drains. It is expected that the resulting solution, containing the drain spacing implicitly, can be transformed into an explicit form to give the drain spacing directly. The drain spacing formula will then be put into a graphical form so that it can be easily used by the designers. The effects of various soil and drainage parameters on drain spacing will be explored from the standpoint of setting up useful design criteria.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Iowa State University

2.0487, INJURY AND RESISTANCE IN PLANTS

D.G. WOLLEY, Iowa State University, Agricultural Experiment Sta., *Ames, Iowa* 50010

The overall objective is to determine how and to what degree the water status of plants is related to growth and development and is influenced by physical factors of the environment.

A number of measurements relating to plant moisture stress will be made. These include relative turgidity, stomatal opening, beta-ray gauging and leaf temperature. The accuracy of each and the relationship between them will be examined. Work will be conducted primarily on soybeans and corn. Plant observations to be related to moisture stress measurements are leaf area and efficiency, growth rate, grain yield and seed quality. The effect of timing of moisture stress will be determined by applying moisture stress at different stages of plant development. The photosynthetic response of varieties will be studied in controlled growth chambers under various moisture stress regimes. Growth chambers will also be used in evaluating the effect of moisture stress on nutrient uptake and translocation. Measurements of plant moisture stress will be related to environmental factors more easily measured (solar radiation, evaporation, soil moisture, etc.) in an attempt to obtain some degree of predictability.

SUPPORTED BY U.S. Dept. of Agriculture
Iowa State Government

2.0488, WATER AVAILABILITY OF MUSCATINE ISLAND, IOWA

R.E. HANSEN, U.S. Dept. of Interior, Water Resources Division, *Iowa City, Iowa*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with State and local agencies in Iowa.

Purpose: To provide guidelines for optimum development and management of the water resources of the area by defining the hydrologic system and analyzing the system's response to present and anticipated development.

Methods: Test holes will be drilled to define the extent, thickness, and physical characteristics of the aquifer. Observation wells will be installed and periodic measurements will be made to determine the water table and the vertical flow component. Aquifer inventory of withdrawals from the aquifer will be made. Water samples from observation wells and existing wells will be collected and analyzed to determine areal distribution and time variation of chemical constituents. An analog model will be constructed and analyzed to predict and define the hydrologic system's response to additional development.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Iowa State Government

2.0489, LOW-FLOW STUDIES OF IOWA STREAMS

H.H. SCHWOB, U.S. Dept. of Interior, Water Resources Division, *Iowa City, Iowa*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Iowa.

Purpose: To evaluate the firm water-supply potential of streams which will assist in the administration of the Iowa water law and in the development, administration and enforcement of water quality criteria applicable to surface waters.

Methods: Approximately 435 low-flow partial-record stations were established where at least one low-flow discharge measurement is made each year. By correlation with complete-record stations, data from the low-flow partial-record stations can be used to estimate low-flow yields in practically every area of the State. A report prepared in 1958, 'Low-flow Characteristics of Iowa Streams,' is currently being updated. The updated report will include duration-of-flow data, low- flow frequency analyses, and methods for predicting the mean flow and possibly on other index of low flow at ungaged sites.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Iowa State Government

2.0490, FLOOD PROFILES AND FLOOD-PLAIN INFORMATION, CEDAR RAPIDS, IOWA

H.H. SCHWOB, U.S. Dept. of Interior, Water Resources Division, *Iowa City, Iowa*

This research is part of the program of water resources investigations conducted by the U.S. Geological Survey in cooperation with State and local agencies in Iowa.

Purpose: To provide flood information on creeks in the city and proposed expansion areas for use by planning and zoning agencies.

Methods: Flood-profile data will be obtained in the field immediately after the occurrence of significant floods or by computation using channel cross sections and other pertinent field data.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Iowa State Government

2.0491, FLOOD PROFILES AND FLOOD-PLAIN INFORMATION, LINN COUNTY, IOWA

H.H. SCHWOB, U.S. Dept. of Interior, Water Resources Division, *Iowa City, Iowa*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with State and local agencies in Iowa.

Purpose: To define flood profiles and obtain flood information on several small streams in Linn County that will be useful to local agencies in future development and in formulating and administering zoning regulations.

Methods: Profiles of flood flow and low flow will be obtained and discharge measurements made at a sufficient number of points along the selected streams to define the stage-discharge relations. Flood- frequency data will be computed.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Iowa State Government

2.0492, STATISTICAL, METEOROLOGICAL AND DEPTH-AREA ANALYSIS OF RAINFALL

N. ROSENAN, Israel Meteorological Service, *Bet Dagan, Israel*

This research project which is funded under the Special Currency Program of the United States Government consists of three separate studies: (a) Statistical analysis of long period (105 years) rainfall series and its application to hydrological middle-range and long-range forecasting. (b) Correlations between rainfall in the central Mediterranean and in eastern Mediterranean and possible explanation by typical configurations of the 500 mb. surface. (c) Comparison of point and areal rainfall.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.0493, DETERMINATION OF EVAPOTRANSPIRATION FOR SHORT INTERVALS ON A BENCHMARK BASIN

D. ROSENZWEIG, Ruppin Inst. of Agriculture, *Emek Hefer, Israel*

The description of this research project which is funded under the Special Currency Program of the United States is as follows: The benchmark basin is located in the Karst area of the Nahal Oren catchment on Mount Carmel. The purpose of the study is to (a) develop relationships between soil moisture changes (actual evapotranspiration) and various meteorological factors, (b) compare long period evapotranspiration obtained by neutron scattering meter to those obtained by energy budget, (c) study hydrologic balance for the basin.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.0494, MOVEMENT OF IONS AND SALTS IN SOILS

R.S. MOKADY, Technion Res. & Develop. Fdn. , *Haifa, Israel*

Object: To study the movement of ions in saturated and unsaturated soils and clays and the effect of soil stratification on this movement.

Plan of work: Theoretical development: Present theories for chromatography, miscible displacement, ion diffusion, and hydrodynamic dispersion will be examined, modified, and consolidated into a unified model applying to the practical problem of salt movement and fertilizer distribution in soils. Simplifying assumptions, when necessary, will be those most compatible with the conditions of the laboratory trials. Laboratory trials: The rate of salt and ion movement during water flow through clays and through real and simulated layers of soil will be measured, as well as the salt distribution pattern through one dimensional and three-dimensional flow. The movement will be monitored both conductimetrically and through the use of radioactive tracers. Radioactive sodium, chlorine, and tritium will be used as much as possible in tracing the relative movement of salt and water through the layers. Variables involved will include soil moisture content, soil profile homogeneity, salt composition and concentration, and temperature. After the preliminary stage, in which many of these variables will be studied independently, the variables will be combined and the interactions examined.

SUPPORTED BY U.S. Dept. of Agriculture

2.0495, DEVELOPMENT OF METHODS FOR MEASURING PARTIAL VAPOR PRESSURE OF SOIL WATER

D. ZASLAVSKY, Technion Res. & Develop. Fdn. , *Haifa, Israel*

Object: To develop (1) a convenient method for measuring the partial vapor pressure of soil water, (2) a method which does not require strict laboratory conditions, and (3) a method usable in the 98 to 100% relative humidity range.

Plan of Work: This project concerns itself with development of instrumentation for measuring the partial vapor pressure of plant and soil water. The first stage of this research would be the development of some improved methods for measuring the partial vapor pressure of soil and plant water. The second stage of the research would be to use the method in some preliminary investigations of water movement in soil. Methods of instrumentation to be investigated and their order of investigation are: (1) measurement of dielectric constant, (2) osmotic pressure, (3) refractive index, and (4) radioactive krypton.

SUPPORTED BY U.S. Dept. of Agriculture

2.0496, PRECIPITATION, STREAMFLOW AND SEDIMENT CONVEYANCE IN A SMALL ARID WATERSHED

D. AMIRAN, Hebrew University, *Jerusalem, Israel*

This research project which is funded under the Special Currency Program of the United States will investigate precipitation to determine maximum intensities, areal variability, and effects of relief, exposure and wind. Peak flows will be obtained at numerous locations and continuous flow at the mouth. Flash floods will be sampled for sediment concentration, erosion on slopes and in channels, and sediment tracing by isotope or fluorescent dyes. It is hoped that desert flash floods with recurrence interval of 5-10 years will provide conclusions relevant to more infrequent events in humid environments.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.0497, THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF THE MECHANISM OF FLOW OF WATER AND SOLUTES IN PLANT ROOTS

B. BINZBURG, Hebrew University, *Jerusalem, Israel*

Object: 1. To analyze the steady-state flows of water and solutes across roots; (2) To explain the mechanism and site of separation of solute from the water which occurs in the plant root tissue; (3) To explain the salt tolerance of plants on the basis of both water flow and chemical reaction.

Plan of Work: Theoretical attempts will be made to adapt the thermodynamics of irreversible processes to a study of ultrafiltration. The theory should deal with flows through homogenous membranes as well as those through complex membranes. It should resolve the dependence of ultrafiltration on the composition of solutions and on driving forces as gradients of hydrostatic pressure, osmotic pressure and electrical potential.

SUPPORTED BY U.S. Dept. of Agriculture

2.0498, SOIL WATER EVAPORATION AND MEANS OF MINIMIZING IT

D. HILLEL, Volcani Inst. of Agric Res., *Rehovot, Israel*

Object: To test recent developments in the theory of unsaturated soil-moisture flow; to determine the extent to which evaporation losses can be minimized by modification of surface conditions; and to develop methods for moisture conservation in baresurface soils.

Plan of work: A rigorous examination and development of theory for various boundary conditions and planning of laboratory and field trials will be conducted. In this stage, it may be necessary to submit problems to solution by electronic computers. All pertinent soil-water and soil-thermal properties will be determined, including diffusivity, conductivity and retention properties. The experiments will include steady-state and transient-state processes, finite and semi-infinite columns; uniform and layered profiles; steady and intermittent evaporation; as well as isothermal and non-isothermal columns. Each variable will be tested separately and later combined and the interactions examined with a view toward finding a feasible combination of profile properties and environmental conditions likely to result in diminution of evaporative losses. The theoretical and experimental results will be tested in the field, to determine their applicability under varying conditions of soil and natural climate. These experiments will include pre-wetting and post-wetting tillage, structural stabilization by chemical means, and the use of materials.

SUPPORTED BY U.S. Dept. of Agriculture

2.0499, SOIL STRUCTURE - TILLAGE INTERACTIONS

D. HILLEL, Volcani Inst. of Agric Res., *Rehovot, Israel*

Object: To investigate the influences of tillage operations on soil physical conditions related to crop growth.

Plan of Work: Theoretical development: A rigorous examination will be made of the dynamics of soil-water systems, and the application of the theories of elastic, plastic and rheological models to compaction and tillage of unsaturated soils.

Laboratory trials: Measurements will be made of stress - deformation - failure properties of soils for boundary conditions simulating tillage, and tests made of similitude models of simple tillage tools. Field trials: Theoretical and laboratory results will be applied in the field, and field techniques developed for evaluating tillage efficiency. These experiments will measure and analyze soil and tool stresses, power requirements and tractability. In addition to the mechanical factors, soil physical processes will be followed, as well as crop response under various tillage systems. The study thus envisages the cooperative effort of soil physicists, engineers, and agronomists.

SUPPORTED BY U.S. Dept. of Agriculture

2.0500, THE PHYSIOLOGICAL BASIS OF THE TOLERANCE OF HORTICULTURAL CROPS TO COLD, DROUGHT, AND WATER

B. KESSLER, Volcani Inst. of Agric Res., *Rehovot, Israel*

Object: To determine the basic plant structures which are susceptible and become injured through the effect of cold, drought, and high water stress and to then develop chemicals which may aid the plants in meeting these stress conditions.

Plan of Work: Experiments will be conducted under induced cold and water stress. Initially studies will be done with gramineous plants such as wheat and barley and research findings adapted to similar studies of various subtropical and temperate zone fruit plants. The correlationships between nucleic acid, enzymes, and stress resistance will be determined; and will include RNA - synthesizing polymerase and the elucidation of the metabolic pathways through which water stress influences the synthesis of this enzyme in drought-resistant plants. The nature and distribution of plant lysosomes, the inherent centers of high concentrations of destructive catabolic enzymes, will also be studied. The effect of extreme external conditions of temperature & water upon reticulate and nucleoprotinous fine structures in the cell will be examined as will the stability of catabolic centers associated with these fine structures. Biochemical laboratory assay methods will be developed to determine the relative degree of stress resistance of a given plant or type. Chemical agents which can induce drought and cold hardening processes or otherwise stabilize the fine cellular structures and catabolic enzyme centers under unfavorable conditions will be sought, developed and field tested.

SUPPORTED BY U.S. Dept. of Agriculture

2.0501, INFLUENCE OF PLANT AND ENVIRONMENTAL FACTORS ON PHOTOSYNTHESIS, STOMATAL APERTURE AND TRANSPIRATION

E. SHMUELI, Volcani Inst. of Agric Res., *Rehovot, Israel*

Object: To (1) study stomatal aperture and gaseous exchange of the plant as influenced by the internal water potential of the plant, and the energy status of water in the rooting medium and in the atmosphere, and (2) basic aspects of diffusion through the stomata and the whole leaf, and (3) to develop field techniques to measure stomatal aperture to gauge irrigation needs.

Plan of Work: Study will be made of the effect of stomatal aperture on gaseous exchange of plants, and an assay developed for stomatal aperture as an indicator of the need for irrigation. Relevant soil, plant, and atmosphere parameters coupled with plant responses will be measured over short periods under semicontrolled conditions. Parameters to be measured or evaluated are for the soil: moisture content, water potential and hydraulic conductivity; for the atmosphere: air temperature, humidity, wind flow and net radiation flux; and for the plant: leaf gaseous diffusion, stomatal aperture, stomatal resistance, transpiration, photosynthesis, respiration, growth, water potential of the plant tissue, and leaf temperature. It will contribute significantly toward understanding the role of the plant in the hydrological cycle and thus increase our potential for water conservation.

2. WATER CYCLE

SUPPORTED BY U.S. Dept. of Agriculture

2.0502, GRAVITY FLOW OF WATER IN SOILS AND AQUIFERS OF WESTERN KANSAS

R.C. PRILL, U.S. Dept. of Interior, Geological Survey, *Lawrence, Kansas*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Kansas. The problem is to determine the rate of recharge in the High Plains of southwestern Kansas and to determine the storage coefficients of the principal aquifers. Although most of the area has been studied before, the standard methods used have failed to yield reliable results. It is proposed to determine by means of logging with a neutron meter (1) the rate of recharge through each of the major soil types and trace the downward movement of water beneath the root zone and (2) the rate and amount of dewatering as a result of pumping. A continuing project started in 1965.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Kansas State Government

2.0503, RECENT VARIATIONS IN COURSE AND REGIMEN, KANSAS RIVER AND NEARBY REACHES OF MISSOURI RIVER

W. DORT, Univ. of Kansas, Graduate School, *Lawrence, Kansas* 66045

A pilot study of the lower Kansas River and a portion of the Missouri River near the Kansas confluence. Compilation of data on variations in stream course, floodplain landforms, and floodplain sediment patterns. Data to be obtained from study of maps and aerial photographs and in the field.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Kansas

2.0504, EFFECTS OF BANK SEEPAGE ON FLOOD HYDROGRAPHS

E.C. POGGE, Univ. of Kansas, School of Engineering, *Lawrence, Kansas* 66045

Two analytical methods which have been developed for determining bank seepage and bank storage at a particular location during the passage of a flood wave will be utilized to study the effects of bank seepage on a flood wave as it passes through a reach of an alluvial channel. Based on the results of this study a method will be formulated for the separation of groundwater runoff from surface water runoff for a flood hydrograph analysis.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Kansas

2.0505, WATER UTILIZATION ASPECTS OF WEATHER MODIFICATION AS APPLIED TO KANSAS

R.L. SMITH, Univ. of Kansas, School of Engineering, *Lawrence, Kansas* 66045

The primary objective of this study is to ascertain the relative magnitude of incremental precipitation (weather modification) required to produce significant water management results in Kansas.

A digital model of the hydrologic cycle is being used to study the probable response to augmented precipitation patterns. Four Kansas basins, representing a variety of climatic, geologic, and hydrologic conditions will be studied. A variety of rainfall augmentation patterns will be utilized. These will range from a simple percentage increase in the historic record to the use of random variables and selected operational constraints reflective of the water managment and control needs of the area. Comparative analysis of the various model runs is expected to give some insight to the degree of weather modification needed to provide measureable improvement in water supplies for various beneficial uses.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Kansas

2.0506, NUMERICAL MODELING OF GROUND WATER FLOW

C.F. WEINAUG, Univ. of Kansas, Water Resources Institute, *Lawrence, Kansas* 66045

A mathematical model of ground water flow is being developed. The model basically consists of the numerical solution of the partial differential equations describing two phase, two-dimentsional flow in porous media, e.g., water flow in the presence of partial air saturation. A digital computer is required in the solution technique. Calculations made with the model are to be checked against experimental aquifer-recharge data obtained by the U.S. Geological Survey.

The mathematical model will be useful for such studies as an evaluation of methods of artificial recharge of ground-water aquifers or the determination of rate of flow between adjacent aquifers.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Kansas

2.0507, LONGITUDINAL DISPERSION OF THE LOWER KANSAS RIVER BASIN

Y.S. YU, Univ. of Kansas, School of Engineering, *Lawrence, Kansas* 66045

The purpose of this project is to determine the longitudinal dispersion characteristics of the Lower Kansas River Basin.

This study will be based on the field measurements of time concentration of dye at different stations in the Lower Kansas River Basin. The longitudinal dispersion coefficient will be determined from the time-concentration curves and the flow parameters.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Kansas

2.0508, WEATHER IN RELATION TO KANSAS AGRICULTURE

L.D. BARK, Kansas State University, Agricultural Experiment Sta., *Manhattan, Kansas* 66504

(1) To analyze and interpret weather data on a regional basis for application to agriculture and related industries. (2) To develop phenology as a climatic tool to characterize seasonal weather patterns. (3) To develop instrumentation of particular value to agriculture. (4) To coordinate the collection, reporting and summarization of weather data on a regional and inter-regional basis.

Sixty years of weather records from 24 Kansas stations are placed on magnetic tape for computer analysis. These data are subjected to statistical procedures to obtain the probabilities of occurrence of weather factors of importance to Kansas Agriculture. When existing statistical procedures are inadequate, the data are used to develop new techniques.

SUPPORTED BY U.S. Dept. of Agriculture
Kansas State Government

2.0509, RECHARGE IN RIVER VALLEYS OF CENTRAL AND EASTERN KANSAS - EFFECT OF TUTTLE CREEK RESERVOIR ON GROUNDWATER LEVELS

H.V. BECK, Kansas State University, Graduate School, *Manhattan, Kansas* 66504

Water level measurements on project one were started in June 1966 and have been maintained to date. Records indicate no major change in water level during this time, even though there has been extensive irrigation and periods of below normal rainfall. No direct correlation has been determined as yet.

Electrical resistivity and refraction siesmograph surveys will be made in the next year in order to determine lateral and vertical variations in the aquifer.

K. A. E. S. Bull. 512 summarizes the findings of project two. Reservoir elevation affects the ground water level indirectly by governing the amount of water released from storage which governs the level of the river below the dam.

Report in preparation on the effects of pumping on the chemistry of the ground water.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Kansas State University

2.0510, THE ECONOMIC EFFECTS OF DROUGHT ON AN AGRICULTURAL ECONOMY

O. BULLER, Kansas State University, Graduate School, *Manhattan, Kansas* 66504

1. To evaluate the economic effects of drought on farms and to rural communities and, if possible, to improve some existing strategies used by farmers and to derive improved strategies to minimize the effects of drought on farm firm; 2. To derive estimates of the effect of weather as compared with other inputs, in the production of the most important crops grown in the great Plains.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.0511, ECONOMICS OF CLIMATE

O. BULLER, Kansas State University, School of Agriculture, *Manhattan, Kansas* 66504

Analysis of the economic effects of weather variability on Kansas farm income began with the study of the relationship between crop yields and weather variables. Due to climatic differences and form in which data was available, the analyses considered Kansas as nine crop reported districts.

Crops considered in Western Kansas were wheat and grain sorghum; in Central Kansas, wheat, grain sorghum and corn; in Eastern Kansas, wheat grain sorghum, corn and soybeans. A good statistical relationship was for crops and weather variables, but not for livestock production and weather.

Relationship between crop yield and weather were easier to establish in Western Kansas than in Eastern Kansas. Weather variables used in Western Kansas were indexes established by Wayne Palmer and reported in 'Meterological Drought,' research paper number 45, U.S. Department of Commerce, Weather Bureau. Weather variables in Eastern Kansas were based on a measure of evapotranspiration rate.

The influence of weather on farm income has been relatively favorable in Eastern Kansas but has had an adverse affect in Western Kansas.

SUPPORTED BY Kansas State University
U.S. Dept. of Commerce - E.S.S.A.
Kansas State Government

2.0512, IRRIGATION PROJECT

R.E. GWIN, Kansas State University, Agricultural Experiment Sta., *Manhattan, Kansas* 66504

Corn and grain sorghum performance tests. Forage tests. Bean, date and varieties. Onion varieties and weed control, onion fertility. Potato varieties. Castor bean fertility. Corn, and grain sorghum fertility. Winter wheat fertility. Winter wheat and winter barley varieties. Alfalfa seed production.

SUPPORTED BY Kansas State Government

2.0513, ECOLOGICAL STUDIES OF GRASSLANDS, ETC.

L.C. HULBERT, Kansas State University, Agricultural Experiment Sta., *Manhattan, Kansas* 66504

Description of Work: The major emphasis is on the delineation and description of the plant communities in the true prarie of the Flint Hills of Kansas. Areas are selected possessing different site conditions (ridge tops, rocky slopes, gently sloping deep soil, etc.) and different treatments (ungrazed and grazed, burned and unburned, unmowed and annually mowed). On these areas canopy coverage of each species of vascular plant is measured. From these data the expected composition under different conditions will be compiled, and the effect of different treatments on each species will be interpreted.

Relationships and causes of the relationships among the plants of the communities will be studied more after the communities are known.

SUPPORTED BY U.S. Dept. of Agriculture
Kansas State Government

2.0514, GROUND WATER RECHARGE THROUGH PITS AND WELLS

H.L. MANGES, Kansas State University, School of Engineering, *Manhattan, Kansas* 66504

Irrigation development increases the drainage problem in areas with poor natural surface drainage. An alternative to an organized Drainage District is to dispose of excess water by recharge into the underground aquifer. This can be accomplished by pits or wells if suspended material is removed from the surface water.

A series of recharge pits will be dug to the top of the underground aquifer. The pits will be backfilled with a filter material. Various materials, including fiberglass, sands and gravels, will be evaluated in the laboratory before selecting a filter design for field trails.

Underground draintile will be installed to determine if the natural soil profile can be used as an effective filter for removing suspended particles from surface runoff water. Runoff from rainfall and irrigation will be diverted onto the area and the flow rate and amount of suspended sediment determined.

The potential recharge rate of a selected aquifer will be determined. Water will be pumped from an existing irrigation well into a recharge well.

The work will be accomplished at Kansas State University, Manhattan, and the Sandyland Irrigation Field at St. John, Kansas.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Kansas State University

2.0515, ZOOPLANKTON NUTRITION IN LARGE RESERVOIRS

G.R. MARZOLF, Kansas State University, Graduate School, *Manhattan, Kansas* 66504

The utilization of aquatic bacteria as a food source for zooplankton is suspected in reservoirs where low light penetration limits primary production. Study of the nutrition of the exceptionally large zooplankton populations living in these environments will add significant information to the flow of energy thru reservoirs and to role of bacteria generally in surface waters. The approach will be that of measuring the efficacy of bacterial, algal, and detrital feeding by populations of zooplankton in laboratory. This will be estimated by monitoring population attributes (i.e., birth rates, and death rates) rather than dealing with individuals. The experiments will be conducted under controlled temperature conditions, using food sources of known quantity and caloric content.

SUPPORTED BY U.S. National Science Foundation

2.0516, MICROMETEOROLOGICAL INVESTIGATIONS OF THE ENERGY BUDGET - EFFECT OF SUMMER WINDS

E.L. SKIDMORE, Kansas State University, School of Agriculture, *Manhattan, Kansas* 66504

The influence of summer winds on energy budget in semiarid agricultural regions will be characterized and effectiveness of slat-fence windbreaks in reducing windspeed and evapotranspiration determined. Eight-foot-tall slat fence will be installed perpendicular to direction of prevailing summer wind about midfield. Observations stations will be established at 6H windward and 2, 6, and 12H leeward of the windbreak (H equal height of windbreak). Measurement of temperature, humidity, and windspeed gradients, net radiation, and soil heat flux density will be obtained at each observation station and used to compute energy balance. Observations will be made at various levels of windspeed and soil moisture.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Kansas State University

2.0517. IMPACTS OF DROUTH ON LOCAL ECONOMIES IN KANSAS

M.D. SKOLD, Kansas State University, Agricultural Experiment Sta., *Manhattan, Kansas* 66504

Objectives: 1. Identify and measure the occurrence, duration, and intensity of recent historical agricultural drouths in Southwest Kansas. 2. Analyze the direct effects of these drouths on the composition and level of farm output and income. 3. Analyze the indirect effects of these drouths on the levels and flows of income in agriculturally related industries in local economies. 4. Assess the extent to which improved agricultural water management practices might have reduced the direct and indirect economic effects of drouths.

Rather than attempt to establish a new technique for measuring drouth, plans are to adopt a technique already developed and test it as to its ability to relate to changes in agriculture that occur as a consequence of drouth. These agricultural adjustments will be analyzed as to their effect upon the local economy and perhaps to certain sectors of the local economy.

SUPPORTED BY Kansas State Government

2.0518, MOISTURE USE ESTIMATION AND RELATIONSHIP BETWEEN MOISTURE USE AND NITROGEN RESPONSE IN WINTER WHEAT

R.L. VANDERLIP, Kansas State University, School of Agriculture, *Manhattan, Kansas* 66504

Moisture use by dryland winter wheat will be characterized and used to provide a basis for decisions on fertilization of winter wheat with nitrogen. This information should result in increased efficiency of water use and greater returns for fertilizer investment.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Kansas State University

2.0519, DEVELOPMENT OF A PRACTICAL METHOD OF LOCATING AND TRACING SEEPAGE WATER IN UNSTABLE SLOPES

J.H. HAVENS, State Dept. of Highways, *Frankfort, Kentucky*

Recurrence of movement in slide areas during wet weather is indicative of troublesome underground seepage which is often associated with stratified shales in side-hill cuts and benched, side-hill embankments. In order to evaluate such situations and to methodically undertake corrective repairs, it is essential that the source of the seepage be located and diverted. A systematic investigation of each slide would thus obviate trial-and-error methods which are often expensive and disheartening. The project is primarily a field study of existing slides. A procedure for determining the source of seepage water associated with unstable slopes is being developed.

Work has been started to develop a technique of using an electrical resistivity method to locate and trace seepage water in a landslide.

Preliminary indications are that four-probe resistivity data may be used to trace water as well as geologic strata with only a minimum of drill-hole date.

Reports Issued: Development of a practical method of locating and tracing seepage water in unstable slopes, R. C. Deen, Status Report of Landslide Area on I-75, Covington, Kentucky, Highway Research Laboratory, Kentucky Dept. of Highways, May 15, 1963.

Development of a practical method of locating and tracing seepage water in unstable slopes, R. C. Deen, Part II, Status Report on Landslide Area on I-75, Covington, Kentucky, Highway Research Laboratory, Kentucky Dept. of Highways, Aug. 1, 1963.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Kentucky State Government

2.0520, STUDY OF RUNOFF FROM SMALL DRAINAGE AREAS

J.H. HAVENS, State Dept. of Highways, *Frankfort, Kentucky*

Extensive records are available in reference to the rainfall runoff relationships for the larger watersheds throughout the state. However, little data are available in regard to these relationships for the smaller watersheds. The major portion of expenditures for drainage facilities on most highway projects goes toward provision for drainage from the smaller areas. It is thus desirable to obtain reliable rainfall-runoff relationships for the smaller areas and to develop a design criterion on the basis of these relationships. Intensity-duration curves are available for the entire state and, with minor revisions to correct for the greater years of records presently available, they should be incorporated into a criterion developed as mentioned.

Reports Issued: Report No 1 on a study of runoff from small drainage areas and the openings in attendant drainage structures, E.M. West and J.D. Cornell, Highway Res. Lab., Ky. Dept. of highways, April 1952. Report No 2 on a study of runoff from small drainage areas and the openings in attendant drainage structures, E.M. West and W.H. Sammons Highway Res. Lab., Ky. Dept. of Highways, July 1955.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Kentucky State Government

2.0521, PLANT SOIL MOISTURE ENVIRONMENT AND ITS EFFECT ON WATER MOVEMENT INTO PLANT ROOTS

C.T. HAAN, Univ. of Kentucky, Water Resources Institute, *Lexington, Kentucky* 40506

Objectives of Research: 1. Develop a means of controlling soil moisture so that plants can be grown at controlled levels of soil moisture stress. 2. Develop a mathematical model of water movement from the soil into the plant root.

Summary: Studies on water stress of plants have been hampered by the lack of an adequate means of controlling the water potential in soils within narrow limits at high values of moisture tension. Part of the work of this project will be devoted to testing several methods of overcoming this obstacle.

The second part of the project will be devoted to a study of moisture movement through the soil into plant roots when the soil moisture is controlled at several levels of moisture potential and the aerial environment of the plant is controlled at one level in a growth chamber. A mathematical model of moisture movement into plant roots under these conditions will be developed and tested.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Kentucky

2.0522, UNSTEADY FLOW TOWARD PARTIALLY PENETRATING ARTESIAN WELLS

Y.H. HUANG, Univ. of Kentucky, Water Resources Institute, *Lexington, Kentucky* 40506

Current solutions for unsteady flow toward partially penetrating artesian wells are based on many ideal assumptions. Among these assumptions are that (a) the aquifer is elastic, homogeneous, isotropic, horizontal in position, uniform in thickness, and infinite in extent, (b) the well is of a small radius, and (c) the discharge from the well does not vary with time. Since actual field conditions may not fulfill the above assumptions, these solutions may be of limited application.

The objectives of the proposed research are twofold: (a) to develop a numerical procedure using a finite difference method and a high speed computer for the analysis of unsteady flow toward partially penetrating artesian wells so that solutions for uses other than those ideally assumed can be obtained, and (b) to construct a test model having the same dimensions as those assumed in the theoretical analysis and check the validity of the theory.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Kentucky

2.0523, COMPUTER ANALYSIS OF WATERSHED CHARACTERISTICS AFFECTING FLOOD HYDROLOGY

L.D. JAMES, Univ. of Kentucky, School of Engineering, *Lexington, Kentucky* 40506

A computer program known as the Stanford Watershed Model has been developed for generating long term streamflow values from rainfall records and parameters describing watershed characteristics as determined by a trial and error process of adjustment to match short term streamflow records. The research plan is to 1. Program a computerized procedure for finding the best value for these parameters from the standpoint of flood analysis. 2. Apply the procedure to a number of small watersheds to see how the selected values vary and to develop relationships expressing flood peaks and volumes as functions of these parameters. 3. Apply the results to a computer program previously developed by the principal investigator for determining by economic efficiency criteria the best combination of structural and nonstructural measures for flood control to analyze how this best combination varies with these watershed parameters.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Kentucky

2.0524, CRITERIA FOR EVALUATION AND FUNCTIONAL DESIGN OF IRRIGATION SYSTEMS

J.T. LIGON, Univ. of Kentucky, Agricultural Experiment Sta. , *Lexington, Kentucky* 40506

1. To determine the effects of moisture stress on the rate of growth, development, final yield and quality of certain potentially irrigable crops. 2. To determine the soil moisture withdrawal patterns for certain potentially irrigable crops. 3. To determine the water intake rates of typical Kentucky soils and their relationships to other measurable physical quantities. 4. To determine from climatological data the frequency of occurrence of various levels of soil moisture deficiency during the growing season in Kentucky.

Emphasis will be placed on the acquisition and analysis of basic data pertaining to the interactions between water, soil, climate, and plants as related to supplement irrigation. The overall objective is to develop dependable criteria for the evaluation of irrigation needs and the functional design of irrigation systems.

SUPPORTED BY U.S. Dept. of Agriculture
Kentucky State Government

2.0525, CAPILLARY-DIFFUSION AND SELF-DIFFUSION OF LIQUID WATER IN UNSATURATED SOIL

R.E. PHILLIPS, Univ. of Kentucky, School of Agriculture, *Lexington, Kentucky* 40506

Objectives of the Project: 1. To evaluate the effect of soil water content, clay type, and clay content upon the capillary-diffusion and self-diffusion of liquid water in unsaturated soil. 2. To attempt to establish a functional relationship between capillary-diffusion and self-diffusion of liquid water in unsaturated soil.

Summary: The movement of liquid water within the unsaturated soil is a key mechanism in the process of evapo-transpiration. Evapo- transpiration, in turn, is an important controlling factor in the hydrologic cycle. At the present time, our knowledge of the mechanics of soil water movement in unsaturated soils and the factors controlling it is of a qualitative nature rather than of a quantitative nature.

In this study the movement of water in unsaturated soils and some of the basic soil properties affecting soil water movement will be studied. The movement of water within the soil mass is the initial step in the process of evapo-transpiration. Both capillary-diffusion coefficients and self-diffusion coefficients will be measured to characterize soil water movement. The measurement and understanding of capillary-diffusion coefficients, especially with reference to the mobility of the water molecule as affected by soil properties. In the past, the interpretation and prediction of soil water movement in unsaturated soil has been based upon capillary-diffusion coefficients.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Kentucky

2.0526, DIFFUSION OF WATER AND IONS IN SOIL

R.E. PHILLIPS, Univ. of Kentucky, Agricultural Experiment Sta. , *Lexington, Kentucky* 40506

1. To determine the effect of physical, mineralogical, and chemical properties of soils on the self diffusion of water and plant nutrient ions in soils. 2. To investigate interactions which are likely to exist between particular physical, mineralogical, and chemical properties of soils when either water or plant nutrient ions are diffusing in soil. 3. To compare the magnitude of molecular-self diffusion coefficients of water in soil to the diffusion coefficients of water defined as the product of capillary conductivity and the rate of change of soil water tension with soil water content.

Diffusion coefficients of water and plant nutrient ions as affected by soil properties will be evaluated. Soil properties to be studied include: soil water content, clay mineralogy, soil texture, soil compaction, soil temperature, organic matter content, and cation population. Interactions existing between these soil properties when either water or ions are diffusing will be evaluated. Both molecular- diffusion coefficients and capillary potential gradient-diffusion coefficients of water in soil will be measured.

SUPPORTED BY U.S. Dept. of Agriculture
Kentucky State Government

2.0527, HYDROLOGY OF BURIED PENNSYLVANIAN CHANNEL SANDSTONE, KENTUCKY

R.W. DAVIS, U.S. Dept. of Interior, Water Resources Division, *Louisville, Kentucky*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Kentucky.

Purpose: To obtain adequate information on the geohydrology of the deeply buried basal Pennsylvanian channel sandstones and the relation of deep fresh water to saline water in the Western Coal Field area to guide future development and proper management of water resources.

Method: Detailed information on the geology and hydrology of the channel sandstones will be obtained by inventory of currently available sources, such as existing water and oil wells, coal-test holes, and geologic maps. The trend, distribution, and volume of the channel sandstones will be presented on maps, fence diagrams, and sections. The movement of ground water through the sandstones will be documented by means of water-level information, pumping tests, and stremflow measurements. The relationship of large-yielding wells to the occurrence of the sandstone and channel geometry will be analyzed. Water samples will be collected to delineate the areas of fresh water and periodic sampling will be made near centers of pumping to document effects of pumping on quality.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Kentucky State Government

2.0523, WATER RESOURCES OF THE BOWLING GREEN AREA, KENTUCKY

T.W. LAMBERT, U.S. Dept. of Interior, Water Resources Division, *Louisville, Kentucky*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Kentucky.

Purpose: To provide information on the quantity and quality of the water in the Bowling Green area for use in planning additional industrial development.

Methods: Detailed information on ground-water sources will be collected with particular emphasis on delineating the areas of potentially high yield. The investigation will include a study of the underground flow patterns and potential sources of contamination. Information on water quality of streams and aquifers will be collected and changes in water quality monitored. The relationship between ground water and water in streams is particularly significant because of large base flows and recurrent flooding of large solution channels by high river stages. Partial-record stations will be operated on tributary streams for correlation of record with the gaging and water- quality station on Barren River at Bowling Green.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Kentucky State Government

2.0529, A DETAILED STUDY OF THE ENERGY FLOW THROUGH THE BIOTA OF DOE RUN, MEADE COUNTY, KENTUCKY

L.A. KRUMHOLZ, Univ. of Louisville, Graduate School, *Louisville, Kentucky* 40208 (AT(40-1)-3540)

Doe Run, a stream that arises as a torrent spring, has been studied intensively since 1959. Background data indicate that the uptake of fission products from nuclear fallout was quite prompt following the Russian and American tests that began in 1961. That accumulation reached a maximum by 1964 and by the summer of 1966 the amounts in the biota had returned essentially to the 1960 levels. On the basis of these background data it was proposed to try to define the pathways of accumulation of radioisotopes of biologically important fission products and their possible relationships to energy flow through the stream ecosystem.

As a part of this study, Doe Run has been inoculated with cesium 134 three times: 10 mc on 17 December 1966, 25 mc on 17 June 1967, and 25 mc on 16 December 1967. Physical characteristics of the stream were different during each inoculation, and data on stream flow indicate that at low discharge (ca 20 cfs, June 1967) the 'slug' of cesium moved very slowly and became greatly elongated as it passed downstream, whereas at high discharge (ca 85 cfs, December 1967) the slug moved quite rapidly and remained quite compact.

Calorific values of various plants remained constant throughout the year, but there was a gradual marked decline in calorific values of some amphipods. Data on respiration indicate that oxygen consumption by some stream invertebrates fluctuates with no seasonal pattern or relationship to inoculation of the stream. Samller individuals of each species consume oxygen at relatively higher rates than larger individuals of the same species.

SUPPORTED BY U.S. Atomic Energy Commission

2.0530, GEOCHEMISTRY OF AQUIFERS AS AFFECTED, OR POTENTIALLY AFFECTED BY OFFTAKE OR ARTIFICIAL RECHARGE

G.K. BILLINGS, Louisiana State University, Graduate School, *Baton Rouge, Louisiana* 70803

It is proposed to determine the chemical parameters significant to such existing problems as: a) salt water encroachment; b) river water encroachment; and c) injection water. Potentiometric and atomic absorption methods will be used to determine the variables. Analyses will be made on samples of precipitation, runoff, and ground water at recharge, discharge, and potential mixing sites. Analyses will be made of experimentally filtered water in contact with proposed storage aquifers and of aquifer solid material. Data will be used in the examination of such problems as watermass mixing, rock-water equilibrium, and potential alteration of water quality by proposed engineering manipulation of the Baton Rouge water system. Information gained is highly extrapolatable to other Gulf Coast areas.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Louisiana State University

2.0531, RUNOFF OF SMALL WATERSHEDS

H.J. BRAND, Louisiana State University, Agricultural Experiment Sta., *Baton Rouge, Louisiana* 70803

A map will be prepared showing soil types and drainage pattern with gauging stations to be established and continuous records kept of all flow rates, as well as total rates. A complete weather station will be maintained on the project to provide correlating data. Soil moistures and different soil types, moisture intake, retention and crop moisture requirements will be determined.

SUPPORTED BY U.S. Dept. of Agriculture
Louisiana State Government

2.0532, EROSION CONTROL STUDY

A.L. COX, Louisiana State University, Agricultural Experiment Sta., *Baton Rouge, Louisiana* 70803

Present methods are being evaluated to develop new methods and equipment for establishment of a permanent sod cover. Erosion control practices are being developed for existing highway drains and ditches and highway bank stabilization methods that do not require top soil from adjacent agricultural lands. Structures are installed at various locations to incorporate soils, slopes and length of run in order to obtain detail information on the amount of soil lost. To prevent erosion sod drains, slopes and materials such as chemicals and mats are being installed. Soil and water loss are being studied to determine the correct slope and length of ditches for various soils. An attempt is being made to evaluate sodded, asphalt paved, concrete paved and other types of waterway to establish the best type under different conditions. Recommendations will be made to the Louisiana highway department for the revision of erosion control and sod establishment practices.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Louisiana State Government

2.0533, ROW CROP IRRIGATION IN NORTHWEST LOUISIANA - COTTON IRRIGATION

J.W. ROBBINS, Louisiana State University, Agricultural Experiment Sta., *Baton Rouge, Louisiana* 70803

1. To determine crop response to irrigation in Northwest La.
2. To determine evapotransporation rate of the crops irrigated.

Will continue test plots on irrigated and non-irrigated cotton for yield study and continue study of evapotranspiration of cotton in this area.

SUPPORTED BY Louisiana State Government

2.0534, ROW CROP IRRIGATION IN NORTHEAST LOUISIANA

J.W. ROBBINS, Louisiana State University, Agricultural Experiment Sta., *Baton Rouge, Louisiana* 70803

To determine the following concerning cotton and corn under irrigation in northeast Louisiana: 1. Economics of row crop irrigation. 2. Evapotranspiration rates. 3. Optimum plant population.

Continue study of yield data of different varieties of cotton in the Macon Ridge area. This includes land forming plots for furrow irrigation study, selection of varieties for testing and continuing study of evapotranspiration in the cotton area. Revise project after this year.

SUPPORTED BY Louisiana State Government

2.0535, BAYOU LAFOURCHE SEDIMENTATION STUDY, LOUISIANA

W.H. BOYLE, U.S. Dept. of Interior, Water Resources Division, *Baton Rouge, Louisiana*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Louisiana.

Purpose: To determine the rate of sedimentation and the resulting channel characteristics such as size, shape, and slope.

Methods: A quantitative analysis of data collected by the U. S. Geological Survey and other agencies since 1955 will be initiated so that an estimate of the amount of sediment coming into the bayou can be made. This estimate will be compared to an amount derived by using a gamma probe at 18 cross-sections within the study reach by which the density of the sediment at each cross-section is obtained. Finally a prediction of the stabilized channel will be made for the bayou within the study reach.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Louisiana State Government

2.0536, GEOLOGIC STRUCTURE AND FRESH GROUND WATER IN GULF COASTAL PLAIN

P.H. JONES, U.S. Dept. of Interior, Geological Survey, *Baton Rouge, Louisiana*

Major elements of structural deformation in the Gulf Coast Plain that have marked effect on deposits of post-Oligocene age will be identified and mapped at a suitable scale, together with the distribution (areally and with depth) of fresh and saline waters in aquifer systems affected by the deformation. The relative importance of individual structural features, together with companion features (e.g., regional normal faults and associated salt domes) will be evaluated using this map, and key structures in the Plain will be selected for intensive study. These type studies will involve all geologic and hydrologic factors for which data can be obtained, and each will be completed with a separate report. Concepts derived and analytical methods developed in the type studies will be employed in a comprehensive analysis of conditions throughout the Plains. The report on this work will include structural maps for entire acquifer systems and flow nets for principal aquifers; it will show the locus and hydraulic controls on salty water in proximity to fresh-water systems, and define, as well as may be possible, the probable consequences of changes in direction of flow and gradient in head in aquifer systems subjected to heavy withdrawal in the future.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0537, FLOODS IN NORTH LOUISIANA - RAINFALL-RUNOFF RELATIONSHIPS

F.N. LEE, U.S. Dept. of Interior, Water Resources Division, *Baton Rouge, Louisiana*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Louisiana.

Purpose: To determine the relationship between rainfall and runoff in northern Louisiana as a part of a program to provide statewide coverage.

Methods: Regressions will be made from rainfall-runoff data computed at 34 gaging stations. Approximately 1700 storms will be analyzed, and the regressions regionalized.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Louisiana State Government

2.0538, GEOHYDROLOGIC ENVIRONMENTAL STUDIES

J.N. PAYNE, U.S. Dept. of Interior, Water Resources Division, *Baton Rouge, Louisiana*

A study of the Cockfield Formation is being carried on in Arkansas, Louisiana,Mississippi, and Texas to determine the relationship of hydrologic factors to various geologic factors such as facies development, degree of variability of the formation laterally and vertically, and the unit thickness of individual sand members. Ultimately various geologic parameters can be used in conjunction with the hydraulic constants of the aquifers to describe the hydraulic systems quantitatively. In order to accomplish the objective, maps have been and are being prepared to show sand percentage, thickness of the Cockfield Formation, maximum sand unit thickness, degree of fresh water saturation of the sand section, total transmissibility of the fresh water sand section, the altitude of the base of fresh water and quality of water.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.059, UNIT HYDROGRAPHS FOR SOUTHWESTERN LOUISIANA

V.B. SAUER, U.S. Dept. of Interior, Water Resources Division, *Baton Rouge, Louisiana*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Louisiana.

Purpose: This study is part of a program to provide statewide coverage of unit hydrographs.

Methods: Unit hydrographs will be developed for each site where gaging station records are available in the study area. About 200 flood hydrographs will be studied. Data will be regionalized for use at ungaged sites.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Louisiana State Government

2.0540, UNIT HYDROGRAPHS FOR NORTHERN LOUISIANA

V.B. SAUER, U.S. Dept. of Interior, Water Resources Division, *Baton Rouge, Louisiana*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Louisiana.

Purpose: This study is part of a program to provide statewide coverage of unit hydrographs.

Methods: Unit hydrographs will be developed for each site where gaging station records are available in the study area. About 200 flood hydrographs will be studied. Data will be regionalized for use at ungaged sites.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Louisiana State Government

2.0541, FLOOD FREQUENCY OF SMALL STREAMS IN LOUISIANA

UNKNOWN, U.S. Dept. of Interior, Geological Survey, *Baton Rouge, Louisiana*

This research proposal is to obtain and analyze hydrologic data which can be used in the hydrologic design of highway drainage structures. More specifically, to determine the magnitude and frequency of floods for drainage areas requiring culverts in Louisiana. Project will consist of 75 flood hydrograph recording stations. These gages will be installed within a three year period. The gages will be located throughout the state so that many different parameters will be sampled. In addition to flood hydrographs, information will be obtained on amount and distribution of rainfall, land use, basin slope and stream slope. The gaging equipment will consist of rainfall and stage /RS/ recorders and creststage gages upstream and downstream at each site.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Louisiana State Government

2.0542, ECOLOGY OF LOUISIANAS ESTUARINE WATERS - MARINE LABORATRY

J.G. BROOM, State Wildlife & Fish Comm. , *New Orleans, Louisiana*

This project area incorporates all six of the previous described phase areas, namely coastal Louisiana. Here, the project leader will compile, analyze and interpret the data.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.
Louisiana State Government

2.0543, LAKEBORGNE-CHANDELEUR SOUND SYSTEM

J.G. BROOM, State Wildlife & Fish Comm. , *New Orleans, Louisiana*

Objectives: 1. Determine the distribution and density of the fauna of the phase area. 2. Determine the hydrography of the phase area. 3. Process the data.

Procedures and Work Schedule: 1. Weekly plankton sampling in the major passes and throughout the system with a 6-foot bean plankton net. 2. Weekly sampling throughout the major nursery areas with a 6-foot 1/4' mesh trawl. 3. Bi-weekly sampling throughout the major nursery and near off-shore areas with trawls. 4. Bi-weekly seine sampling at selected sites. 5. Monthly benthic sampling at selected sites. 6. Collection of selected hydrographic information at each sample station and continuous recordings of salinity temperature and tidal movements at selected stations. 7. The processing, tabulating and summarizing of collections and raw data which are to be transmitted to the project leader at the marine laboratory for compilation, analysis and interpretation.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.
Louisiana State Government

2.0544, BRETON SOUND - MOUTH OF MISSISSIPPI RIVER SYSTEM

J.G. BROOM, State Wildlife & Fish Comm. , *New Orleans, Louisiana*

Objectives: 1. Determine the distribution and density of the fauna of the phase area. 2. Determine the hydrography of the phase area. 3. Process the data.

Procedures and Work Schedule: 1. Weekly plankton sampling in the major passes and throughout the system with a 6-foot beam plankton net. 2. Weekly sampling throughout the major nursery areas with a 6- foot 1/4' mesh trawl. 3. Bi-weekly sampling throughout the major nursery and near off-shore areas with trawl. 4. Bi-weekly seine sampling at selected sites. 5. Monthly benthic sampling at selected sites. 6. Collection of selected dydrographic information at each sample station and continuous recordings of salinity, temperature and tidal movements at selected stations. 7. The processing tabulating and summarizing of collections and raw data which are to be transmitted to the project leader at the marine laboratory for compilations, analysis and interpretation.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.
Louisiana State Government

2.0545, ATCHAFALAYA RIVER - CALLIOU LAKE SYSTEM

J.G. BROOM, State Wildlife & Fish Comm. , *New Orleans, Louisiana*

Objectives - 1. Determine the distribution and density of the fauna of the phase area. 2. Determine the hydrography of the phase area. 3. Process the data.

Procedures and Work Schedule: 1. Weekly plankton sampling in the major passes and throughout the system with a 6-foot beam plankton net. 2. Weekly sampling throughout the major nursery areas with a 6-foot 1/4' mesh trawl. 3. Bi-weekly sampling throughout the major nursery and near off-shore areas with trawls. 4. Bi-weekly seine sampling at selected sites. 5. Monthly benthic sampling at selected sites. 6. Collection of selected hydrographic information at each sample station and continuous recordings of salinity temperature and tidal movements at selected stations. 7. The processing, tabulating and summarizing of collections and raw data which are to be transmitted to the project leader at the marine laboratory for compilations, analysis and interpretation.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.
Louisiana State Government

2.0546, VERMILION - CALCASIEU - SABINE SYSTEM

J.G. BROOM, State Wildlife & Fish Comm. , *New Orleans, Louisiana*

Objectives: 1. Determine the distribution and density of the fauna of the phase area. 2. Determine the hydrography of the phase area. 3. Process the data.

Procedures and Work Schedule: l. Weekly plankton sampling in the major passes and throughout the system with a 6-foot beam plankton net. 2. Weekly sampling throughout the major nursery areas with a 6-foot 1/4' mesh trawl. 3. Bi-weekly sampling throughout the major nursery and near off-shore areas with trawls. 4. Bi-weekly sampling at selected sites. 5. Monthly benthic sampling at selected sites. 6. Collection of selected hydrographic information at each sample station and continuous hydrographic information at each sample station and continuous recordings of salinity temperature and tidal movements at selected stations. 7. The processing, tabulating and sumarizing of collections and raw data which are to be transmitted to the project leader at the marine laboratory for compilations, analysis and interpretation.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.
Louisiana State Government

2.0547, TIMBALIER - TERREBONNE BAYS SYSTEM

J.G. BROOM, State Wildlife & Fish Comm. , *New Orleans, Louisiana*

Objectives: 1. Determine the distribution and density of the fauna of the phase area. 2. Determine the hydrography of the phase area. 3. Process the data.

Procedures and Work Schedule: 1. Weekly plankton sampling in the major passes and throughout the system with a 6-foot beam plankton net. 2. Weekly sampling throughout the major nursery areas with a 6-foot 1/4' mesh trawl. 3. Bi-weekly sampling throughout the major nursery and near off-shore areas with trawls. 4. Bi-weekly seine sampling at selected sites. 5. Monthly benthic sampling at selected sites. 6. Collection of selected hydrographic information at each sample station and continuous recordings of salinity temperature and tidal movements at selected stations. 7. The processing, tabulating and summarizing of collections and raw data which are to be transmitted to the project leader at the marine laboratory for compilations, analysis and interpretation.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.
Louisiana State Government

2.0548, CHEMICAL AND PHYSICAL ANALYSES OF WATER AND SOILS

K.E. LANTZ, State Wildlife & Fish Comm. , *New Orleans, Louisiana*

Objectives: 1. To determine physical and chemical characteristics of water in the four lakes prior to fluctuation, during the water level changes and following fluctuation when water levels return to normal. 2. To determine chemical conditions of bottom muds in the four lakes prior to water fluctuation and chemical conditions in the soils exposed to aeration during the drawdown period.

Procedure: Water chemistries will include turbidity, dissolved oxygen, free carbon dioxide, pH, alkalinity, hardness, sulfate, iron, copper, manganese, phosphate, ammonium nitrogen, nitrate nitrogen and nitrite nitrogen. These measurements will be made with a Hach Direct Reading Colorimeter. Sampling will be monthly in the spring prior to fluctuation, monthly during the water level changes, and monthly in the winter when water levels return to normal.

Soil samples will be collected at the same time as water samples and dried for measurement for pH, phosphorus, potassium, magnesium, calcium and total soluble salts. Analyses will be conducted by the Soils Testing Laboratory at Louisiana State University. A Coleman Flame photometer, Beckman atomic absorption spectrophotometer, and Bausch and Lomb Spectronic 20 Colorimeter will be used to analyze these bottom muds.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Louisiana State Government

2.0549, HYDROLOGIC STUDIES (STORM STUDIES)

R.L. DALLAS, U.S. Army, Engineer District, *New Orleans, Louisiana* 70160

There are 7 Part I and 12 Part II studies to be completed. Results of Storm Studies are summarized and published by office of the Chief of Engineers as 'Storm Rainfall of the United States,' and distributed to U. S. Army Engineer Divisions and Districts for pertinency to basic design criteria for flood control and other projects.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0550, MOISTURE RESPONSE OF SOILS

H.K. HUCKABAY, Louisiana Polytechnic Inst. , School of Engineering, *Ruston, Louisiana* 71270

An apparatus is to be developed which will be sufficiently accurate to measure the capillary potential of various representative

Louisiana soils but not so fragile or ponderous as to make it impractical for field use. In development of the apparatus, the literature will be searched and various proposed designs considered. These will be modified or discarded in the light of current instrumentation techniques, thermodynamics, and rate process theory. Preliminary designs will be constructed, tested, and discarded or modified. This screening of alternate designs may require the preparation of some type of artificial reference soil. In any case, the criteria of performance will be: (1) Reproducability of reading, (2) Portability, (3) Durability, (4) Rapidity of reading, and (5) Low cost. It is anticipated that the final design will be the optimum combination of these factors.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Louisiana State Government

2.0551, URBAN HYDROLOGIC STUDIES

UNKNOWN, Louisiana Polytechnic Inst. , Graduate School, *Ruston, Louisiana* 71270

Current methods for estimating peak runoff rates for design of urban area drainage structures in Louisiana are being improved. Instrumentation is being developed for automatic recording of rainfall and runoff data from urban drainage areas and for transferring the recorded data for digital computer analysis.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Louisiana State Government

2.0552, HYDROLOGIC RELATIONSHIPS IN A CONIFEROUS FOREST

C.E. SCHOMAKER, Univ. of Maine, Graduate School, *Orono, Maine* 04473

This investigation proposes to study the water budget of a coniferous forest in central Maine, taking particular note of evapotranspiration losses and changes in ground water storage in relation to the quantity of incoming precipitation.

Environmental measuring instruments will be located in a mature conifer stand with normal stocking. Ground water wells will be drilled and soil moisture measurements made throughout the year. Precipitation will be traced from the time of its inception until it appears in the ground water or is lost from the area by evaporation or runoff.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Maine

2.0553, EFFECTS OF COARSE SKELETON ON PHYSICAL PROPERTIES OF SOIL

R.A. STRUCHTEMEYER, Univ. of Maine, Agricultural Experiment Sta. , *Orono, Maine* 04473

Description of Work: Runoff plots will be installed on a caribou loam in Aroostook County. All plots have a uniform eight per cent slope.

Soil treatments will consist of leaving the soil in its natural condition, removing rocks over 1 1/2 inches in diameter and removing rocks but then crushing them and returning them to the plots.

Measurements will be made of the amount of runoff and soil removal. Bulk density and penetrometer measurements will also be made throughout the season.

SUPPORTED BY U.S. Dept. of Agriculture
Maine State Government

2.0554, URBAN HYDROLOGIC RELATIONSHIPS

W. VIESSMAN, Univ. of Maine, Graduate School, *Orono, Maine* 04473

This project is designed to provide more adequate procedures for predicting, in a reliable manner, the complete runoff hydrograph for urban drainage areas of varying physical characteristics. Effective rainflall inputs specified as a sequence of average one minute intensities will be used to generate the output hydrograph. Research on timing of urban hydrologic events is also included.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Maine

2.0555, STUDIES OF NEAR-SURFACE SEDIMENTS IN LAKES, AND RELATIONSHIPS BETWEEN SURFACE SEDIMENT POLLEN SPECTRA AND VEGETATION

R.B. DAVIS, Colby College, Undergraduate School, *Waterville, Maine* 04901

From the time of release of pollen from plants to the time the grains become deeply buried in sediments numerous processes occur which determine the 'final' pollen representation in the sediments. Understanding these processes is essential if the capacity of pollen analysis to provide paleoecological information is to be greatly extended.

It is proposed to continue investigation of phenomena taking place in the surface and near-surface sediments of lakes, and to continue work on the relationships between vegetation and pollen spectra, viz: A. Pollen stratigraphy in near-surface sediments, especially vertical displacement of sediments by benthos, laboratory and field experiments; construction of new corer and associated equipment. B. Differential destruction of pollen in sediments, including pollen breakage by various taxa of benthos, laboratory and field experiments; relationship of limnological conditions to pollen destruction. C. Comparisons of surface pollen spectra and vegetation along transects crossing vegetational 'zones,' and within single vegetational types for study of variation in spectra and related pollen dispersal phenomena; New England and Maritime Provinces of Canada.

SUPPORTED BY U.S. National Science Foundation

2.0556, THE BIOLOGY AND CHEMISTRY OF TRACE ELEMENTS IN MARINE AND ESTUARINE WATERS

W.R. TAYLOR, Johns Hopkins University, Graduate School, *Annapolis, Maryland* (AT(30-1)-3497)

The objective of the project is to clarify the biogeochemical cycles of trace elements through the initial trophic levels of the Chesapeake Bay. Both biological and chemical samples have been collected in the major river entering the upper Chesapeake Bay and a series of stations in the Bay. Chemical analyses are done by atomic absorption spectrophotometry. Both phytoplankton and zooplankton organisms are being surveyed quantitatively for spatial and time distribution patterns.

The chemical sampling program is nearly complete. Analyses for iron, manganese, copper, nickel, zinc and cobalt have been partially completed. The trace metal requirements of representative phytoplankton organisms are being investigated. An iron requirement has been found for five algae. Cladocerans appear to be a major component of the zooplankton.

SUPPORTED BY U.S. Atomic Energy Commission

2.0557, SUSPENDED SEDIMENTS IN THE UPPER CHESAPEAKE BAY - EVALUATION OF METHODS FOR SIZE ANALYSIS OF SUSPENDED MATERIALS

J.H. MANNING, State Dept. of Ches. Bay Afrs. , *Annapolis, Maryland*

The objective of this study is to determine the method or combination of methods which provides the most consistent data on the size distribution of the suspended material in the Upper Chesapeake Bay, for use as a routine procedure. Large volume samples from the Upper Bay will be divided into several sub-samples. One sub-sample will be spun down in an ultra-centrifuge, and the sediment homogeneously resuspended in a reduced volume. Size distribution will be determined using the homogeneous technique in the Mine Safety Appliances Company's Particle Size Analyzer. A second sub-sample will be filtered through a 0.2 micron filter, the filter dissolved in acetone, and the sediments resuspended in the acetone. Size distribution of this resuspension will be determined using the layer technique. A third sub-sample will be filtered through a 3 micron membrane filter, and then through an 0.2 micron filter, in order to provide gross size separation. Microphotographs of the large filter, and both microphotographs and electron-micro-photographs of the smaller filter will be made. A Zeiss Particle Size Analyzer will be used to obtain size distribution. Variations of each of the above techniques will be used in which the suspended organic fraction is eliminated from the raw sample by wet incineration. This study will be carried out by J. R. Schubel, Chesapeake Bay Institute, The Johns Hopkins University.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.
Maryland State Government

2.0558, FIELD MEASUREMENTS OF THE TEMPORAL AND SPATIAL VARIATIONS IN CONCENTRATION AND PARTICLE SIZE DISTRIBUTION OF SUSPENDED MATERIALS IN THE UPPER

J.H. MANNING, State Dept. of Ches. Bay Afrs. , *Annapolis, Maryland*

The objectives of this study are to determine the temporal and spatial variations in (1) the concentration; (2) particle size distribution; (3) percent organic matter; and (4) mineralogical composition of inorganic fraction. Samples will be collected at the surface, mid-depth and near the bottom at each of 31 stations in the Upper Chesapeake Bay from the mouth of the Susquehanna at Havre de Grace to just below Pooles Island, on a monthly basis. Total weight of suspended material per unit volume, and weight of inorganic fraction will be determined. Size distribution of the suspended material will be determined using the methods selected on the basis of the evaluation study conducted under another phase of this project. Work will also be initiated on mineralogical analysis of the inorganic fraction, although the major effort on this part of the program will be undertaken during the second year of the study. Field work will be carried out aboard the research vessels MAURY and LYDIA LOUISEII, of the Cesapeake Bay Institute, The Johns Hopkins University. The study will be conducted by J. R. Schubel, Chesapeake Bay Institute, The Johns Hopkins University.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.
Maryland State Government

2.0559, COMPARISON OF OPTICAL PROPERTIES WITH DIRECT MEASUREMENTS OF CONCENTRATION AND SIZE DISTRIBUTION OF SUSPENDED MATERIALS

J.H. MANNING, State Dept. of Ches. Bay Afrs. , *Annapolis, Maryland*

The objective of this study is to determine the relationships between various optical properties of the waters of the Upper Chesapeake Bay and the concentration and size distribution of suspended materials in these waters. At each of 31 stations in the Upper Bay samples will be collected at three depths and at monthly intervals for determination of suspended particle concentration and size distribution, as described under another phase of this project. Duplicate samples will also be employed for light transmission and scattering measurements at each of three wave lengths. Scattering measurements will be made at 90o to the light beam path using a Turner filter fluorometer. Beam transmittance measurements will be made using a Beckman DU spectrophotometer with a special narrow beam columnation attachment. In situ measurements of beam transmittance will also be made. These optical measurements will be compared with the determinations of suspended particle concentration and size distribution, with the intent of establishing a relationship between the optical parameters and the suspended particle concentration and size distribution. This study will be conducted by J. Williams, J. R. Schubel, and D. W. Pritchard, Chesapeake Bay Institute, The Johns Hopkins University.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.
Maryland State Government

2.0560, COLLECTION OF HYDROLOGIC DATA OF SMALL DRAINAGE AREAS

FORREST, State Roads Commission, *Annapolis, Maryland*

Storm water runoff from small drainage areas is a rather troublesome problem in most highway design offices. The objective of this project is to provide highway drainage designers with reliable runoff information as affected by various hydrologic areas of this state and size of area. The work is under the direction of U.S. Geological Survey and results will be based on statistical studies of observed rainfall and runoff data.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Maryland State Government

2.0561, AQUIFER STUDIES IN MARYLAND - SEDIMENTARY ROCKS IN THE COASTAL PLAIN

H.H. HANSEN, Johns Hopkins University, State Geological Survey, *Baltimore, Maryland* 21218

A better understanding of the geohydrology of the aquifers in the Patapsco and Raritan Formations in the Maryland Coastal Plain is needed for intelligent water-management decisions in allocating ground water. The nature of the aquifers and their sedimentary environment will be studied and a report will be prepared to show the stratigraphic and hydrologic relationships by means of cross sections, lithofacies maps, isopach maps, and other illustrations.

SUPPORTED BY Maryland State Government
U.S. Dept. of Interior - Geological Survey

2.0562, EXTENT OF BRACKISH WATER IN TIDAL RIVERS

S.G. HEIDEL, Johns Hopkins University, State Geological Survey, *Baltimore, Maryland* 21218

The tidal areas of Maryland's rivers represent large volumes of water that have been proposed for and may be useful for domestic and industrial water supply. The boundary zone between brackish and fresh water must be delineated for maximum utilization. The approach used is to make salinity runs on the tidal rivers, and use field observations at principal points supplemented by installation of continuous conductivity recorders to locate the saline water front at varying tide conditions and different seasons.

SUPPORTED BY Maryland State Government
U.S. Dept. of Interior - Geological Survey

2.0563, PHYSIOGRAPHIC STUDY OF PART OF THE HENRY MOUTAINS REGION, UTAH

C.B. HUNT, Johns Hopkins University, Graduate School, *Baltimore, Maryland* 21218

The Principal Investigator plans to complete research, supported under NSF grant GA-454, on the physiography of the Henry Mountains, Utah. Principal objectives of the research are: to determine relationships between the bedrock geology, kinds and rates of weathering and of soil development, kinds and rates of fluvial processes, effects of these on plant distribution, and archeological evidence for dating changes and estimating rates in geomorphic processes. The investigations will center largely on a small part of the Henry Mountain area, especially the north and east sides of Mount Ellen and the pedimented foothills north and east of that mountain.

The high relief of the Henry Mountains provides contrasting climatic zones for comparison of weathering features and development of pediments, terraces and other landform features. In the continuing research emphasis will be placed on understanding geomorphic processes and testing of concepts of landform development, particularly as related to erosion and deposition by streams. It is hoped that datable archeological remains in some deposits will give a basis for determining absolute rates of deposition, and formation of landforms. In addition, it is hoped that information relative to the water budget, distribution of acquifers, and other factors important in potential land-use development will emerge from the research.

SUPPORTED BY U.S. National Science Foundation

2.0564, EVALUATION OF MAGOTHY AQUIFER - ANNAPOLIS AREA

F.K. MACK, Johns Hopkins University, State Geological Survey, *Baltimore, Maryland* 21218

The City of Annapolis, Md. and other users pump from 3 to 5 million gallons of water per day from the Raritan and Magothy Formations in the Annapolis area. Because the demand for water is expected to increase substantially in the next 10 years further information is needed on the quantity of water available, the possibility of salt water contamination, and the optimum development of the supply. To provide this information it is proposed to: 1. Prepare cross-sections showing the geologic framework and local variations in the aquifer. 2. Prepare piezometric maps on a periodic basis. 3. Construct an electric analog model for analyzing the behavior of the hydrologic system. 4. Make studies of geochemical characteristics of the water.

SUPPORTED BY Maryland State Government
U.S. Dept. of Interior - Geological Survey

2.0565, TIME OF TRAVEL - PRINCIPAL MARYLAND STREAMS

K.R. TAYLOR, Johns Hopkins University, State Geological Survey, *Baltimore, Maryland* 21218

The objective of this project is to provide water users with a time-of-travel guide to let them know when possible contaminants will reach their intakes, how long such contaminants will persist and at what levels of concentration if such contaminants are discharged accidentally into a stream. To obtain the time-of-travel data a fluorescent dye is put in selected streams, and the time of arrival measured for the leading edge, the maximum concentration and the time of passage at successive downstream locations. By such determinations at selected rates of discharge a relationship between discharge and time-of-travel is being developed for principal Maryland streams.

SUPPORTED BY Maryland State Government
U.S. Dept. of Interior - Geological Survey

2.0566, EXPLORATION AND MAPPING OF THE SALISBURY PALEOCHANNEL

J.M. WEIGLE, Johns Hopkins University, State Geological Survey, *Baltimore, Maryland* 21218

A major aquifer consisting of a buried channel filled with sand and gravel of Pleistocene age occurs several miles north of Salisbury, Md. The objective of this project is to gain further knowledge about the extent and limitations of the aquifer and provide experience in application of techniques for more rapid location of such features. Plans include test drilling, gamma-logging, obtaining material samples and preparation of map(s) showing the extent and character of the channel.

SUPPORTED BY Maryland State Government
U.S. Dept. of Interior - Geological Survey

2.0567, SOURCES, MOVEMENT, AND DISTRIBUTION OF SEDIMENT IN A SMALL WATERSHED

M.G. WOLMAN, Johns Hopkins University, Graduate School, *Baltimore, Maryland* 21218

The proposed study will be directed toward an understanding of the system by which sediment is removed from upland surfaces and makes its way downstream and thence out of a drainage basin. The proposed research will test the fundamental working hypothesis in geomorphology which states that under normal circumstances a kind of equilibrium exists in the landforms within an area. This hypothesis further postulates that landforms change only very slowly, and that over relatively short periods of time the forms are so adjusted to the existing processes that material eroded from the landscape is transported throughout the drainage system without producing major changes in the forms of hill slopes, valley bottoms and river channels.

SUPPORTED BY U.S. National Science Foundation

2.0568, SOURCES, MOVEMENT, AND DISTRIBUTION OF SEDIMENT IN A SMALL WATER SHED

M.G. WOLMAN, U.S. Dept. of Interior, Water Resources Division, *Baltimore, Maryland* 21218

Recent studies of delivery of sediment from watersheds indicate that in many cases the computed quantity of sediment which leaves the surface of a drainage basin may be considerably more than the amount of sediment delivered to reservoirs at some downstream location, taking into account the trap efficiency of the latter.

This study is directed toward an understanding of the system by which sediment is removed from the upland surfaces and makes its way downstream and thence out of the drainage basin. It has been suggested in the literature that the flood plain acts as a storage site for the intermittent movement of sediment throughout the stream system. Before sediment reaches the stream system from the hill slopes, however, it may pass either from hill slope to stream channel or through an intermediate stage represented by the colluvium at the valley margins. This stage of colluvium and flood-plain storage and migration is perhaps the least well understood portion of the system.

Stream flow and sediment discharge are being measured at two locations, one located directly below a source area of 100 acres of agricultural crop land, the other downstream at one square mile. Most of the intervening area is forested thus providing relatively little additional sediment inflow. Comparisons of particle size and sediment load by individual storms are being made. In addition, measurements of channel cross sections, particle movement, and slope processes are being made. Geomorphic studies including both stratigraphic observations and mapping are being undertaken to establish long term trends and history in the drainage basin as a basis for evaluating and extrapolating relatively short term measurements.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0569, EXTENT OF BRACKISH WATER IN TIDAL RIVERS, MARYLAND

S.G. HEIDEL, U.S. Dept. of Interior, Water Resources Division, *Baltimore - Towson, Maryland*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Maryland.

Purpose: To delineate the boundary zone between brackish and fresh water and provide information to permit maximum utilization of the water in the tidal portions of Maryland rivers.

Methods: Location of the saline water front in all the inland tidal areas of Maryland at varying conditions of tide and runoff and different seasons of the year will be determined through use of continuous conductivity recorders, periodic spot measurements of chloride concentrations and determination of river profiles of salinities. A comprehensive report will be prepared on the extent and variation of the salt water encroachment in surface waters on the basis of these field observations and available supplementary information.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Maryland State Government

2.0570, RICE CULTURE

C.R. ADAIR, U.S. Dept. of Agriculture, *Beltsville, Maryland*

Object: To determine the effect of time and method of seeding; time, method, and rate of application and ratio of the various fertilizer elements; and the effect of stage of maturity when harvested and of the temperature during the period of maturation on plant growth, grain yield and on chemical, physical and cooking characteristics of new rice varieties.

Plan of Work: Early, midseason and late maturing advanced breeding lines and standard commercial types of rice will be grown in a quadruplicated split-plot experiment with varieties as the main plots and fertilizer rates as the subplots. These experiments will be conducted in a similar manner at the southern rice stations although the amounts and time of application of the fertilizer and the varieties and selections used may differ slightly. In California, the same general plan will be used except the rice will be sown in water and different varieties used. The response to photo-period and temperatures will be determined by growing the various advanced breeding lines with standard commercial types in replicated plots sown at early, midseason and late dates. Similar experiments will be conducted in regard to seeding rates and methods, and effect of stage of maturity when harvested in quality characteristics.

2. WATER CYCLE

SUPPORTED BY U.S. Dept. of Agriculture

2.0571, REYNOLDS CREEK WATERSHED STUDY

W.R. HAMON, U.S. Dept. of Agriculture, *Beltsville, Maryland*

The objective of this study, initiated in 1961, was to conduct research into the basic principles and factors involved in and affecting field runoff, water yields, and sediment movement from sagebrush range watersheds in the northwest. The study site is located in the Reynolds Creek watershed drainage approximately 45 miles southwest of Nampa, Idaho.

SUPPORTED BY U.S. Dept. of Interior - Bu. Land Mgmt.
U.S. Dept. of Agriculture

2.0572, PHYSIOLOGICAL STUDIES OF ALFALFA AS RELATED TO COLD AND HEAT TOLERANCE, DROUGHT RESISTANCE, AND FORAGE QUALITY AND YIELD

C.H. HANSON, U.S. Dept. of Agriculture, *Beltsville, Maryland*

Object: To determine the effects of temperature, light, moisture stress, and other environmental factors on alfalfa growth and quality, and to study the physiological basis of resistance in alfalfa to drought, heat, cold, disease, and insects.

Plan of Work: Study will be made of (1) the effects of removal of alfalfa seed coats before grinding, length and severity of grinding, and addition of bovine serum albumin on oxidative phosphorylation, with attention to possible beneficial effects of serum albumin resulting from tying up lipid-like material which may inhibit respiration and phosphorylation. Correlations will be made between varietal differences in cold resistance and mitochondrial activity with alfalfa seedlings undergoing hardening. In the initial coumestrol experiment, Ranger alfalfa will be grown in sand nutrient cultures under three temperature regimens (95 degrees, 80 degrees and 65 degrees Fahrenheit during the 16-hour daily illumination period and 80 degrees, 65 degrees and 5-degrees Fahrenheit during the respective 8-hour dark periods. Light intensity will range from 1800 to 2000 foot-candles. A phosphorus level variable will be included. The alfalfa will be harvested at four stages of growth. At each sampling, plants will be divided into growing tips, leaves, stems, and flowers plus flower buds (when present), and coumestrol content determined. Other variables for study will include length of the photoperiod, moisture stress, other nutrients, and Rhizobium symbiosis.

SUPPORTED BY U.S. Dept. of Agriculture

2.0573, LABORATORY TESTING OF HYDRAULIC FORMULATIONS FOR OPEN CHANNEL FLOW

H.N. HOLTAN, U.S. Dept. of Agriculture, *Beltsville, Maryland*

Object: To physically test flood routing equations derived from simultaneous solutions of equations for continuity of mass and motion; to relate deviations between observed and predicted flow depths to the second flow pattern developed during transition from channel to out- of-bank flow; and to test a reformulation of Manning's equation for estimating flow velocities.

Plan of Work: Tests will include two types of channel models-- straight rectangular channel in a rectangular flood plain and a meandering rectangular channel in a flood plain. Each channel flood plain geometry will be studied by varying channel width, depth, and roughness coefficient, width and roughness coefficient of the flood plain, and depth of the channel below the flood plain. Each channel geometry combination will be subjected to steady uniform flow, steady, nonuniform flow, and unsteady, nonuniform flow. For each test, the depth of flow, water surface topography, lateral and longitudinal velocity components will be measured and recorded on punch cards or tape for computer analysis.

SUPPORTED BY U.S. Dept. of Agriculture

2.0574, BREEDING AND EVALUATION OF IMPROVED VARIETIES OF PERENNIAL COOL-SEASON GRASSES ADAPTED TO SEMIARID AND ARID REGIONS

A. HOVIN, U.S. Dept. of Agriculture, *Beltsville, Maryland*

Object: To select or develop by appropriate breeding methods superior varieties of the wheatgrasses, needlegrasses, and wildryes. Characteristics sought include increased productivity and persistence, seedling vigor, better seed size, shattering and lodging resistance, adaptation to specific environments, and disease and insect resistance.

Plan of work: Breeding methods which include inbreeding, hybridization, various types of progeny testing, and procedures for evaluating progeny response will be compared. The heritability of quantitative characters will be studied. The physiological response of strains will be studied. Interspecific and intergeneric crosses will be attempted in the search for superior adaptive characteristics and to create new forms for use in range revegetation. Particular emphasis will be devoted to increasing the range of adaptation of these grasses through hybridization and plant introduction. Regional tests will be developed and seed distributed to agencies interested in evaluating new experimental varieties. (1.6 pmy per yr.) Cooperation: Nebr., N. Dak., Okla., and Utah Agr. Expt. Stas; and others.

SUPPORTED BY U.S. Dept. of Agriculture

2.0575, BEHAVIOR AND FOOD PREFERENCES OF INTRODUCED ANNUAL FISHES IN RELATION TO MOSQUITOES

C.H. SCHMIDT, U.S. Dept. of Agriculture, *Beltsville, Maryland*

Object: Basic studies are to be conducted at Riverside both in the laboratory and a well-equipped aquatic field-study station on food preferences, survival, habitat adaption, fecundity, prey-seeking ability, and competition with indigenous fishes of introduced annual fishes of the family Cyprinodontidae. Laboratory and field aquaria along with sampling equipment are available for these studies in Riverside. In both laboratory and field environments annual fishes will be studied to determine their feeding habits and their preferences for bottom or top feeding activity and their ability to reduce populations of different types and species of mosquitoes. The effects of temperature, pH, and desiciation on survival, egg hatch, and fecundity of annual fishes under both laboratory and field conditions will be studied. Aestivation and hibernation along with the effect of drying eggs will be studied at varying temperatures and with different soil types. Comparative feeding, behavior, and survival of annual fishes and the mosquito fish, Gambusia offinis, will be made in field aquaria.

SUPPORTED BY U.S. Dept. of Agriculture

2.0576, BIOLOGY AND CONTROL OF SALT-MARSH AND RICE-FIELD MOSQUITOES IN GULF COAST AREAS

C.H. SCHMIDT, U.S. Dept. of Agriculture, *Beltsville, Maryland*

Object: To study the biology and control of mosquitoes especially in coastal marsh and rice growing areas of Louisiana.

Plan of work: Marsh areas will be classified as to topography, vegetation, soil, etc., and mosquito breeding potential determined. Studies will be made of egg populations and preferred oviposition sites in relation to environment; the physiology and embryonic development of different species of eggs; and effects of single, successive, and continuous floodings on eggs of various ages. The effects on mosquito breeding will be determined under different water management procedures in relation to environmental changes, and under different soil and water management schemes. Adult mosquito abundance and seasonal trends will be measured in relation to breeding conditions. Studies will be made of migration habits of different species, in relation to age and environmental and meteorological conditions; sex attraction in different species and factors affecting adult female attraction to man and animals; isolation and development of sex attractants; parasites, predators, pathogens and other biological agents that attract mosquito larvae and methods for their mass production and distribution; and insecticides, chemosterilants, and other materials for use against mosquitoes.

SUPPORTED BY U.S. Dept. of Agriculture

2.0577, THE EFFECT OF PREDATORS AND PARASITES ON THE BREEDING POTENTIAL OF MOSQUITOES

C.H. SCHMIDT, U.S. Dept. of Agriculture, *Beltsville, Maryland*

Object: To determine predators and parasites of mosquito larvae found in coastal-marsh areas of Louisiana and to study in this area their influence on the breeding potential of mosquitoes and factors affecting their role in the control of mosquito larvae.

Plan of work: In salt-, brackish-, and fresh-water areas, ditched, impounded and natural marshes will be selected for studies on predators and parasites of Aedes sollicitans and other marsh-breeding species of mosquitoes. The types of predators and parasites, particulary predatory fishes and aquatic insects which thrive under wide ranges of environmental conditions, which are prevalent, will be determined. For each predatory species the relative preference for feeding on mosquito larvae compared with other food items will be studied in laboratory and small-field plot environments. The effect of various factors, such as the species of aquatic plants present and their density and fluctuations in water level and salinity, on the abundance of predators and parasites, and their effectiveness in reducing mosquito populations will be determined. As opportunities present themselves in the course of field work by the contractor, he will collect marsh mosquito larvae which show signs of infection by pathogens and transmit this material to the Insects Affecting Man and Animals Research Laboratory at Lake Charles, Louisiana, for study by specialists in mosquito pathology.

SUPPORTED BY U.S. Dept. of Agriculture

2.0578, DIFFERENTIAL RESPONSE OF SORGHUMS TO DIFFERENCES IN CULTURE AND ENVIRONMENT

G.F. SPRAGUE, U.S. Dept. of Agriculture, *Beltsville, Maryland*

Object: To conduct basic physiological and biochemical investigations on grain sorghum to provide information about the effects of environmental factors, such as temperature, moisture, light and nutritional status on basic mechanisms of plant growth and metabolism, and ultimately, on grain yield and quality, and about other physiological phenomena.

Plan of work: Research will be conducted in the laboratory, greenhouse, growth chamber, and/or field on: (1) drought resistance, including the efficiency of water use at varying levels of moisture availability and nutrients; (2) the efficiency of light utilization at various population densities; (3) relative growth rates of different height and maturity genotypes under varying conditions of moisture stress, population and nutrient levels; and (4) the relationship of content and composition of protein in the grain to date and rate of planting, fertility level, genotypes of plant, and moisture regime.

SUPPORTED BY U.S. Dept. of Agriculture

2.0579, HIGHWAY DRAINAGE STUDY

H.W. PIPER, Univ. of Maryland, School of Engineering, *College Park, Maryland*

This project contemplates reviews of current drainage practices in various parts of Maryland. Particular attention will be directed to methods of removal of surface water and ground water with respect to adequacy and efficiency. Laboratory and field studies will be undertaken to improve current drainage designs.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Maryland State Government

2.0580, THE DETERMINATION OF ZONES OF INTENSE CONTRIBUTION TO STREAM FLOW AS RELATED TO THE CONCEPT OF PARTIAL AREA CONTRIBUTIONS

R.M. RAGAN, Univ. of Maryland, School of Engineering, *College Park, Maryland*

The proposal is to develop a simulation model of a watershed that will be capable of isolating components of the runoff cycle of the watershed for intensive investigation. Numerical investigations of data already available from a pair of well-instrumented research watersheds will be made using the IBM 7094 Digital Computer.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Maryland

2.0581, PARTIAL AREA CONTRIBUTION TO STREAM FLOW

R.M. RAGAN, Univ. of Maryland, School of Engineering, *College Park, Maryland*

The proposal is to develop a simulation model of a watershead that will be capable of isolating components of the runoff cycle of the watershed for intensive investigation. Numerical investigations of data already available from a pair of well-instrumented research watersheads will be made using the IBM 7094 Digital Computer. The study proposed is a continuation of work initiated under project B-003 MD in September 1968.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Maryland

2.0582, SOIL - PLANT - WATER RELATIONSHIPS

C.W. REYNOLDS, Univ. of Maryland, Agricultural Experiment Sta., *College Park, Maryland*

Objective: 1. To determine the influence of plant and environmental variables upon water extraction from the soil profile.

Description of Work Proposed: Effects of irrigation treatments, varieties, plant populations, stages of growth, and growth retardants on water extraction patterns of selected vegetable crops will be determined. Extraction from various depths of the profile will be measured with the neutron moisture meter and related to patterns of root development of the crops.

SUPPORTED BY U.S. Dept. of Agriculture
Maryland State Government

2.0583, STUDY OF ROOT DISTRIBUTION AND DENSITY OF VEGETABLE CROPS

C.W. REYNOLDS, Univ. of Maryland, Agricultural Experiment Sta., *College Park, Maryland*

Objectives: 1) To delineate the pattern of root development of selected vegetable crops through the soil profile in soils of different types. 2) To measure the relationships between the density and distribution of roots of vegetable crops and the losses of water from the soil profile as measured by the neutron meter. 3) To determine the relationships between the density and distribution of roots of vegetable crops and the absorption and utilization of p32 from different zones of the soil profile.

Description of Work: Root distribution of selected vegetable crops (including snap beans, tomatoes, and sweet potatoes) will be estimated at intervals during the growing season by a) obtaining soil cores and extracting roots from the samples obtained at various locations in the soil profile, b) measuring the absorption by plants of p32 emplaced at different locations in the soil profile, and c) by determining losses of water from various layers of the profile with the neutron moisture meter. A limited number of plants will be excavated during the season to determine the extent and distribution of root systems.

SUPPORTED BY U.S. Dept. of Agriculture
Maryland State Government

2.0584, EXPERIMENTAL AND THEORETICAL STUDY OF THE HYDRODYNAMICS OF DISPERSION IN RIVERS AND ESTUARIES

M.P. TULIN, Hydronautics Incorporated, *Laurel, Maryland*

The general aims of the proposed research are: 1. To improve understanding of river hydraulics inasmuch as it has a bearing on dispersion. 2. To develop methods enabling the calculation of the velocity distribution in streams, which may be used to determine the dispersion coefficient, and to provide systematical experimental assessment of the results. 3. To provide experimentally verified, quantitative results relating to dispersion in channels with varying aspect ratio and boundary roughness distribution. 4. To develop quantitative verified theories relating components of the dispersion tensor to the mean flow characteristics. 5. To provide useful and verified information and procedures relating to the scaling and model testing of dispersion in streams.

2. WATER CYCLE

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

2.0585, THE EFFECT OF OCEAN WATER INTRUSION INTO BACK BAY, VIRGINIA, AND CURRITUCK SOUND, NORTH CAROLINA, ON THE WATERFOWL AND FISH HABITAT

J.L. SINCOCK, U.S. Dept. of Interior, Patuxent Wlife. Res. Ctr., *Laurel, Maryland*

The initial investigation into the ecology of Back Bay, Virginia, and Currituck Sound, North Carolina, was terminated on March 7, 1962, when an Atlantic Coastal storm introduced ocean water into the fresh to slightly brackish water of the area. The second phase of the investigation is now in progress and its objectives are to determine the effects of the increased water salinity on the waterfowl and fresh water fish habitat. The methods employed are identical to the first phase of the investigation.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

2.0586, MICROBIOLOGY OF MARINE AND ESTUARINE INVERTEBRATES

R.R. COLWELL, U.S. Dept. of Interior, Biological Laboratory, *Oxford, Maryland*

A study of the natural bacterial flora of oysters and associated invertebrate animals has been initiated. Animals from specified areas of Chesapeake Bay and off the Atlantic Coast are being sampled, using specified aseptic techniques to determine the quantitative and qualitative bacteriological flora of the animals. The normal commensal flora of oysters is being determined by examination of the shell liquor, body flesh, and intestine.

Standard bacteriological procedures are being followed for sampling, testing, and analysis. However, newer techniques of diagnosis and taxonomy will be applied, including the high-speed computer methods and the nucleic acid analyses, techniques developed and/or adapted by the Principal Investigator in previous published research.

Ancillary studies of the environment of the animals, i.e., water and mud samples, are also being undertaken. Unique features of the bacterial populations which are observed will be studied in detail.

The work is being undertaken at Georgetown University with the active collaboration of personnel at the Biological Laboratory, Bureau of Commercial Fisheries, U. S. Fish and Wildlife Service, Oxford, Maryland.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

2.0587, FIRE WEATHER FORECAST TECHNIQUES

R.C. ELVANDER, U.S. Dept. of Commerce, Weather Bureau, *Silver Spring, Maryland* 20910

To develop objective Fire Weather forecast techniques in the prediction of temperature, relative humidity, winds, precipitation, and thunderstorms over selected stations throughout the U. S.

Multiple regression and screening of surface and upper air predictors on dependent samples, and application to the National Meteorological Center prognoses in forecast operation. Techniques will be developed for both local and centralized use. An objective system of map typing will be used to stratify the data and a special study will be made of the Santa Ana winds.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.0588, NUMERICAL PRECIPITATION MODEL

H.R. GLAHN, U.S. Dept. of Commerce, Weather Bureau, *Silver Spring, Maryland* 20910

To develop numerical models which will predict precipitation on a scale of about 50 miles and a time scale of about 3-hours for up to 18-hours projection. Subsynoptic forecasts of this type are required by many special users, as well as general public.

Existing models will be adapted to the smaller scale in a workable manner and present computer programs will be streamlined so that latest possible data can be used.

As of July 1968 the Subsynoptic Advection Model is expected to be fully operational. Extension of the model or the development of a different model to be used in the western U.S. will probably be desirable. This task is part of a project which will continue until June 1972.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.0589, NATIONWIDE PRECIPITATION - NMC FORECAST TECHNIQUES

W.H. KLEIN, U.S. Dept. of Commerce, Weather Bureau, *Silver Spring, Maryland* 20910

To improve and automate nationwide forecasts of precipitation probability, timing, and amount for public and hydrologic use.

Conditional probabilities of precipitation are computed for 108 cities. Multiple regression equations are derived for each city by the screening program. The equations are applied to NMC prognoses to forecast precipitation 12-72 hours in advance. Also, forecasts of net vertical displacement and moisture are prepared from 3 dimensional computers trajectories on a current basis and related to clouds and precipitation by synoptic, theoretical, and statistical means.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.0590, IMPROVE PRECIPITATION MEASURING EQUIPMENT - PRESSURE TRANSDUCER ANALYSIS

F.V. KOHL, U.S. Dept. of Commerce, Weather Bureau, *Silver Spring, Maryland* 20910

Make a study of the availability of a suitable aneroid pressure transducer to replace mercury manometer on telemetering storage precipitation gage. This will make the instrument less bulky, more rugged, and better suited for transportation and operation in remote rugged environments.

Equipment from several manufacturers will be surveyed to find out which is best suited for modification to meet the needed requirements.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.0591, IMPROVE PRECIPITATION MEASURING EQUIPMENT - D-III PRECIPITATION EQUIPMENT

F.V. KOHL, U.S. Dept. of Commerce, Weather Bureau, *Silver Spring, Maryland* 20910

Make a study of the adequacy of the D111 precipitation gage design and the data supplied by it, and make recommendations for improvements, particularly in the areas of registering and telemetering of data.

An analysis will be made of the users need and the mechanical and electrical characteristics of the equipment. Improvements needed in the equipment to best satisfy the users need will be highlighted.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.0592, SUBSYNOPTIC WEATHER SPECIFICATION

D.A. LOWRY, U.S. Dept. of Commerce, Weather Bureau, *Silver Spring, Maryland* 20910

To determine statistical relationships between actual weather variables and parameters forecast by numerical models. Requirement is for better forecasts of local weather on subsynoptic scale.

Three-hourly values of observed weather variables, including cooling, total sky cover, weather, dew point, wind, temperature and precipitation amounts, are obtained from Asheville and related to the output of numerical models developed at the National Meteorological Center and the Techniques Development Laboratory. These relationships will be used to produce forecasts for field use. The results of the Numerical Precipitation model (2121 22 216) are necessary for this task.

As of July 1, 1968 data from Asheville (NWRC) will be collected and error checked on a monthly basis and initial results will be incorporated in the operational forecast for surface wind. The task is part of a project which will continue until June 1973.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.0593, METEOROLOGICAL DROUGHT

***W.C. PALMER*, U.S. Dept. of Commerce, Lab. For Environ. Data Res. , *Silver Spring, Maryland* 20910**

A continuing study to develop techniques to evaluate drought probabilities, to compare severities, and to develop means of computing current conditions. In the advanced phases of the project, drought criteria for specific purposes will be attempted, for example, with respect to growing plants.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.0594, PROBABLE MAXIMUM PRECIPITATION FOR SMALL BASIN IN THE TENNESSEE RIVER DRAINAGE SYSTEM

***J.L. PAULHUS*, U.S. Dept. of Commerce, Off. of Hydrology, *Silver Spring, Maryland* 20910**

Objectives are to provide generalized estimates of probable maximum precipitation and standard project storm rainfall for basins ranging from 5 to 3000 sq. mi. The estimates are to be presented on maps on which topographic influences will be reflected in much greater detail than in previous work.

SUPPORTED BY U.S. Tennessee Valley Auth.
U.S. Dept. of Commerce - E.S.S.A.

2.0595, TROPICAL STORM RAINFALL AND HURRICANE WIND FIELDS

***J.L. PAULHUS*, U.S. Dept. of Commerce, Off. of Hydrology, *Silver Spring, Maryland* 20910**

Two separate investigations are included in this research. One study attempts to specify in detail the frequency and spatial distribution of 6- and 12-hour tropical storm rainfall for the period from 24 hours before to 24 hours after landfall for storms entering the United States coastline between Apalachicola, Florida, and Brownsville, Texas. The other investigation aims to define the surface wind field and other parameters of standardized and probable maximum hurricanes for any location along the Gulf or Atlantic Coasts of the United States. The other parameters are: lowest central pressure, maximum wind speed, radius of belt of maximum winds, and rate of storm movement. Investigations were initiated in fiscal year 1967 and will be completed in fiscal year 1969.

SUPPORTED BY U.S. Dept. of Defense - Army
U.S. Dept. of Commerce - E.S.S.A.

2.0596, EXTREME RAINFALL FOR THE MEKONG RIVER BASIN

***J.L. PAULHUS*, U.S. Dept. of Commerce, Off. of Hydrology, *Silver Spring, Maryland* 20910**

Objectives are to develop precipitation criteria required for comprehensive planning for water management purposes, such as flood control, hydroelectric power, and irrigation. Of primary interest are rainfall data for developing maximum flows on the main stem of the Mekong above three proposed dam sites controlling drainage from areas from 105,000 to 250,000 sq. mi. This involves rainfall for periods up to five months in the monsoon season, May-September. Also required are estimates of probable maximum precipitation for durations up to 72 hours and areas from 2,000 to 10,000 sq. mi. to be used in tributary water management planning and design. Project was begun in fiscal year 1968 and is scheduled for completion in fiscal year 1969.

SUPPORTED BY U.S. Dept. of Defense - Army
U.S. Dept. of Commerce - E.S.S.A.

2.0597, PROBABLE MAXIMUM PRECIPITATION FOR SOUTHWEST STATES

***J.L. PAULHUS*, U.S. Dept. of Commerce, Off. of Hydrology, *Silver Spring, Maryland* 20910**

Objectives are to provide generalized estimates of probable maximum precipitation for durations up to 72 hours and areas up to 5000 sq. mi. and its seasonal variation from fall through spring for determining combined rainfall and snowmelt spillway design floods. Generalized estimates of probable maximum summer thunderstorm rainfall will be developed for small areas. The study area includes Nevada, Utah, Arizona, New Mexico and the interior drainage of California. Investigation was begun in fiscal year 1967 and is scheduled for completion in fiscal year 1970.

SUPPORTED BY U.S. Dept. of Defense - Army
U.S. Dept. of Commerce - E.S.S.A.

2.0598, PROBABLE MAXIMUM PRECIPITATION FOR THE LOWER RIO GRANDE

***J.L. PAULHUS*, U.S. Dept. of Commerce, Off. of Hydrology, *Silver Spring, Maryland* 20910**

Estimates of probable maximum precipitation for durations up to 96 hours are being made for five basins ranging in size from 1,700 to 18,000 sq. mi. Three of the basins are on the Rio San Juan and Rio Alamo, entirely in Mexico. In addition, the 50- and 100-year 1- to 3-day basin rainfalls are being determined. Project was begun in fiscal year 1968 and will be completed early in fiscal year 1969.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.0599, MARINE SURFACE FORECASTING TECHNIQUES

***N.A. PORE*, U.S. Dept. of Commerce, Weather Bureau, *Silver Spring, Maryland* 20910**

To develop objective techniques to improve forecasting of storm surges; i.e., changes in water level due to atmospheric disturbances. The approach is of a physical - statistical nature. The relationship of extratropical storm surges along the East Coast to off-shore wind circulation will be determined. A similar relation will be derived for the wind set-up on Lake Erie.

As of July 1, 1968, data on observed tide, astronomical tide, and storm surge will be compiled for eight (8) stations on the U.S. East Coast, beginning with 1955, and prediction equations for Lake Erie set-up will be tested. This task is part of a project which will continue until June 1973.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A

2.0600, HYDROLOGIC MODEL FOR STREAMFLOW FORECASTING

***A.K. SHOWALTER*, U.S. Dept. of Commerce, Off. of Hydrology, *Silver Spring, Maryland* 20910**

The objective of this research is to develop a conceptual hydrologic model that will provide continuous simulation of the streamflow hydrograph. A successful model would provide increased accuracy in prediction of flood peaks, inflow to water control reservoirs and low flows (for water pollution control). The model is based on an evaluation and individual treatment of the several components of total runoff and provides the synthesis of the continuous streamflow hydrograph directly from precipitation and selected meteorological factors. Several models are being tested, including well known Stanford Watershed Model, on several watersheds in the United States representing a wide variety of hydrologic regimes.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A

2.0601, PRECIPITATION

***A.K. SHOWALTER*, U.S. Dept. of Commerce, Environ. Sci. Serv. Admin. , *Silver Spring, Maryland* 20910**

Precipitation studies consist of the following: (1) In cooperation with the Agricultural Research Service at their Sleepers River Research Watershed, sets of 5 recording precipitation gages are being installed at three sites with significantly different exposure characteristics. These installations include a gage installed at ground level to provide 'ground truth' rainfall. At one site, 'ground truth' water equivalent of snowfall will be obtained by a twin-probe snow density gage. Data from these and other locations will be analyzed to test the validity of various techniques for estimating 'ground truth' precipitation from standard observations.

(2) Precipitation and selected meteorological data are being collected from a line of stations traversing the Wasatch Front near Salt Lake City, Utah. These data will be used with upper air meteorological information to develop methods for determining the distribution of precipitation in mountainous areas. Such information is needed for short-and long-term streamflow forecasting.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.0602, SNOW METAMORPHOSIS AND SNOWMELT

A.K. SHOWALTER, U.S. Dept. of Commerce, Environ. Sci. Serv. Admin., *Silver Spring, Maryland* 20910

A research project on snow metamorphosis and snowmelt has been established in cooperation with the Agricultural Research Service at their Sleepers River Research Watershed at Danville, Vt. All aspects of snow metamorphosis will be studied to provide the basis for developing improved techniques for estimating rate of snowmelt from meteorological factors. Another objective is to develop better instrumentation for measuring the water equivalent of the snow pack to provide reliable values of daily change. Efforts are also devoted to developing an inexpensive instrument or method for determining the albedo of the snow. More reliable estimates of daily increments of snowmelt would provide improved operational river forecasts prepared and issued by the Weather Bureau.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.0603, EVAPORATION

A.K. SHOWALTER, U.S. Dept. of Commerce, Environ. Sci. Serv. Admin., *Silver Spring, Maryland* 20910

Research continues on development of improved methods for estimating free-water evaporation. Current evaporation studies consist of the following: (1) At the request of the Working Group on Evaporation of the World Meteorological Organization, evaporation comparisons are being made of the Class A and Soviet GGI-3000 pans to assist in the selection of an interim international reference evaporimeter. These comparisons are being made at evaporation installations located at Sterling, Va., Lake Mead, Ariz-Nev., and Davis, Calif. (2) A new insulated evaporation pan has been developed and is being tested at sites noted above. It is hoped that this pan will prove superior to existing pans. This insulated pan will also provide values of incident minus reflected all-wave radiation. (3) Analysis of evaporation data from a network of 13 Class A stations located in U. S. Forest Service Davis County Experimental Watershed near Farmington, Utah at elevations ranging from 4,000 to 9,000 m.s.l. is underway. The objective is to evaluate the effect of elevation and exposure on rate of evaporation. (4) In cooperation with the Geological Survey, a study is being made at Salton Sea of the effect of lake size on evaporation. (5) Continued efforts are devoted to development of improved techniques for computing free-water evaporation from meteorological factors.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.0604, PROBABILITY TABLES FOR PRECIPITATION

H.C. THOM, U.S. Dept. of Commerce, Environ. Data Serv., *Silver Spring, Maryland* 20910

Probability tables and method for fitting distribution to precipitation. A new method is being developed for inverting the gamma distribution making possible inverse as well as direct tables which are also being computed.

Develop an index of plant-water requirement and its probability of occurrence. Precipitation and soil moisture will be treated jointly.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.0605, SCALE OF PRECIPITATION

H.C. THOM, U.S. Dept. of Commerce, Environ. Sci. Serv. Admin., *Silver Spring, Maryland* 20910

Investigation of the scale property of the precipitation variable in relation to meteorological conditions. This should be useful in the investigation of the artificial augmentation of precipitation.

Precipitation network design improvements are being developed in the light of current studies of the variability of precipitation with time and space.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.0606, MISCELLANEOUS FIELD RESEARCH IN CLIMATOLOGY

UNKNOWN, U.S. Dept. of Commerce, Environ. Data Serv., *Silver Spring, Maryland* 20910

In general, the 48 professional Climatologists located throughout the United States devote about 50% of their time to work which is other than operational--about half of this or 25% can be classed as research. Individual projects vary greatly depending upon local requirements as well as the individual backgrounds and interests of the Climatologists concerned.

Many of them are pursuing projects associated with water availability: Alaska - National associated assessment of Water and Related Land Resources. Illinois - Snow Climatology, Glaze and Ice Storms. Missouri - Weather Modification; evaluation of effects. Wyoming - Precipitation in the Upper North Platte Valley. Oregon - Climatological Handbook, 'Columbia Basin States'. Oklahoma - A comprehensive Plan for Development of Water and Related Land Resources. Washington - Climatological Handbook, Columbia Basin States. Michigan - Precipitation Probabilities and snowfall statistics for Michigan. Southern New England - Topographic precipitation relationships. Northern New England - Study of snowfall and snow cover. New Jersey - Snowfall and snow depth studies. Virginia - Monthly Precipitation Probabilities. Florida - The Climate of the St. Johns River Basin. Maryland - Delaware - Stidies of snow frequency, and tropical storms. Kentycky - Precipitation and soil moisture. Louisiana - Tropical storm and hurricane precipitation. Montana - Trends in glacier formation and extension. Ohio - Precipitation probability. Utah - Precipitation altitude relationships. West virginia - Precipitation probabilities.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.0607, THE ECOLOGY OF THE YOUNG FISHES OF THE WEWEANTIC RIVER ESTUARY

C.F. COLE, Univ. of Massachusetts, School of Agriculture, *Amherst, Massachusetts* 01003

The 7.5 km. long Weweantic River estuary (upper Buzzards Bay, Massachusetts) is being sampled weekly at seven stations for surface and bottom plankton as well as salinity and temperature data. Additionally, otter trawling, beach seining and gill and fyke netting are being conducted as necessary. Data for a year's study of the reproductive life history and early growth of the tomcod (Microgadus tomcod) have been gathered and are being analyzed by Arnold Howe for his master's thesis. The biology of the American smelt (Osmerus mordax) in the Weweantic is also being studied by David Crestin for his master's thesis. Roderick Smith, supported in part by this grant and also by an FWPCA grant is studying the effects of pesticides on winter flounder reproduction in this river. Robert Lebida has completed a thesis on the seasonality of fishes in the Weweantic during 1966. A continuing study on the seasonality of fish eggs and larvae in the Weweantic has been underway since December 1965 and upon termination of this study program in 1969 will have an insight into year-to-year variation in this estuary's fish population and some idea of the effects of the environment on larval fishes. As a phase of this program, we are also attempting to devise a system for estimating mortality rates of larval flounder for comparison between polluted and unpolluted estuaries in Massachusetts.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Massachusetts

2.0608, WATERSHED RESPONSE TO HYDROLOGIC INFLUENCES

G.R. HIGGINS, Univ. of Massachusetts, School of Engineering, *Amherst, Massachusetts* 01003

This project is directed to improvement of the methodology of analysis of reservoir evaporation phenomena; analysis, evaluation and application of existing theories on thermal stratification in lakes and reservoirs; and computing precipitation response functions for watersheds in Massachusetts. The project will include refined automation of data reduction processes and energy budget computations, formulation of mathematical models for prediction of temperature stratification, and determination of hydrologic response functions for drainage basins.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Massachusetts

2.0609, THE ROLE OF AQUATIC VASCULAR PLANTS IN THE EUTROPHICATION OF SELECTED LAKES IN WESTERN MASSACHUSETTS

R.B. LIVINGSTON, Univ. of Massachusetts, Graduate School, *Amherst, Massachusetts* 01003

The proposed study will utilize SCUBA gear to obtain quantitative measurements on the productivity (standing crop) of the aquatic vascular plants in oligotrophic and eutrophic lakes in western Massachusetts. The field collections will also add to the record of the aquatic flora of western Massachusetts.

The distribution and abundance of these plants will be correlated with the geological and limnological conditions (pH, temperature, dissolved oxygen, total alkalinity, conductivity and light intensity). The sampling will be carried out in four lakes at monthly (hopefully bi-weekly) intervals.

The seasonal growth of the plants and the nutrient content of their tissues (total nitrogen and phosphorus) will be correlated with the limnological data and particularly the nutrient supplies avail- able in the water and the substrate. This should reveal the presence of any accumulators or indicators of trophic conditions.

Laboratory studies are being carried out on the significance of nutrient absorption by the roots in the metabolism of the aquatic vascular plant.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Massachusetts

2.0610, DETERMINATION OF THE FEASIBILITY OF REMOVAL OF ALGAL NUTRIENTS IN LAKE WATERS BY ION-EXCHANGE

O.T. ZAJICEK, Univ. of Massachusetts, Graduate School, *Amherst, Massachusetts* 01003

The objective of this project is to develop a simple and (relatively) inexpensive technique for the 'in situ' removal of phosphate from natural waters by an ion exchange process. To this end, the behavior of various ion exchangers will be studied for exchange characteristics and selectivity for phosphate species as a function of pH, counter ions, temperature, and flow rate. In addition, attempts will be made to prepare phosphate specific ion exhangers. The information acquired will be used to develop a device and optimum conditions for the removal of phosphates from natural waters.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Massachusetts

2.0611, PROPOSAL FOR COMPILATION OF CUMULATIVE DROUGHT BIBLIOGRAPHY

T. CALESS, Amer. Meterological Society, *Boston, Massachusetts*

Some 2,000-2,500 references and abstracts are being compiled to assist research workers in their attempts to learn the causes and predictability of large scale drought as well as its relations with economic and social endeavors.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.0612, ANALYSIS OF RUN-OFF FROM SMALL DRAINAGE AREAS

UNKNOWN, State Dept. of Pub. Works, *Boston, Massachusetts*

Drainage areas in the Commonwealth are being studied to develop new formulae for computing design flows for small drainage areas. Flood frequency formulas have been developed and additional gaging stations were established. Field work in small drainage areas is continuing using 10 gaging stations, 10 recording rain gages, and about 40 crest-stage gages.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Massachusetts State Government

2.0613, GROUND WATER CONDITIONS OF THE CENTRAL BOSTON AREA, MASSACHUSETTS

J.E. COTTON, U.S. Dept. of Interior, Water Resources Division, *Boston, Massachusetts*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Massachusetts.

Purpose: To describe the configuration of the water table, record any fluctuations related to major excavations, and determine the hydrologic character of the unconsolidated deposits.

Methods: Existing and procured water-level and subsurface records will be analyzed. Observation wells will be established. Aquifer materials will be sampled for laboratory analysis to determine the hydrologic character of the materials (permeability, grain size, specific yield, etc.). Maps with the contours illustrating bedrock surface, water table, and saturated thickness will be prepared. A material distribution map will be prepared.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Massachusetts State Government

2.0614, WATER RESOURCES OF BRANCH-BLACKSTONE RIVER BASIN, RHODE ISLAND

J.B. GONTHIER, U.S. Dept. of Interior, Water Resources Division, *Boston, Massachusetts*

This research is part of the program of water resources investigations conducted by the U.S. Geological Survey in cooperation with the State of Rhode Island.

Purpose: To obtain water resources information which will aid planners of facilities for future water needs of Rhode Island.

Methods: The principal emphasis will be on the evaluation of the practical sustained yield of the subsurface reservoirs in the area.

Data from the 4 existing stream-gaging stations in the basin will be analyzed and additional low-flow measurements will be made in order to evaluate the ground-water runoff in all parts of the basin. Surface- water runoff and recharge will be determined in topographically and geologically dissimilar environments. Aquifer transmissibility will be computed from existing data and from materials analyses from proposed drilling. Sediment and water-quality samples will be collected and evaluated.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Rhode Island State Government

2.0615, ANALYSIS AND SYNTHESIS OF HYDROLOGIC SYSTEMS

P.S. EAGLESON, Mass. Inst. of Technology, School of Engineering, *Cambridge, Massachusetts* 02139

Development of improved analytical techniques for the prediction of the time variable in stream flow at some point in a drainage basin due to a given temporal and areal distribution precipitation. Development of the means for synthesizing these predictors in the absence of long term hydrologic records. The laboratory rainmaker is being used in conjunction with a computer simulation of overland flow to study the errors accompanying the unavoidable lack of dynamic similarity in using scale models of surface runoff. The equipment is also being used in the development and evaluation of analytical methods for separating thessurface and groundwater components in streamflow.

SUPPORTED BY Massachusetts Institute of Technology

2.0616, THERMAL STRATIFICATION IN RESERVOIRS

D.R. HARLEMAN, Mass. Inst. of Technology, School of Engineering, *Cambridge, Massachusetts* 02139

Determination of analytical methods of predicting the transient temperature distribution in a reservoir having inflow and outflow. Study includes determination of flow through time in reservoir as well as the time variation of the outlet water temperature. The two dimensional heat transfer equation has been simplified by making assumptions regarding internal velocities and temperature gradients. The resulting differential equation includes the temperature variation of the inflowing river, solar radiation input, heat losses from the reservoir surface, and outlet flow rate. The equation is solved by means of an implicit finite difference scheme on a digital computer. Experiments have been conducted on a 40 ft. laboratory reservoir model in which solar radiation is simulated by infra-red heat lamps. Internal temperature distributions and outlet water temperature are compared with predicted values.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Massachusetts Institute of Technology

2.0617, TECHNIQUES OF MODELING THERMAL STRATIFICATION IN LAKES

D.R. HARLEMAN, Mass. Inst. of Technology, School of Engineering, *Cambridge, Massachusetts* 02139

A theory for the vertical temperature distribution has been developed. The theory predicts the development of a surface mixed layer of varying temperature and depth. The results are applicable to deep lakes or shallow ponds in which various bottom thermal boundary conditions may be assumed. Experiments were conducted to verify the theory in a laboratory tank using insolation supplied by mercury vapor and infra-red lamps. The experiments indicate that thermal stratification may be reproduced in the laboratory for the study of wind induced circulation or mechanical de-stratification by pumping. Current investigations are concerned with evaporative heat losses in laboratory tanks.

SUPPORTED BY Massachusetts Institute of Technology

2.0618, TIDAL, SALINITY AND SEDIMENTATION PROBLEMS IN LAKE MARACAIBO CHANNEL, VENEZUELA

A.T. IPPEN, Mass. Inst. of Technology, School of Engineering, *Cambridge, Massachusetts* 02139

Purpose of basic research: Investigation of flow variables and soil properties controlling rates of erosion and deposition of fine cohesive sediment in a flow field. Purpose of field investigation: To determine the sources and motion of sediment and the time and spacial salinity distribution within the Maracaibo estuary in Venezuela, and to utilize this information for designing remedial works in order to reduce shoaling in the Maracaibo Navigable Channel and control salt water intrusion into Lake Maracaibo. Basic research: The special apparatus developed consists of an annular rotating channel and a counterrotating annular ring placed in the channel and in contact with the water surface. The relative motion of channel and ring generates a uniform turbulent flow field. Experiments with kaolinite clay suspensions have revealed two important properties: (1) The existence of a critical flow velocity for clay deposition. (2) For a given flow, the equilibrium concentration is a constant percentage of the initial sediment concentration in the channel. Field investigations: Results point out that most of the sediment comes from the Gulf of Venezuela transported near the bottom by tidal and salinity currents. Also a bottom layer at high salinity has been found to exist all the way to the entrance to the Lake throughout the year.

SUPPORTED BY Massachusetts Institute of Technology
Instituto Nacional De Canalizaciones
Universidad Del Zulia

2.0619, RESEARCH IN OCEANIC PHYSICS

H.M. STOMMEL, Mass. Inst. of Technology, Graduate School, *Cambridge, Massachusetts* 02139

The program centers about a field study of the small scale structures and mixing processes within the main thermocline of the subtropical Atlantic ocean. Various new forms of instrumentation will be used to measure shear, density stability, and life history of laminae on vertical scales of less than ten meters. The field study is scheduled for the Research Vessel ATLANTIS II on August 28 - September 19, 1968, southeast of Bermuda.

Theoretical study of the Ekman layer in the presence of strong heating and application to the Trade wind region of the ocean is contemplated. Also a laboratory model-study and theoretical study of density tongues in rotating density-stratified fluids is being pursued: with the hope of eventual application to interpretation of the spreading of water-masses at depth.

During the Spring of 1969 an attempt will be made to locate, identify, and intensively survey a region of active bottom -water formation in the Ligurian Sea. A continuous monitoring of the cold- upwelling region off Somalia, associated with the Monsoon induced Somali Current is also in progress in the hope of providing definite information on the time of response of an ocean current to variable wind-stress. The latter investigations are meant to be part of the U.S.-Italy Cooperative Science Program.

SUPPORTED BY U.S. National Science Foundation

2.0620, THE ECOLOGY OF SELECTED SUBMERSED AQUATIC WEEDS

R.M. DEVLIN, Univ. of Massachusetts, Agricultural Experiment Sta., *East Wareham, Massachusetts* 02538

1. To study the growth and development of Myriophyllum, Potamogeton, Elodea and Najas as affected by: a. Chemical variables - such as nutrients and other dissolved solids, pH, and dissolved gases. b. Physical variables - such as light, temperature, water depth and flow and turbidity. c. Biological variables - including competition, predation and stimulation.

2. To relate the results obtained to the incidence, distribution, management and control of the above-mentioned genera.

The Massachusetts Agricultural Experiment Station will study the physical, chemical, and biological variables affecting the growth and development of Myriophyllum, Potamogeton, and Algae.

SUPPORTED BY U.S. Dept. of Agriculture
Massachusetts State Government

2.0621, GEOMORPHOLOGY OF LOW-ORDER STREAMS

J. VILETTO, U.S. Army, Natick Laboratories, *Natick, Massachusetts*

Technical Objective - To study the geomorphology of low order streams in order to develop terrain design criteria. To test the accuracy and validity of relations between selected stream parameters /numbers, length, density, gradients, confluence angles, channel cross sections and channel bank material/of low-order drainage systems. Better information on the number and physical characteristics of streams in selected basins will be useful in providing data for terrain design conditions.

Approach - Four low-order basins were selected in a twenty square mile area. By limiting the study to a small area, several factors remain essentially constant, thereby decreasing the complexity of the problem. Field measuring of the parameters and mapping is necessary because published maps, including the 1967 U.S. Geological survey topographic quadrangles of the study area seldom show streams lower than third order.

Progress - /Jul 67 - Aug 68/ - Library research and field work are complete, profiles were measured, and data analyzed from field notes. These data have been found to be directly applicable to the development of terrain design criteria. Data on stream numbers and lengths, and confluence angles have been analyzed and found to differ from theoretical values by twenty to fifty percent in several instances. A modified method for computing the number of streams has decreased the error by about 50 percent. A report summarizing this work has been prepared.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0622, ENERGY SOURCES OF HETEROTROPHIC MICROORGANISMS IN AN AQUATIC ENVIRONMENT

R.T. WRIGHT, Gordon College, Undergraduate School, *Wenham, Massachusetts* 01984

Previous work by the investigator has helped point to methods leading to an understanding of the trophic relationships between the planktonic algae, bacteria and dissolved organic matter. More recent applications of the methods have dealt with glycolic acid and indicate that bacteria in natural waters are using this important algal excretory product for energy. Continued research along these lines may lead to a basic understanding of how most of the planktonic bacteria obtain energy and influence the concentrations and array of organic compounds in aquatic systems. The proposed lines of continuing investigation are: 1. Identification and production rates of the dissolved organic compounds lost by algae during photosynthesis. 2. Measurement of the rates at which certain important dissolved organic compounds lost by algae are assimilated by populations of heterotrophic microorganisms in natural waters. 3. Laboratory and field studies aimed at discovering the roles of different species of microorganisms involved in the uptake and transformation of specific organic compounds under natural conditions.

SUPPORTED BY U.S. National Science Foundation

2.0623, MARINE HYDROLOGY AND GEOCHEMISTRY, ATLANTIC CONTINENTAL SHELF AND SLOPE

R.H. MEADE, U.S. Dept. of Interior, Water Resources Division, *Woods Hole, Massachusetts*

Objectives: (1) To determine the rates and loci of fresh water (both surface and ground waters) and salt water along the Atlantic Coast, and to understand the influences of different factors on mixing processes. (2) To determine the chemical compositions of surficial sediments and older sedimentary rocks of the Atlantic Continental Shelf and Slope -- including the composition of their interstitial waters - and to understand their areal and stratigraphic variations. (3) To determine the amount of suspended matter and to understand the dispersal of sediments in coastal waters.

Approaches: (1) Information on salinity (the main index of mixing of fresh and salt waters) and its variations in coastal waters is being compiled in atlas form, largely from existing data. (2) Chemical analyses (major and selected minor elements) are being made of surficial bottom sediments from the continental shelf and slope, and of rocks and interstitial waters that lie below the shelf and slope. Concentrations of suspended matter have been measured gravimetrically, and suspended constituents have been identified microscopically.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0624, CIRCULATION ON THE CONTINENTAL SHELF

D.F. BUMPUS, Woods Hole Oceanographic Inst. , *Woods Hole, Massachusetts* 02543

This investigator has endeavored to delineate the horizontal motions in the circulatory system of the continental shelf of the east coast of the United States. With the generalized pattern in hand we are trying to work out the secular changes in the circulation and their causes. We will use a Lagrangian technique with drift bottles at the surface and sea-bed drifters at the bottom and make use of all the physical oceanographic, hydrological, climatic and meteorological data and theory to elucidate these motions.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

2.0625, CHEMISTRY OF THE HYPOLIMNION OF LAKE ERIE

H.E. ALLEN, U.S. Dept. of Interior, Biological Laboratory, *Ann Arbor, Michigan*

During the period of summer stratification much of the hypolimnetic water in Lake Erie experiences severe oxygen depletion. Concurrent large changes occur in the concentration of nitrate, ammonia, phosphate, iron, maganese, and sulfide. Our objectives include describing the magnitude and rate of these changes, determining the chemical compounds involved and determining the effects of these changes on the ecosystem. Subsequent to fall overturn concentrations of these materials return to those concentrations existing prior to stratification. Field studies are being made to determine the concentrations of these and other substances in the waters. Laboratory studies are being conducted to determine the oxidation-reduction potential at which materials are released from the sediments and to determine the kinetics of their buildup in the water. The chemical composition of materials precipitated upon overturn is being investigated. Various sediments are being investigated to determine the substances responsible for oxygen depletion.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

2.0626, ECOLOGY OF GREAT LAKES ESTUARIES

J.F. CARR, U.S. Dept. of Interior, Biological Laboratory, *Ann Arbor, Michigan*

The various bays are among the most productive environments of the Great Lakes and they are also the most vulnerable to human activities. Industrial and domestic wastes impair the fertility of the water as well as the edibility of the fish. The immediate objectives of this project are to determine to what extent oceanographic methods can be applied to studies of these bays. Subsequent work will be concerned with the movements and influence on the biota of waters flowing into these areas. Thermal, light transmission, chemical, surface current, sediment, plankton, and benthos data have been collected from Saginaw Bay, Lake Huron. Flushing-rate estimates, using oceanographic methods, have been made for Saginaw Bay. Drogue studies have been made in northern Green Bay, Lake Michigan.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

2.0627, OXYGEN DEMAND OF LAKE ERIE SEDIMENT

J.F. CARR, U.S. Dept. of Interior, Biological Laboratory, *Ann Arbor, Michigan*

Quantitative measurements of the oxygen demand of Lake Erie sediment are being made using Warburg respirometers. Studies are being made on the effects of temperature and age of the sediments on the oxygen demand.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

2.0628, QUANTITATIVE AND QUALITATIVE CHARACTERISTICS OF MATERIALS CONTRIBUTING TO SEDIMENTATION IN LAKE ERIE

J.F. CARR, U.S. Dept. of Interior, Biological Laboratory, *Ann Arbor, Michigan*

Collecting devices are being used to obtain materials as they settle from the water column but before reaching the bottom. Measurements are made of the percentage of the various components (plankton, clay, detritus, etc.) making up the sediments. In addition, measurements are made of sedimentation rate, oxygen demand, percent organic matter, nutrient content, and (hopefully) geographic origin of the material.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

2.0629, WAVE FORCES ON SUBMERGED STRUCTURES

E.F. BRATER, Univ. of Michigan, School of Engineering, *Ann Arbor, Michigan*

This research will investigate the vertical and horizontal forces on submerged structures resulting from oscillatory waves. Particular attention will be given to conduits located near or on the bottom or in a shallow trench. Analytical treatment of the inertial drag and lift forces will be supplemented by experimental determination of appropriate coefficients. The results of the studies will be applicable to the design of water intakes, sewer outlets, and other off-shore coastal structures.

SUPPORTED BY U.S. National Science Foundation

2.0630, GEOLOGICAL STUDIES IN NORTHERN LAKE MICHIGAN

J.L. HOUGH, Univ. of Michigan, Graduate School, *Ann Arbor, Michigan*

Northern Lake Michigan is the locale of several unsolved problems pertinent to the bedrock geology of the region and to the postglacial history of the lake. Most of the existing geological knowledge of the area stems from land-based exploration and drilling; most of the critical areas are offshore and, prior to the existence of properly equipped research vessels, could not be examined. Suitable research ships are now available and, aided by underwater photography, television and Scuba diving, offer promise of solution of hitherto insoluble problems.

Two aspects of postglacial geology to which this research may make new contributions are (1) the altitudes and areal extent of submerged shorelines of old lake stages, in the area which has undergone postglacial upwarp, and (2) the depth and nature of sedimentary deposits now occupying depressions in the lake basin left at the recession of the last glaciation. Previous work in the southern and central parts of the lake, which have not undergone upwarp indicates that submerged shorelines can be traced and that seismic profiles and long core samples yield useful information of postglacial events.

SUPPORTED BY U.S. National Science Foundation

2.0631, WINTER TEMPERATURE STRUCTURE OF THE GREAT LAKES

V.E. NOBLE, Univ. of Michigan, Institute of Sci. & Technology, *Ann Arbor, Michigan*

The program outlined in this proposal is a two-year continuation of work began under NSF grant GP-2411. During the period of the original grant, investigation of the winter temperature structure of Lake Michigan revealed strong indications of newly discovered mechanisms involved in the winter circulation patterns of the lake, and of new approaches to the prediction of the annual amount of ice cover based upon the thermal budget of the lake. The present proposal will provide additional statistical data necessary to establish confidence limits for the prediction capabilities developed under the original grant. Because of the slow accumulation of required data, two years are requested for the proposed program.

SUPPORTED BY U.S. National Science Foundation

2.0632, VERTICAL CURRENT STRUCTURE IN THE GREAT LAKES

V.E. NOBLE, Univ. of Michigan, Great Lakes Research Division, *Ann Arbor, Michigan*

Experimental data from Great Lakes Research Division shipboard measurements and the FWPCA GLIRBP buoy systems are being used to evaluate theoretical models for the prediction of the three-dimensional current structure in the Great Lakes. Particular emphasis is being placed on the interpretation of current meter data in order to study the dynamic interaction between geostrophic-and wind-driven currents.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

2.0633, ANALYSIS OF DRAINAGE BASINS AND LANDSCAPES

F.E. SMITH, Univ. of Michigan, Graduate School, *Ann Arbor, Michigan*

NO SUMMARY HAS BEEN PROVIDED TO THE SCIENCE INFORMATION EXCHANGE

SUPPORTED BY U.S. National Science Foundation

2.0634, TRANSIENT FLOW THROUGH CLOSED CONDUITS

V.L. STREETER, Univ. of Michigan, School of Engineering, *Ann Arbor, Michigan*

This research will be concerned with problems of fluid transients. The studies will provide basic information essential to some of the following problems: 1. Series-pump failures; also transients caused by pump startup. 2. Optimum valving and arrangement of pumping stations for long pipelines (with respect to hydraulic transients). 3. Resonance in systems caused by self excited means, such as leaky seals, fluttering air valves, pump or turbine vanes, governor instability. 4. Resonance in systems caused by external forced excitation, such as reciprocating pumps, arbitrary periodic valve motion, or surface waves on reservoirs; computer analysis of methods for alleviating the resonance. 5. Extension of valve stroking concepts to complex systems. 6. General study of equivalent lengths in water hammer analysis of complex piping systems, taking wave speeds into account. 7. Study of interpolation errors in characteristic method. 8. Study of gas coming out of solution during the water hammer cycle; its damping effect on pressure. 9. Study of wave speed from the characteristic equations and comparison with impedance methods. 10. Design construction and test of a valve that will produce a predetermined rate of closure; by cam drive, profiled seat, or other method.

SUPPORTED BY U.S. National Science Foundation

2.0635, PREDICTION OF THE MAGNITUDES AND FREQUENCIES OF FLOODS IN MICHIGAN

UNKNOWN, Univ. of Michigan, Graduate School, *Ann Arbor, Michigan*

Objective: Determination of the influence of various rainfall and drainage basin characteristics on the volume and distribution of flood runoff. The specific practical result will be the development of more accurate methods of predicting floods of various frequencies for watersheds of all sizes for selected regions in Michigan.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Michigan State Government

2.0636, GREAT LAKES RESEARCH - RIVER ICE JAMS

S.J. BOLSENGA, U.S. Army, Lake Survey, *Detroit, Michigan* 48226

The causes of ice jams in rivers and methods of possible elimination of destructive jams or reduction of their power are being studied.

In the first step of the study pertinent manuscripts from all areas of the world have been collected, examined, and summarized. Foreign language manuscripts account for a significant portion of the items and were translated as required. Report acquisition was through standard library sources, translation agencies, and by direct contact with investigators in the field.

The final results of the survey will be a narrative summary and selected bibliography prepared from the reports. Completion will be in June 1968.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0637, GREAT LAKES RESEARCH - LAKE EVAPORATION

J.A. DERECKI, U.S. Army, Lake Survey, *Detroit, Michigan* 48226

Objective is to determine the evaporation from the Great Lakes and the factors causing variation in evaporation rates. Two thirds of water supplied by precipitation over lake and land areas is being lost by evaporation; this has large effect on the availability of water in lakes, water quality and on heat budget of the lakes.

A research station located on South Manitou Island in Lake Michigan is operated to provide continuous recording of wind speed direction, precipitation, air and water temperature, humidity, barometric pressure, incoming and outgoing radiation, cloud cover, evaporation (pan), lake level, and ice cover. Field operations started December 1963 and are scheduled for completion October 1968. Data reduction is in progress.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0638, GREAT LAKES RESEARCH - LAKE PRECIPITATION

J.A. DERECKI, U.S. Army, Lake Survey, *Detroit, Michigan* 48226

Purpose is to determine the precipitation over the large water areas of the Great Lakes and to derive methods to calculate the overwater precipitation from the overland records.

In cooperation with U. S. Weather Bureau, the lake precipitation is being recorded on selected small islands. In Lake Michigan precipitation recording started October 1963 on South Manitou, North Manitou, South Fox, Beaver and Ile aux Gallets Islands. In Lake Erie precipitation recorders were placed on West Sister and East Sister islands during May 1964. Field program will continue through October 1968. Hourly precipitation data are available in tables and on punch cards.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0639, GREAT LAKES RESEARCH - ENERGY TRANSFER AT THE AIR-WATER INTERFACE

J.G. HOUSLEY, U.S. Army, Lake Survey, *Detroit, Michigan* 48226

The direct contact between water and air at their interface produces an exchange of energy and mass. Analysis of the interface activity will establish the mechanism by which energy and mass transfers, both air to water and water to air, are accomplished. These transfers are in the form of heat energy, such as radiation, conduction, convection, condensation, and evapaoration; kinetic energy as in wind tides and waves; mass as in absorption of gases and soldis by water; and electic charge transfer. Results will lead to improved methods of predicting waves, currents, wind tides, water supply, and modification of regional climate by the lakes.

Under contract with the University of Michigan, data are being obtained at an instrumented tower about one mile offshore, near Muskegon in Lake Michigan. The tower was in operation for the seasons 1963, 1964, and 1965, and 1967. Reduction and analysis of the data will continue in FY 69; the instrumented tower was reestablished in May 1968. Development of equipment for wind-stress measurements on a continuous basis is underway.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0640, GREAT LAKES RESEARCH - WATER-LEVEL DISTURBANCES

J.G. HOUSLEY, U.S. Army, Lake Survey, *Detroit, Michigan* 48226

Water-level disturbances are caused by various forces, including astronomical tides, wind tides, surges, and seiches. Research investigates the formation of these water-level disturbances, their patterns and distribution over the lakes, and their effects on water levels in harbors and in rivers. The derived mathematical models of water motion and its relationship with causative forces are used to develop methods of forecasting dangerous long-period waves and currents, and changes in depths and quantities of water.

A set of 16 water-level recorders was in operation on Lake Michigan in 1964. The data have been reduced, and spectral analysis is in progress. Data from 22 water-level gages in Lake Erie will be used to investigate three-dimensional oscillations of Lake Erie in FY 69.

A contract for theoretical investigation of three-dimensional seiches in Lake Erie is in progress.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0641, GREAT LAKES RESEARCH - LAKE WAVES

J.G. HOUSLEY, U.S. Army, Lake Survey, *Detroit, Michigan* 48226

The generation, propagation, and decay of waves in the Great Lakes are being investigated and correlated with wind speed and resulting wind stress, wind direction, and lake geometry. The characteristics of waves, including the expected maximum height given locations, will be established; wave climate charts will be prepared; and wave hindcasting methods developed.

Deep-water wave characteristics are being measured at five locations: Eagle Harbor and Whitefish Point on Lake Superior, Point Betsie and Muskegon on Lake Michigan, and Dunkirk on Lake Erie. This program was started in 1964 and will continue through 1971, with subsequent analysis of data.

In FY 69, shallow-water wave characteristics will also be measured at Knife River Harbor, Lake Superior, and Lorain, Lake Erie.

Techniques for wave hindcasting are being developed under contract with the University of Michigan. A report 'Wave Hindcasts vs Recorded Waves' by S. J. Jacobs was published in June 1965; 'Wave Hindcasts vs Recorded Waves Supplement No. 1' by A. L. Cole was published in May 1967. A second contract to apply the developed techniques to the hindcast of waves for Lakes Superior and Huron is in progress.

A contract to develop a sonic wave sensor will be undertaken.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0642, GREAT LAKES RESEARCH - HARBOR CURRENTS

J.G. HOUSLEY, U.S. Army, Lake Survey, *Detroit, Michigan* 48226

Objective is to acquire data on winds, currents, waves, water-level fluctuations, atmospheric pressure variations, and lake currents in the vicinity of harbors in order to determine their effect on currents in harbors, and pollution hazards engendered by the lack of currents. Mathematical equations or models will be derived relating currents in harbors with their causative forces and harbor geometry. Flushing rates will be established. The results are applicable to the design or redesign of new and existing harbors, including approach channels.

Currents were measured: 1964 in Calument, Racine, Muskegon, and Sturgeon Bay harbors; 1965 in Little Lake, Fairport, and Buffalo harbors; and 1966 in Harbor Beach and Toledo harbors. Data and analysis of currents and associated variables in Little Lake Harbor, Lake Superior, was published in 1966. During FY 69 analysis of the data will be continued, and preparation of reports for the various harbors will be continued.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0643, GREAT LAKES RESEARCH - GREAT LAKES DEICING

E.W. MARSHALL, U.S. Army, Lake Survey, *Detroit, Michigan* 48226

This investigation will prepare three reports (1) Annotated bibliography based on the world's literature on the natural conditions of the formation and decay of fresh-water ice on lakes, harbors, rivers and locks as well as scientific and engineering information on techniques used to aid the delay of ice formation and to accelerate the ice both in fresh and marine environments. (2) A summary of the pertinent papers identified in the above and (3) a summary of information developed by the in-house projects of the Research Center on Great Lakes ice characteristics and areal distribution.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0644, GREAT LAKES RESEARCH - ICE CHARACTERISTICS

E.W. MARSHALL, U.S. Army, Lake Survey, *Detroit, Michigan* 48226

The investigation seeks to determine the physical characteristics of ice cover in the Great Lakes by field measurements and laboratory analysis of samples from representative localities.

Field investigations are conducted during the 1965-66 and 66-67 winters in the Whitefish Bay area of Lake Superior. Among the factors investigated were: ice thickness, structure, crystal size and orientation, floe characteristics, pressure ridge configuration and ice foot formation. Aerial photomapping provided control for selection of ice samples and a permanent record for additional investigations. Micrometeorological measurements were taken at Whitefish Point during the 1966-67 season with particular emphasis on global radiation in four spectral bands. Petrographic studies of the ice samples collected in the field are conducted in the cold laboratory.

During the 1967-68 winter season studies will be continued in Whitefish Bay and extended to other areas on and near Lake Superior.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0645, GREAT LAKES RESEARCH - ICE COVER DISTRIBUTION

E.W. MARSHALL, U.S. Army, Lake Survey, *Detroit, Michigan* 48226

2. WATER CYCLE

This investigation seeks to determine the changes that take place in the areal distribution, structure, and imagery of the Great Lakes ice cover throughout the winter.

Currently three methods and levels are employed: low level visual reconnaissance, up to 8,000 feet, medium altitude aerial photography, 23,000 feet, and high level satellite imagery, 400 to 800 nautical miles.

The visual aerial reconnaissance program provides the extent and relative concentration of ice. These observations are coordinated with those of the Canadian Department of Transportation which covers the Canadian portions of the Great Lakes. These observations provide a general synoptic view of ice conditions at 10-15 day intervals.

Aerial photomapping of the ice cover at the scale of 1:46,000 is carried out over eleven areas critical to Great Lakes shipping. Weather satellite imagery is monitored to aid in determining ice distribution and program planning.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0646, GREAT LAKES RESEARCH - GREAT LAKES DEICING

E.W. MARSHALL, U.S. Army, Lake Survey, *Detroit, Michigan* 48226

This investigation will prepare three reports (1) Annotated bibliography based on the world's literature on the natural conditions of the formation and decay of freshwater ice on lakes, harbors, rivers and locks as well as scientific and engineering information on techniques used to aid the delay of ice formation and to accelerate the ice in both fresh and marine environments. (2) A summary of the pertinent papers identified in the above and (3) A summary of information developed by the in-house projects of the Research Center on Great Lakes ice characteristics and areal distribution.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0647, GREAT LAKES RESEARCH - MONITORING OF WATER CHARACTERISTICS

A.P. PINSAK, U.S. Army, Lake Survey, *Detroit, Michigan* 48226

A system of permanent automatic monitor stations will be developed to continuously measure and record geophysical processes that affect or are influenced by the Great Lakes and their environment and to program observations for timely use in forecasts and control. As a first phase in this program continuous automatic water temperature recorders have been installed at 10 sites along the periphery of the U. S. portion of the Great Lakes. These stations will be removed as the comprehensive monitoring program develops.

Hourly water temperatures, daily and monthly mean temperatures at each of the ten sites are published regularly.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0648, GREAT LAKES RESEARCH - CHARACTERISTICS OF LAKE WATER

A.P. PINSAK, U.S. Army, Lake Survey, *Detroit, Michigan* 48226

The research involves collection, analysis, and interpretation of data pertaining or related to physical and chemical characteristics of the fresh water in the Great Lakes, including radiological contamination and sound propagation; definition of those water properties which may be utilized as indices of water characteristics and quality; and installation of permanent automatic monitor stations. The broad objectives are to investigate short term variations in water quality and properties, including the factors causing these variations, and to determine and monitor the long term trends. Energy budgets and chemical budgets will be developed to explain evaporation, lake currents and other physical variables.

Systematic collection of data on physical and chemical water characteristics, bottom sediments, meteorological parameters, and wave observations was performed during summer and fall 1965 in Lake Erie and in Lake Huron during the open water season 1966. A similar program will be carried out in the eastern basin of Lake Superior during the 1968 open water season. Reduction, analysis and publication of data from Lakes Erie and Huron is in progress.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0649, GREAT LAKES RESEARCH - MONITORING OF WATER CHARACTERISTICS

A.P. PINSAK, U.S. Army, Lake Survey, *Detroit, Michigan* 48226

A system of permanent automatic monitor stations will be developed to continuously measure and record geophysical processes that affect or are influenced by the Great Lakes and their environment and to program observations for timely use in forecasts and control. As a first phase in this program continuous automatic water temperature recorders have been installed at 10 sites along the periphery of the U. S. portion of the Great Lakes. These stations will be removed as the comprehensive monitoring program develops.

Hourly water temperatures, daily and monthly mean temperatures at each of the ten sites are published regularly.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0650, GREAT LAKES RESEARCH - EFFECTS OF STRUCTURES ON COASTAL SEDIMENTATION

J.H. SAYLOR, U.S. Army, Lake Survey, *Detroit, Michigan* 48226

Effects of man-made structures on environmental energy-sediment relationships, and the resulting effects on the beach and nearshore areas of the Great Lakes will be studied. Results are needed for the planning and design of shoreline structures, for methods to predict the changes in shoreline caused by such structures, and for assessing the efficiency of various structure designs.

Data on stream velocity, suspended sediment, and bedload sediment in the headwaters of the St. Clair River were collected under varying energy conditions extant in Lower Lake Huron during spring and fall of 1965. The site will be resampled at a later date down the St. Clair River and the sediment deposition pattern. A report on the amount and distribution of sediment in the river has been published.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0651, GREAT LAKES RESEARCH - COASTAL AREA SEDIMENTATION

J.H. SAYLOR, U.S. Army, Lake Survey, *Detroit, Michigan* 48226

Data on energy sources (waves, winds, currents) impinging on selected coastal reaches along the Great Lakes will be collected and studied to learn how environmental energy affects sediment movement, characteristics, and distribution in beach and nearshore areas. Results will be used to derive relationships and/or mathematical models. Investigations will devise methods of establishing rates of coastline change and how to forecast the future behavior of the coastline. Information is needed for the design and location of harbors, marinas, industrial plants, and recreational areas.

Data collection at Little Lake Harbor on Lake Superior was completed in 1964, and a report was presented at the Tenth Conference on Coastal Engineering held in Tokyo, Japan.

Data collection on Lower Lake Huron in the vicinity of Port Huron, Michigan and Sarnia, Ontario, was completed during 1965. Analysis of the data is in progress.

Preliminary investigations were conducted at Pentwater, Mich on the eastern shore of Lake Michigan during 1967. An intensive field program is planned at Pentwater during the spring and fall of 1969.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0652, EFFECTS OF WATER APPLICATION ON CROP PLANTS

R.L. CAROLUS, Michigan State University, Agricultural Experiment Sta., *East Lansing, Michigan* 48824

Objectives: 1) To determine the minimum quantity of evaporating water required under varying levels of atmospheric stress parameters to assure optimum plant growth, development, and quality with a minimum application of water.

Work Proposed: Soil surface, ambient air and plant temperatures (soil moisture, air humidity, and air movement) will be regulated and varied by water application, infra-red radiation and other procedures. The effects of the resultant variations in the plant micro-climate on transpiration levels, seedling emergence and plant growth, development and chemical and physical qualities will be evaluated for various horticultural crops. The optimum internal plant water balance for maximum net photosynthetic activity and crop productivity and quality will be delineated. The resulting data will be used to increase the efficiency of water utilization and for reducing the water requirement of crops.

SUPPORTED BY U.S. Dept. of Agriculture
Michigan State Government

2.0653, THE EFFECTS OF LIMNOLOGICAL FACTORS ON THE UPTAKE OF CS137 BY FISH

N.R. KEVERN, Michigan State University, School of Agriculture, *East Lansing, Michigan* 48824

Cesium - 137, one of the potentially hazardous components of radioactive fallout, is accumulated by plants and animals, eventually reaching man through the food chain. Information about the behavior and fate of cesium in our environments would have predictive value should the levels of fallout increase. It has been shown that fish from different linmological lake types accumulate 137Cs in widely different concentrations. This study is designed to investigate the relationships between pertinent limnological factors and the accumulation of 137Cs by fish and as such broadly involves the fate of cesium in aquatic environments and biogeochemical processes in lakes.

A series of lakes near Gull Lake, Michigan and representing a range of factors was selected. Measurements are being made of alkalinity, specific conductivity, pH and temperature. Both fish and water are being made of alkalinity, specific condictivity, pH and temperature. Both fish and water are being analyzed for 137Cs, stable Cs, K, and Na. Largemouth bass, common to all of the lakes, is the fish being studied. Stable Cs is being analyzed by the method of Feldman and Rains (Anal. Chem., 36:405, 1964) with an atomic absorption/emission spectrometer. The study was initiated in FY-1967 and will probably be completed in FY-1969.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Michigan State University

2.0654, WATER REQUIREMENTS OF CROPS

R.Z. WHEATON, Michigan State University, Agricultural Experiment Sta. , *East Lansing, Michigan* 48824

Determine the use of water by crops, as influenced by climate, soils, and farming practices; basic relationships between soil moisture and crop production; optimum growth conditions for crops under various irrigation, fertilizer and management practices; and proper irrigation equipment design principles and operational practices as affected by peak moisture use, crop rooting habits, fertilizer practices, and other design factors.

Description of work: Eight plots are automatically covered by roofs whenever it rains. Four water regimes are maintained on these paired plots during the crop growing season by irrigation. The soil moisture level can be determined daily by an automatically operated recorder. When the moisture level in the surface 18 inches of a plot reaches a prescribed minimum level, it is irrigated with enough water to restore it to field capacity. Weather data including solar energy and pan evaporation are collected. Crop yield data are taken.

SUPPORTED BY U.S. Dept. of Agriculture
Michigan State Government

2.0655, METAMORPHOSIS OF SNOWPACK PROFILES AND CHANGES IN WATER STORAGE FOLLOWING STRIP CUTTING IN PINE FORESTS IN MICHIGAN

D.P. WHITE, Michigan State University, School of Agriculture, *East Lansing, Michigan* 48824

To define in situ, using gamma ray attenuation techniques, the metamorphosis of snowpack profiles and changes in the water equivalent after strip cutting a jack pine forest in Michigan.

The increasing significance of groundwater as a source for municipal and industrial water supplies has prompted interest in the groundwater recharge of watersheds. In northern regions groundwater is recharged almost entirely from snow melt. On the Manistee National Forest, Michigan, this recharge was shown to be significantly less under pine populations than under hardwood forests. Interception and subsequent evaporation of snow from conifer crowns appears to be the major cause of the difference. Decreasing the crown density by strip cutting should allow a greater snowpack to accumulate on the ground thereby increasing the groundwater yield of pine forests.

A 'two-probe density gauge' employing the principle of gamma ray attenuation will be used for the first time in the Lake States to intensively measure, in situ, weekly changes in the internal hydrologic characteristics of the snowpack resulting from strip cutting practices. Strip cut and uncut areas in a 34-year-old jack pine plantation on the Manistee National Forest, Michigan will be used for the project. Six- foot access tubes for the 'two - probe density gauge' will be installed two feet into the soil. Measurements of snow density, snow water content, and soil moisture can be measured in successive one-half inch increments. A pyrheliometer and a hygrothermograph will be placed in the study area to measure solar radiation, humidity, and temperature. Data from these measurements will be analyzed for correlations to the snowpack behavior.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Michigan State University

2.0656, INTERRELATIONS OF SEVERAL ABIOTIC FACTORS AND THE HIGHER AQUATIC PLANTS OF A STREAM ECOSYSTEM

R.G. KULLBERG, Michigan State University, W.K. Kellogg G. Lk. Biol. Sta. , *Hickory Corners, Michigan* 49060

The project will be concerned with the effect of several abiotic factors on the higher aquatic plants of a stream as well as the reciprocal effect of the higher aquatic plants on part of the environment. The water passes from a trout stream, past a paper mill, and then into a larger stream. An attempt will be made to correlate several abiotic factors of the stream with the kinds of species, their numbers, and their volumes at measured intervals.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Michigan State University

2.0657, DESIGN TO CONTROL EROSION IN ROADSIDE DRAINAGE CHANNELS

A.G. ANDERSON, Univ. of Minnesota, School of Engineering, *Minneapolis, Minnesota* 55455

The highway drainage engineer is required to provide designs to control erosion in roadside drainage channels over a wide range of conditions. Criteria are being established and existing procedures extended for conditions where easily established grass cover will suffice and for conditions where paved linings are required. The major emphasis of the research is on the development of a procedure for design of armored channels, with investigations into the critical tractive force of gravel and crushed stone and the mechanism of leaching of finer soils and sediments through the stabilizing layers. A literature review of items pertaining to the design of armored channels has been completed and design criteria developed utilizing information obtained from the literature. The criteria will contain two different applications. One will be for stream relocations and other channels that, from a design standpoint, are treated as individual problems. The second application will be a simplified procedure, using charts and curves, for designing aggregrate linings for standard sizes and shapes of roadside ditches. The latter should be particularly applicable in more arid areas where establishment of turf is difficult.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Amer. Assoc. of State Highway Officials

2.0658, FREE-STREAMLINE FLOW OVER DISCONTINUITIES IN A BOUNDARY LAYER

A.G. ANDERSON, Univ. of Minnesota, School of Engineering, *Minneapolis, Minnesota* 55455

Discontinuities on the solid boundaries guiding a high speed flow may produce a cavitating or supercavitating flow. A theoretical and experimental study of free-streamline flow over discontinuities and slender bodies in a fully developed boundary layer will be undertaken. In the theory steady two-dimensional, rotational flow with negligible viscosity will be considered. Perturbation potentials to represent the boundary discontinuities and velocity potentials that satisfy a Poisson type equation for the particular boundary conditions involved will be introduced. The solution will be obtained numerically and results will be presented in graphical form. The experimental program will provide information concerning the physical aspects of supercavitating rotational flow in a boundary layer and such characteristics as drag and cavity lengths associated with various types of bodies under these flow conditions will be measured. The experimental apparatus, with only minor modifications, is now available. The work will be performed at the St. Anthony Falls Hydraulic Laboratory.

SUPPORTED BY U.S. National Science Foundation

2.0659, EVALUATION OF SELECTED COMPUTER PROGRAMS IN HYDROLOGY

C.E. BOWERS, Univ. of Minnesota, School of Engineering, *Minneapolis, Minnesota* 55455

The research will evaluate some existing computer programs and mathematical models relating to the analysis of storm runoff and flood routing. Selected new mathematical models and computer programs will be investigated and compared with established methods to determine the magnitude and nature of differences between new and established methods. Programs that appear to have special merit relative to hydrologic analysis for determination of design floods and for design of spillways and related structures will be selected. Possible factors of safety or other criterion that should be used by practicing engineers will be developed. The research should assist hydrologists in determining peak rates of runoff and flood routing, and in making frequency analysis of hydrologic data by use of new and established computer techniques.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Minnesota

2.0660, CHEMICAL STUDIES ON THE WATERS AND SOILS OF LAKES AND WETLANDS, WITH SPECIAL REFERENCE TO MINOR ELEMENTS

E. GORHAM, Univ. of Minnesota, Graduate School, *Minneapolis, Minnesota* 55455

As may be seen from G. E. Hutchinson's Treatise on Limnology (1957) very little is known of the distribution of minor elements in the waters and sediments of lakes, and even less is known of their distribution in wetland ecosystems. The influences of geological, climatic, topographic and especially biological factors upon their cycles have scarcely been investigated, and their changes in concentration during lake or wetland evolution, as recorded in sediment cores, have only been examined in a cursory way in a very few cases. It therefore appears desirable to undertake intensive studies of minor elements in relation to the 'metabolism' and regional typology of lakes and wetlands. The diversity of lakes in Minnesota -- from acid and dilute waters on the northeastern Laurentian Shield to saline and alkaline potholes in the southwest -- makes the state a most suitable area for regional studies in chemical limnology. Moveover, because of the hundreds of square miles of peatland on the old glacial lake Agassiz basin of northern Minnesota, and the very numerous peat-filled kettle-holes of the southern part of the state, Minnesota is also an excellent area in which to study chemical aspects of wetland ecology.

SUPPORTED BY U.S. National Science Foundation

2.0661, COUPLING OF FLOWS AROUND AND THROUGH POROUS MEDIA

D.D. JOSEPH, Univ. of Minnesota, School of Engineering, *Minneapolis, Minnesota 55455*

This grant will provide continued support for experimental research on coupling conditions for fluid motions in the neighborhood of the boundaries of permeable materials. Coupling conditions are considered as those conditions satisfied at the boundary of a permeable material by a fluid which flows around and through this material. In particular, an examination of these flows for effects of boundary layers within the permeable material will be made.

The research is presently in a data-producing phase. There is one operating experiment and a number of preliminary results. It is expected that within the next two years there will be sufficient reliable experimental data to infer physically valid boundary conditions for the coupled motion.

SUPPORTED BY U.S. National Science Foundation

2.0662, THE IMPROVEMENT OF SOILS DEVELOPED UNDER FOREST VEGETATION

A.F. ARNEMAN, Univ. of Minnesota, Agricultural Experiment Sta., *Saint Paul, Minnesota*

The objectives of the study are: a) to characterize soil morphologic features in soils developed under forest vegetation. b) to define chemical, mineralogical, and physical properties of the profile which affect root development. c) to design and test chemical and physical practices which will improve these soils.

The work proposed, initially, is a study of an area of about 20 acres on typical drumlin topography of north central Minnesota (Wadena Co). In this area a detailed morphologic investigation of the soil profile occurring over the total topography will be made. Thin-section morphologic study will be employed. Hydrologic investigations using applied water will include description of the table as it occurs naturally or in the 'perched' condition. Root distributions will be investigated.

SUPPORTED BY Minnesota State Government
University of Minnesota

2.0663, WATER ADSORPTION AND ITS INTERACTIONS WITH CLAY AND QUARTZ

G.R. BLAKE, Univ. of Minnesota, School of Agriculture, *Saint Paul, Minnesota*

Reactions of water with clays and quartz in soils govern to a large extent the behavior, storage and flow of water into, through and within the soil moisture reservoir. Furthermore the water-clay matrix changes with time and with the formation and deterioration of aggregate- dependent structure.

It is proposed to study water-clay interaction in soil samples and in pure clay-quartz mixtures. Time dependent changes in water adjustment and in clay-quartz bond strengths will be investigated. Backswelling of equilibrium dried aggregations will be investigated as affected by formation and storage conditions of the prepared samples. Development of improved techniques for equilibrating soil water at known free energy levels, for measuring interparticle bond strengths, and for measuring swelling will be attempted.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

2.0664, CHARACTERISTICS OF THE SOIL MATRIX THAT AFFECT WATER STORAGE AND MOVEMENT

G.R. BLAKE, Univ. of Minnesota, School of Agriculture, *Saint Paul, Minnesota*

Objectives of the research proposed in this project are to investigate: A. Water storage and release from the soil as related to the matrix characteristics. B. Reactions occurring between water, clay and quartz during initiation, growth and stabilization of domains in the soil matrix that affect the storage and movement of water.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Minnesota

2.0665, STUDY OF FACTORS AFFECTING THE CHANNEL PHASE OF RUNOFF FROM SMALL WATERSHEDS BY MATHEMATICAL MODELING

C.L. LARSON, Univ. of Minnesota, School of Agriculture, *Saint Paul, Minnesota*

The lead phase determines the volume of runoff and the channel phase its time distribution and depends on the physical characteristics of the channel system. A new time parameter, time to virtual equilibrium, appears to be very useful, but its relationship to channel characteristics has not been determined. A detailed mathematical model of a watershed channel system will be developed, including tributary channels. The length, cross section, slope and roughness of each segment of channel will be varied independently. The input to the system will be overland flow of various durations and rates. The flows will then be routed through the various channel segments by the use of the basic equations of fluid mechanics governing non-steady flow is open channels, using finite difference solutions and a CDC 1604 digital computer. The results will be used to develop, if possible, a general relationship between channel characteristics and the time parameter. The model will also be used to check the tentative relation- ship of the time parameter to runoff time distribution for a variety of watershed sizes and slopes. The data obtained in a laboratory study will be used to develop a mathematical model of unsteady flow at a junction that will accurately describe the effect of a branch channel on the flow in the main channel both above and below the junction.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Minnesota

2.0666, EFFECTS OF AREAL AND TIME DISTRIBUTION OF RUNOFF SUPPLY ON WATERSHED HYDROGRAPHS

C.L. LARSON, Univ. of Minnesota, School of Agriculture, *Saint Paul, Minnesota*

A mathematical model watershed recently developed will be modified for use in this study. In the model, the physical characteristics of all channels of a fourth-order, 21.35 sq. mi., idealized but representative watershed are specified. Runoff supply excess rainfall is routed through the channel system by means of the differential equations governing unsteady flow, in finite difference form for numerical solution. The model will be modified to permit variations in areal distribution of runoff supply over the watershed. Experiments will be made with spatially varied input to the model, and the results will be used to determine what degree of (storm) coverage causes maximum outflow. The shape of the watershed will then be varied systematically to determine the effects of typical shape types and various length width ratios on peak discharge.

For another series of experiments, an overland flow model which will accommodate variable and intermittent supply will be incorporated into the model. Experiments will then be conducted with various time patterns of runoff supply that can be expected on natural watersheds to determine the magnitude of these watershed effects. In all of the tests, results will be related to runoff processes and watershed characteristics to facilitate application.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Minnesota

2.0667, THE EFFECT OF THE NATURAL SEALING OF POTHOLES UPON WATER MOVEMENT AND GROUNDWATER RESOURCES

P.W. MANSON, Univ. of Minnesota, School of Agriculture, *Saint Paul, Minnesota*

The research is aimed at determining the effect of the natural sealing of potholes upon water movement into the underlying subsoil and the effect of this water movement upon groundwater resources. Four typical potholes will be selected from each of four geological environments in Minnesota. The potholes will be instrumented to measure all water inflow and all water outflow. The sediments beneath and surrounding these four potholes will be sampled and carefully studied for permeability and sealing characteristics. Soil borings will be made to determine the water table position and the soil water movement patterns beneath and around the potholes. Vertical and horizontal borings will be made underneath and around the potholes into which instruments will be placed to observe and study the 'unsaturated flow'.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Minnesota

2.0668, INFLUENCES OF MIST IRRIGATION ON MOISTURE STRESS, GROWTH, YIELD, AND QUALITY OF POTATOES AND OTHER VEGETABLE CROPS

R.E. NYLUND, Univ. of Minnesota, School of Agriculture, *Saint Paul, Minnesota*

Vine growth and development, and tuber characteristics and quality of two varieties of potatoes grown under mist irrigation, conventional irrigation, mist plus conventional irrigation, and no irrigation will be compared. The influence of mist irrigation on microclimate within and above the plant canopy, on leaf turgor, on stem-natal aperture, and on soil moisture will be determined to provide a basis for physiological explanations of crop responses. After initial study of potatoes, the study will be extended to bush beans and peas.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Minnesota

2.0669, ANALYSIS OF PUBLIC INVESTMENTS IN NATURAL RESOURCES WITHIN MINNESOTA

R.D. VLASIN, Univ. of Minnesota, Agricultural Experiment Sta. , *Saint Paul, Minnesota*

The overall objective is to improve investments in natural resources in Minnesota for such purposes as parks, recreation and wildlife, water developments, land improvements, drainage, flood control, waste disposal, and forestry. The project will (1) develop a framework showing investments by various governmental units: (2) determine organizational and operational features of various resource districts; (3) compare existing special districts with existing and proposed milti-county districts; and (4) develop suggestions for alternative organizational and operational arrangements to improve investment decisions.

Description of Work: The first part will involve an inventory and categorization of natural resource expenditures by various resource districts and other governmental units from secondary sources. The second part of the project will involve an evaluation of organizational and operational characteristics of selected existing and proposed districts for the development and management of natural resources. The third part, building upon the earlier phases, will develop suggestions for decision making by districts. Attention also will be given the economic and related consequences of vesting investment decisions in other governmental units.

SUPPORTED BY Minnesota State Government

2.0670, COOPERATIVE GULF OF MEXICO INVENTORY AND STUDY - II HYDROLOGY

J.Y. CHRISTMAS, State Marine Conserv. Comm. , *Biloxi, Mississippi*

During 1966, basic information will be gathered on the time and duration of the run of each species of Alosa (with the exception of Alosa sapidissima) which enters the Connecticut River. Physical data will be gathered and temperature will be constantly monitored near the mouth of the river. The entering adults will be sampled with gill nets and lenghts, weights and sex will be recorded. Scale samples will be taken for age determination. This sampling will continue periodically during the entire run. The techniques worked out and the basic data gathered at this time will be used to plan a more intensive study to be conducted in 1967 and 1968.

A survey will be made to ascertain the major spawning areas of each species. This area will be sampled with gill nets, seines and plankton nets to determine the species present and if spawning has occurred. Physical and chemical data will also be collected at this time.

This preliminary survey augmented by information gathered on the other sub-projects shown enable us to design an intensive survey which will be carried out in 1967 and 1969.

The laboratory facilities of the University of Connecticut, Marine Research Laboratory will be utilized for this sub-project.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.
Mississippi State Government

2.0671, COOPERATIVE GULF OF MEXICO INVENTORY AND STUDY - III SEDIMENTOLOGY

J.Y. CHRISTMAS, State Marine Conserv. Comm. , *Biloxi, Mississippi*

Objectives: (1) To determine the sediment forms of Mississippi estuaries as an index of their respective conditions. (2) To establish a base line for the evaluation of expected changes in sediment distribution and its effect on the biota. (3) To develop an atlas of the sediments of Mississippi estuaries. (4) To make the state atlas available, in cooperation with the other Gulf States and the Bureau of Commercial Fisheries, for inclusion in an atlas of Gulf of Mexico estuaries.

Procedures: (1) Locate and complete existing data for textural analysis (sand, silt and clay) and carbonate, carbon, and nitrogen content in the study area. (2) As time permits, collect and analyze additional samples in a pattern arranged to complete a description of the sediment distribution pattern in the study area. (3) Collect, analyze and prepare data in a state atlas in a form which will be available for incorporation as a section in an atlas of the estuaries of the Gulf States in cooperation with members of the Gulf States Marine Fisheries Commission and the Bureau of Commercial Fisheries. (4) Prepare and publish additional notes and papers as necessary.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.
Mississippi State Government

2.0672, COOPERATIVE GULF OF MEXICO INVENTORY AND STUDY - IV BIOLOGY

J.Y. CHRISTMAS, State Marine Conserv. Comm. , *Biloxi, Mississippi*

Objectives: (1) To determine the major commercial species of aquatic fauna and their respective nursery areas, seasonal distribution and utilization. (2) To determine or estimate, from the best available information, the value of harvested species in or resulting from Mississippi estuaries. (3) To determine the correlation between hydrological characteristics and relative abundance of selected organisms. (4) To determine the type and distribution of aquatic vegetation. (5) To make the Mississippi atlas available, in cooperation with other Gulf States and the Bureau of Commercial Fisheries, for inclusion in an atlas of Gulf of Mexico estuaries.

Procedures: (1) Sample benthic, planktonic and pelagic vertebrate and invertebrate forms to indicate quality and relative abundance of these groups. (2) Collect hydrographic samples in conjunction with biological samples. (3) Determine relationship of relative abundance of selected organisms to existing environmental conditions. (4) Type map aquatic vegetation and record associated dominant emergent vegetation as time permits. (5) Collect, analyze and prepare data in a state atlas in a form which will be available for incorporation as a section in an atlas of the estuaries of the Gulf States in cooperation with members of the Gulf States Marine Fisheries Commission and the Bureau of Commercial Fisheries. (6) Prepare and publish additional notes and papers as necessary.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.
Mississippi State Government

2.0673, IRRIGATION

J.A. CAMPBELL, Mississippi St. University, Agricultural Experiment Sta. , *Crystal Springs, Mississippi*

a. To determine the response of various vegetable crops to irrigation during periods of drought as measured in yield, quality and profit. b. To determine the interaction effect of irrigation with various fertilizer treatments and varieties on yield and quality. c. To study methods of management and the economics of maintaining and operating irrigation systems for both the sprinkler and furrow flood methods for a 30 to 40 acre truck farm.

Description of work - During periods of drought irrigation studies will be set up on field experiments already in progress that are adapted to a modified split plot arrangement which will be used. Records on man hour requirements, fuel consumption and depreciation will be kept in order to determine cost of operation. Mechanical inprovisations will be made and tested for the purpose of reducing cost and facilitate handling of equipment.

SUPPORTED BY Mississippi State Government

2.0674, DEVELOPMENT OF SPECIAL REHABILITATION TECHNIQUES AND FOREST MANAGEMENT PRACTICES FOR USE ON SEVERELY ERODED OR HIGHLY EROSIVE WATERSHEDS

D.C. MCCLURKIN, U.S. Dept. of Agriculture, *Oxford, Mississippi*

Object: To develop improved methods of establishing and maintaining vegetation and litter on eroded sites throughout the South for the reduction of storm runoff, erosion and sedimentation; and to develop and test, on a pilot scale, timber management techniques that will permit economic utilization of forests from rehabilitated and erosive watersheds without inducing a new cycle of erosion.

Plan of work: The project staff is engaged in (1) development of methods for establishing protective covers more promptly, especially on the more difficult sites; and (2) prevention of excessive runoff and erosion in connection with the conduct of silvicultural operations on erosive sites of the South.

Cooperation: University of Mississippi; ARS Sedimentation Laboratory; Soil Conservation Service; TVA.

SUPPORTED BY U.S. Dept. of Agriculture

2.0675, SEDIMENT YIELD IN RELATION TO CLIMATIC AND WATERSHED CHARACTERISTICS IN THE SOUTHERN BRANCH

D.A. PARSONS, U.S. Dept. of Agriculture, *Oxford, Mississippi*

Object: To develop procedures and criteria for predicting the sources, amounts, and characteristics of sediment yield from agricultural watersheds of varying size in the principal physiographic and climatic regions of the Southern States.

Plan of work: Information on quantities of sediment carried by streams is obtained by means of reservoir sedimentation surveys and through suspended load sampling on selected watersheds. Records of precipitation, runoff, topography, channel characteristics, soils and geology, land use, conservation practices, and watershed treatment measures are compiled for the areas for which sediment yield records are available. Studies are made to determine and evaluate the processes and rates of erosion on land surfaces including gullies, roadbanks, and stream channels. Radio-active elements and other tracers are used in studying the movement of sediment from erosional sources to points of deposition. Required instrumentation is developed. Data on sediment yield rates and associated causal factors are analyzed and interpreted to derive improved techniques and equations for estimating sediment yield and sources in ungaged watersheds. The physical, chemical and biological attributes of the transported sediments are of concern and measured.

SUPPORTED BY U.S. Dept. of Agriculture

2.0676, THE NATURE AND PROCESSES OF RESERVOIR SEDIMENTATION IN THE SOUTHERN BRANCH AND AT THE USDA SEDIMENTATION LABORATORY

D.A. PARSONS, U.S. Dept. of Agriculture, *Oxford, Mississippi*

Object: To develop procedures and criteria for predicting the distribution of reservoir sediment; sediment densities; trap-efficiency; delta developments and the characteristic rates of storage depletion by sedimentation for reservoirs and ponds affected by agricultural watersheds in the Southern States.

Plan of Work: The program includes reservoir sedimentation surveys; topographic mapping of reservoir basins; measurement of both water and sediment inflow and outflow; tracing of water and sediment movement, including study of density currents in reservoir basins; characterization of basins as to topographic forms, shapes, and capacity -- watershed and capacity-inflow ratios; measurement and study of variations in the density and texture of deposited sediment, and study of the processes of delta formations within basins and their extension upstream beyond the backwater of the reservoir. Particular attention is devoted to development of new and improved instrumentation and sampling techniques, such as radioisotope probes, for measuring the density of deposited sediment and for making reservoir sedimentation surveys. Records are compiled to relate the rates and processes of reservoir silting to sediment yield from agricultural watersheds and to fluctuating levels of water storage.

SUPPORTED BY U.S. Dept. of Agriculture

2.0677, MECHANICS OF SEDIMENT ENTRAINMENT, TRANSPORTATION AND DEPOSITION IN CHANNELS OF THE SOUTHERN BRANCH AND AT THE USDA SEDIMENTATION LABORATO

D.A. PARSONS, U.S. Dept. of Agriculture, *Oxford, Mississippi*

Object: To advance existing knowledge and to develop new and improved equations and formulae for calculating sediment movement and deposition in natural and artificial stream channels in agricultural watersheds.

Plan of Work: Sediment transport is studied in natural and artificial streams and in hydraulic laboratory flumes. Field measurements include rate and depth of flow, rate and volume of transport of bed and suspended load, geology and vegetation at the site and other factors. Flume studies are made to provide a means of controlling variables and of clarifying relationships. Related phenomena such as dune and anti-dune bed configuration, surface waves, and the hydraulic roughness are observed. Instruments and techniques needed to measure and/or compute rates of flow, sediment content and channel dimensions during the flow are devised and tested.

SUPPORTED BY U.S. Dept. of Agriculture

2.0678, INVESTIGATIONS OF STREAM CHANNEL MORPHOLOGY IN THE SOUTHERN BRANCH AND AT THE USDA SEDIMENTATION LABORATORY

D.A. PARSONS, U.S. Dept. of Agriculture, *Oxford, Mississippi*

Object: To establish the regime behavior of natural and artificial channels as influenced by hydraulics of flow, changes in flow pattern, sediment and channel alluvium characteristics and channel roughness; and to determine for channel reaches and bends the relationship between shear stresses and boundary velocities and the scour resistance properties of cohesive and non-cohesive channel periphery materials.

Plan of Work: The field program includes selected channel reaches where flow regime, physical and chemical properties of channel materials such as percent clay, permeability, plasticity indices, dispersion ratios, and shear strength, and shear stresses such as tractive force and shear velocity, are determined. Laboratory experiments are carried out in models and flumes to isolate individual variables and establish fundamental relationships between measured shear forces and known characteristics of soil horizons for a range in both hydraulics of flow and the composition of channel periphery material. Undisturbed samples of known characteristics from field locations are tested under laboratory conditions. Channel meander patterns such as meander belt width, degree of sinuosity, and radius of curvature, and channel geometry factors such as width-depth ratios, width-area ratios, and thalweg gradients, will be determined for correlation with the type of alluviums in the stream channels. Close coordination is maintained between field and laboratory investigations.

SUPPORTED BY U.S. Dept. of Agriculture

2.0679, THE EFFECT OF TEMPERATURE ON WATER FLOW IN SOILS

R.D. JENSEN, Mississippi St. University, Agricultural Experiment Sta. , *State College, Mississippi* 39762

Theoretical aspects of the effect of temperature on water flow in soils have developed more rapidly than the experimental phases. This project is a basic experimental study on the effect of temperature on water flow in soils. The principal objectives are: (1) To determine the type of flux equation which adequately describes the flow of water in soils under non-isothermal conditions. (2) To study the temperature dependence of the conductivity function in unsaturated soil (3) To study the effect of temperature on the pressure head of soil water. (4) To determine the magnitude of the thermal water diffusivity coefficient. (5) To determine, if possible, the nature of the mechanism(s) involved in the transport of water in soils subjected to a temperature gradient.

The soil will be enclosed in specially constructed columns which permit the application of a temperature gradient across the sample and the simultaneous measurement of temperature, pressure head and water content at various positions in the soil sample. The temperature will be measured with thermistors, the pressure head with strain gauge transducer type tensiometers and the water content with gamma absorption apparatus.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Mississippi State University

2.0680, EFFECT OF SOIL DISTURBANCE ON THE PRESSURE HEAD OF SOIL WATER

R.D. JENSEN, Mississippi St. University, Agricultural Experiment Sta. , *State College, Mississippi* 39762

Objectives: 1. To determine the effect of mechanical disturbance of the soil on the pressure head of soil water. 2. To determine the magnitude and practical importance of changes in pressure head, due to mechanical disturbance of the soil, in different textured soils as a function of the water content. 3. To determine if possible, the nature of the phenomena responsible for altering the pressure head when the soil is mechanically disturbed.

Work Proposed: Pressure head measurements will be made on selected soils with a wide range of soil textures at different water contents before and after disturbance of the soil. Mechanical-type disturbances, due to such procedures as mixing, stirring, seiving, packing, etc., which cause a rearrangement of the soil particles, will be the kind of disturbance which will be investigated. The soil will be disturbed in such a manner that the water content of the soil does not change.

SUPPORTED BY U.S. Dept. of Agriculture
Mississippi State Government

2.0681, EROSION CONTROL CRITERIA FOR DRAINAGE STRUCTURES

J.C. MCWHORTER, Mississippi St. University, School of Agriculture, *State College, Mississippi* 39762

This study has been undertaken to determine the interrelationship of gradient, soil type, discharge, and vegetative cover as adapted to drainage within highway right-of-ways, to establish more scientific criteria for dealing with roadside drainage structures.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Mississippi State Government

2.0682, FOREST SITE AMELIORATION IN THE COASTAL FLATWOODS OF MISSISSIPPI - ECONOMIC AND BIOLOGICAL CONSIDERATIONS

W.F. MILLER, Mississippi St. University, Graduate School, *State College, Mississippi* 39762

Based on results obtained from exploratory work supported by the Water Resources Institute, a study of the influence of water table regulation on growth rate and wood properties of slash pine will be initiated. Water table levels will be controlled by a system of ditches and gates so that soil moisture levels will be maintained between tensions of 1/10 and 4 bars. Wood properties to be examined at the termination of the study are fiber length, specific gravity, and alpha cellulose content; periodic height and diameter growth measurements will also be obtained.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Mississippi State University

2.0683, INTERRELATION OF MOISTURE REGIME & NUTRIENT LEVELS OF SELECTED MISSISSIPPI SOILS & THEIR RELATION TO THE SITE INDEX OF LOBLOLLY PINE

W.F. MILLER, Mississippi St. University, Agricultural Experiment Sta. , *State College, Mississippi* 39762

The objective of the study are to establish a valid expression of moisture regime for the various site situations encountered in forest-tree productivity studies, to evaluate the interrelation of moisture regime and nutrient levels and to establish a relationship between moisture regime, nutrient level and site index of loblolly pine.

The study is designed to evaluate the factors of site that are most prominent in the determination of moisture regime. Loblolly pine is used as the indicator species and the soil variables are limited by sampling only on members of the Ruston and Norfolk catenas throughout their range of occurrence in Mississippi. Both bulk soil samples and undisturbed samples are collected from horizons in the profile of each plot. Major emphasis is placed on the differentiation of physical soil properties by means of comparisons of desorption curves constructed for each plot from the undistrubed soil samples. Tension measurements are made at 60 cm. 1/l0, 1/3, 2/3, 1/4, and 15 atmospheres. Also to be evaluated are climatic and topographic variables. Foliar nutrient studies will be made as soon as a supplementary study clearly indicates the proper time of year for sampling.

SUPPORTED BY Mississipi State Government

2.0684, FACTORS INFLUENCING PLANT TRANSPIRATION IN THE SOUTH

D.L. MYHRE, Mississippi St. University, Agricultural Experiment Sta. , *State College, Mississippi* 39762

Object: To determine (1) the effects of quantity and quality of radiant energy, humidity, ambient temperature, and CO2 concentration on transpiration, stomatal behavior growth and apparent photosynthesis, (2) possible pathways of starch and sugar synthesis in guard cells and the effect on transpiration, (3) the soil moisture extraction pattern and use rate of crops in the field.

Plan of Work: Research will be conducted in the growth room where close controls of ambient temperature, humidity, CO2, soil moisture tension and light intensity are possible. Radiant energy equivalent to full sunlight can be attained. The relation of these factors to plant transpiration will be studied. Physiological studies of starch and sugar accumulation in guard cells will be stressed. Parallel studies will be made of the moisture extraction patterns and use rates of a number of crops under varying soil management systems.

SUPPORTED BY U.S. Dept. of Agriculture

2.0685, CHANGES IN NATURAL CHANNELS RESULTING FROM CONTROL DEVICES IN THE UPPER REACHES OF THE BASINS

A. SHINDALA, Mississippi St. University, School of Engineering, *State College, Mississippi* 39762

The intensity of man's activities in altering the character of small drainage basins may have serious and unforeseen effects upon the main stream. Such activities as the construction of retention reservoirs and channel changes must certainly affect the flow and the channel of the main stream. In striving for benefits in the upstream regions, the possibility of undesirable effects on the main stream may have been overlooked.

This study is designed to provide information on the effects of rather intense activities aimed at control of flow and sediment in some of the streams which flow from the escarpment into the Delta region of Mississippi. However, the results of the study will be of general value.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Mississippi State University

2.0686, COMMITTEE ON CHANNEL STABILIZATION

J.H. DOUMA, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objectives of the Committee, with respect to channel stabilization of alluvial rivers, are: (a) to review and evaluate pertinent information and disseminate the results thereof; (b) to determine the need for, recommend, and have advisory technical review responsibility for research; (c) to determine basic principles and design criteria; (d) to provide, at the request of field offices, advice on design and operational problems. Three meetings of the Committee on Channel Stabilization will be held during the year. At each meeting, one or more channel stabilization problems of major concern to the Corps of Engineers will be considered by the Committee. In addition, the Committee will exercise technical supervision over ES 841, Water Temperature Effects on Bed Forms; and will develop and recommend additional research needed in connection with alluvial river channel stabilization. The Committee will render such consultation and advice as may be requested on specific problems referred to it by offices of the Corps of Engineers. Data and information obtained or developed by the Committee which are considered pertinent to problems in alluvial river channel stabilization will be distributed to all interested agencies through Committee reports and technical papers.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0687, SALINITY INTRUSION AND RELATED PHENOMENA

H.B. SIMMONS, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to determine, for conditions of open channels subject to salt-water intrusion and tidal oscillations from the sea, the factors which control the extent of salinity intrusion, the degree of vertical mixing of salt and fresh water, the magnitudes and durations of current velocities at all depths, and the movement and deposition of sediments as influenced by density effects.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0688, TIDAL FLOWS IN RIVERS AND HARBORS

J.B. TIFFANY, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*
SCHULTZ

The committee known as the Committee on Tidal Hydraulic has been established consisting of civilian employees in various Corps of Engineers Division Offices, District offices, and laboratories who are familiar with tidal theories and tidal problems. The objectives of the Committee are to recommend programs of study, investigation, and research designed to provide the knowledge necessary to arrive at adequate solutions for the engineering problems associated with tidal phenomena, and to render such consultations and advice on specific problems in tidal waterways as may be requested by various offices of the Corps of Engineers.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0689, GENERAL COASTAL INLET STUDIES

J.B. TIFFANY, U.S Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this research project is to develop means for computing discharge and velocity distribution through tidal inlets leading to determination of tidal prisms and water surface elevations in inner bay systems; and to determine the factors involved in both inner and outer bar formation, the shoaling of inlet channels, and the stability of inlet shape and location. The following four facilities are being used to conduct necessary investigations: 1. Facility A. This is a facility in which inlets of various shapes can be modeled to a relatively large scale, and tests conducted therein under varying tidal conditions to establish discharge coefficients, flow patterns, and other factors required to compute discharges over the range of head differentials. 2. Facility B. This facility consists of an 'ocean' in which tides of various amplitudes and periods could be generated, a lagoon which could be varied in areas and shapes, and a connecting section between the two in which inlets of various shape could be modeled to a small scale by standard fixed-bed model techniques. 3. Facility C. This facility consists of a movable-bed model ocean, equipped with appurtenances for reproducing tides, waves, littoral currents, and other significant forces; a fixed-bed lagoon which could be varied in area and shape; and provisions for connecting the two by means of a movable-bed inlet section in which inlets of various shape could be modeled by movable-bed model techniques. 4. Facility D. An existing 350-ft by 175-ft basin now in existence at the Coastal Engineering Research Center will be used to develop information on the distribution and quantity of along-shore littoral drift, as a function of wave height, wave length, and other significant factors.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0690, SHOALING PROCESSES

J.B. TIFFANY, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*
SCHULTZ

The scope and objectives of this engineering study are as follows: (a) To determine the basi laws involved in the movement and disposition of muddy sediments; (b) to determine the effects of repetitive scour and deposition on sedimentation; (c) to develop techniques for radioisotope tracing of sediment movement and deposition; (d) to develop an in-place turbidity meter; (e) to determine the effects of stabilization of deposits on shoaling; (f) to determine the effects of flocculation on shoaling; (g) correlation of prototype data to determine the similarity, or lack thereof, of shoaling processes among estuaries or groups of estuaries; (h) classification of sediments which form shoals in estuaries or other tidal waterways improved for navigation; (i) to determine the facts which affect hydraulic and shoaling conditions in navigation slips and tributary channels which are improved for navigation; (j) to standardize sediment and soil sampling techniques in tidal waterways and to determine suitable methods for the packaging and transportation of samples; (k) to develop reliable methods for the predicting tides and currents in tidal waterways. Field investigations and laboratory studies are presently being conducted under the auspices of the Committee on Tidal Hydraulics to accomplish many of the objectives listed above. The lack of adequate space on this form prohibits discussion of each individual investigation under this project.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0691, ENERGY AND WATER BALANCE

G.S. COX, Univ. of Missouri, Agricultural Experiment Sta. , *Columbia, Missouri* 65202

Objectives - A. To determine energy and water fluxes through soil plant interfaces of certain forest and range sites. B. To utilize the heat balance of the plant community to determine rates of evapo- transpiration from growing canopies of forest and adjacent grass openings, and to compare this with the evapotranspiration determined by the water balance method.

Description of Work - Plots will be established in a well-stocked hardwood forest stand and an adjacent grass opening. Radiation will be measured by net radiometers. Energy transfer to and from the soil will be determined by thermopiles. Total air movement will be measured. Soil moisture measurements will be taken with a neutron meter.

The evapotranspiration from each area will be determined from the meteorological data and by the water balance method.

SUPPORTED BY U.S. Dept. of Agriculture

2.0692, RATE OF EVAPOTRANSPIRATION

W.L. DECKER, Univ. of Missouri, School of Agriculture, *Columbia, Missouri* 65202

Investigations into the manner in which meteorological elements control agricultural drought by the movement of water from the earth to the atmosphere under various conditions. Specifically, the objective is to conduct studies on the energy budget of crops under Missouri's environmental conditions. This includes the measurement of factors such as net radiation, air temperature, atmospheric humidity, air movement and precipitation, th correlation of these observations with the response of crops insofar as yield and water use are concerned; and the study of the effect of environment on the radiation balance between the atmosphere and cropped surfaces.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.0693, INFLUENCE OF ENERGY BUDGET ON AGRICULTURAL PRODUCTION

W.L. DECKER, Univ. of Missouri, Agricultural Experiment Sta. , *Columbia, Missouri* 65202

Objective: To measure the water used by agricultural crops and to relate the energy budget of the surface to water use by plants.

Procedure: Measurements of the evapotranspiration for agricultural crops in Missouri will be made. These measurements will be related to concurrent environmental factors including radiational exchanges, evaporative demands of the air mass and soil heat flux. Attempts will be made to modify the environmental conditions for the reduction of evapotranspiration.

SUPPORTED BY U.S. Dept. of Agriculture
Missouri State Government

2.0694, RAINFALL OVER MISSOURI

W.L. DECKER, Univ. of Missouri, Agricultural Experiment Sta. , *Columbia, Missouri* 65202

Objectives: A. To obtain precipitation observations from established stations and reduce the data. B. To correlate the rainfall occurrences with natural geographic features. C. To supply required data for the analysis of the cloud seeding experiment of Project Whitetop.

Rainfall data will be taken from recording rain gages in areas over Missouri. The intensity and amount of precipitation will be correlated with geographic features of the area.

SUPPORTED BY U.S. Dept. of Agriculture
Missouri State Government

2.0695, THE USE OF WATER IN THE PRODUCTION OF HORTICULTURE CROPS

A.D. HIBBARD, Univ. of Missouri, Agricultural Experiment Sta. , *Columbia, Missouri* 65202

Objectives: 1. Utilization of the reserve moisture supply. 2. Cumulative effect of recurring moisture deficiency. 3. Effect of moisture stress on product quality. 4. Soil management and moisture supply.

The available moisture conditions throughout the rooting zone of selected horticulture crops will be continuously monitored with suitably placed moisture sensing units. Controlled conditions will be obtained through irrigation to maintain the desired level of available moisture. Stress conditions will be imposed by the protection of the soil area above the root zone from precipitation. Rate, zone and extent of soil moisture depletion will be measured and the apparent consumptive use rate established. The competition for moisture between plants of the same crop and associated plants will be determined. The effects of moisture stress with reference to time of season and duration on plant response and product quality factors will be measured.

SUPPORTED BY U.S. Dept. of Agriculture
Missouri State Government

2.0696, NON-EQUILIBRIUN TRANSPORT OF SUSPENDED SEDIMENT

C.W. LENAU, Univ. of Missouri, School of Engineering, *Columbia, Missouri* 65202

It is proposed to investigate the non-equilibrium transport of suspended sediment in natural channels. The major intent is to determine the distribution of suspended sediment downstream from a section where the water is initially free of sediment.

The approach will be to view the movement of the suspended sediment as a concentration-diffusion process and to solve the conservation of mass equation with the appropriate boundary conditions. No experimental verification is proposed.

The solution will be useful to determine the channel length required to establish equilibrium in the bed load for laboratory experiments which use movable-bed flumes.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Missouri

2.0697, STAND TREATMENT

J.M. NICHOLS, Univ. of Missouri, Agricultural Experiment Sta., *Columbia, Missouri* 65202

Determine the effect of cutting methods (as they influence stand stocking and structure) and semi-controlled periodic flooding on the seed production and regeneration of bottomland hardwood species.

DESCRIPTION OF WORK - The study will consist of 36 one-half-acre plots. Of these, 18 will be on flooded areas and 18 on areas not flooded. Three degrees of stocking (low, medium, heavy) will be tested, plus two types of stand structure (small and large trees). Periodic fall collections will be made from 900 seed traps. Data analysis will include effects of the variables of water table manipulation on mast production.

SUPPORTED BY U.S. Dept. of Agriculture
Missouri State Government

2.0698, THE RELATIONSHIP BETWEEN ADSORPTION AND PERMEABILITY

R.A. PRIMROSE, Univ. of Missouri, School of Engineering, *Columbia, Missouri* 65202

This investigation proposes to study the inter-relationship between permeability and adsorption by making plugs formed by compressing powdered barrier material such as silica, polystyrene, cellulose acetate, and silicone rubber, and measuring the amount of permeation and the amount of adsorption of these plugs toward various gaseous materials. The initial mixture is planned to be carbon dioxide and propene because of their equal molecular weight, thus any observed differences in behavior will be caused by some difference in attraction. Other barrier materials and other gaseous systems will undoubtedly be investigated in an effort to define the inter-relationship between adsorption and permeability.

SUPPORTED BY U.S. National Science Foundation

2.0699, THICKNESS OF SOIL SOLUM AS A PARAMETER OF PLANT-AVAILABLE WATER STORAGE CAPACITY IN SOILS UNDERLAIN BY CARBONATE ROCKS

C.L. SCRIVNER, Univ. of Missouri, School of Agriculture, *Columbia, Missouri* 65202

This investigation will develop techniques for use of the seismograph in limestone-derived soil areas. The soils have variable contents of chert and the soil depth to carbonate rock is variable over short horizontal distances. The seismic determination of depth to carbonate rock may be complex because of the stated variations. However, the measurement is needed for determination of the volume of soil that can perform the functions of intercepting rainfall, retaining that water and then subsequently releasing it to growing plant canopies. The volume of soil will be used to calculate volumes of plant-available water storage.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Missouri

2.0700, SEASONAL SHALLOW STORAGE AND DEEP SEEPAGE COMPONENTS FOR THE HYDROLOGIC BUDGET OF A SMALL FORESTED OZARK WATERSHED

C.D. SETTERGREN, Univ. of Missouri, Graduate School, *Columbia, Missouri* 65202

The proposed research is directed at ascertaining the magnitude and direction of water movement and fluctuations in storage in the soil and unconsolidated geologic residuum above bedrock in response to seasonal differences in precipitation supply and evapotranspiration demand on a small forested watershed in the Ozarks.

The following investigations will be carried out on a gaged, fully-instrumented watershed: 1. An initial geophysical inventory will be made with portable seismological equipment to determine the total residuum storage characteristics. 2. A network of neutron soil moisture and density sampling tubes will be installed to inventory periodic flucturations in water movement in the soil and residuum. 3. Seasonal changes in moisture at varying depths will be correlated with precipitation, runoff, and estimated evapotranspiration.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Missouri

2.0701, MISSOURI SPRINGFLOW CHARACTERISTICS

A. HOMYK, U.S. Dept. of Interior, Geological Survey, *Rolla, Missouri*

This research is part of the program of water resources investigations conducted by the U.S. Geol. Survey in cooperation with the State of Missouri.

Purpose - To determine hydrologic characteristics of principal springs in Missouri, their water-supply potential and relations to streamflow and aquifer systems.

Methods - Continuous records will be collected at selected springs that are representative of various geologic and hydrologic environments. Periodic measurements will be made of additional springs and correlations will be made with continuous record network for determination of long-term spring behavior. Relationships between spring discharge and aquifers will be studied, as will relationships between spring discharge and streamflow. Changes in chemical quality of spring water and geology of spring areas will be studied and correlation of spring discharge with topography and sink hole and cave development will be made.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Missouri State Government

2.0702, HYDROLOGIC AND PHOTOGEOLOGIC DETERMINATION OF RAINFALL, RUNOFF, AND GROUNDWATER RELATIONSHIPS IN A DOLOMITE AREA

V.A. GEVECKER, Univ. of Missouri, Water Resources Research Ctr., *Rolla, Missouri* 65401

The objective of this interdisciplinary investigation is to develop procedures for quantitative evaluation of relationships between rainfall, runoff, and groundwater in a dolomite area. The study is to be conducted on an 18 square mile area which has a 12-gage raingage network and adequate stream gaging facilities. Two or more years of records are available. Collection of data will be continued during the period of investigation.

The planned objectives are: (a) to analyze existing daily rainfall records to determine intensity, duration, and distribution of individual storms and total amounts of precipitation; (b) to determine effects of local physiography on distribution of rainfall and compare magnitude and frequency of storms to those reported by U.S. Weather Bureau network; (c) to determine the amount and predictability of evaporation from the project area; (d) to analyze existing streamflow records and compare these with various estimation methods; (e) to apply aerial photo interpretation methods to identify characteristics which affect runoff and groundwater; (f) to measure infiltration capacities of area dominant soils; and (g) to evaluate the magnitude of evaporation and other losses from the area.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Missouri

2.0703, SPATIAL BEHAVIOR OF ROUGHNESS IN LABORATORY WATERSHED, PHASE II

T.E. HARBAUGH, Univ. of Missouri, Water Resources Research Ctr., *Rolla, Missouri* 65401

A study is proposed to investigate the variations in flow resistance, i.e., roughness, resulting from differing raindrop size and raindrop impact velocities, of the flow surface of a laboratory test surface.

It is the purpose of this project to (a) vary raindrop impact velocities from 0 to 20 feet per second, and (b) use three different size simulated raindrops in various simulated rainfall intensity experiments conducted on a 2' by 10' adjustable slope testing surface. It is anticipated that results from this investigation will present a basic understanding of the role which roughness plays in watershed and overland flow modeling attempts.

Application of modeling techniques to watershed studies, is an essential supporting study to applied problems in Water Resources. Use of a physical laboratory watershed model would be a more versatile approach if the response of the model could be changed in a predictable manner. It is anticipated that this study, Phase II, will aid materially in an improved understanding of the behavior of flow resistance in watershed models subjected to simulated rainfall.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Missouri

2.0704, DRILLED WELL INVESTIGATION OF DOLOMITE AQUIFER CHARACTERISTICS

J.C. MAXWELL, Univ. of Missouri, Water Resources Research Ctr., *Rolla, Missouri* 65401

Acquifers of cherty dolomite and limestone, of Paleozoic age, are the principal source of groundwater throughout at least 30 percent of the area of the central and mid-western United States. Although approximate depth to water and present yield are known for many individual wells, there is no quantitative information available for estimating transmissibility, storage capacity, or potential reservoir capability of the dolomite rocks.

This investigation consists of drilling three sets each of three to five test and observation wells. The wells will be drilled to the first waterbearing zone. Then measurements will be made of piezometric levels, aquifer transmissibility, storage capacity, undisturbed gradient, and flow rates. Upon completion of each set of tests, and within budgetary and time limits, the wells will be drilled to successively deeper waterbearing zones and retested. The area of investigation is Crawford, Dent and Phelps Counties, Missouri, or roughly a southeast quadrant from the City of Rolla.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Missouri
Missouri State Government

2.0705, HYDROLOGY OF HUNGRY HORSE RESERVOIR, MONTANA

M.I. RORABAUGH, U.S. Dept. of Interior, Water Resources Division, *Saint Louis, Missouri*

Hungry Horse Reservoir, one of the major Federal multipurpose components of the water development program for the Columbia River, is used primarily for at site and downstream power generation and flood control. Since its completion in 1951, operation has revealed the need for determining more accurately the volume of water, including bank storage, available for power production and for developing an operational forecasting procedure for the lowflow season.

Objectives are to define hydrologic parameters related to reservoir management and power production; to more accurately determine volume of water available at Hungry Horse Reservoir; and to improve forecasting procedures.

It is proposed to collect additional data on surface inflow and outflow, subsurface inflow and evaporation from reservoir surface. This would include the establishment of: a permanent inflow station on South Fork Flathead River just above reservoir flow line; reestablishing temporary gages on two tributaries, establishing temporary gages on four additional tributaries; making miscellaneous measurements at about 20 additional locations; and additional measurements on the main outflow gage below the dam. Evaporation from the reservoir surface would be determined by an energy budget procedure.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0706, SOLUTE AND WATER TRANSPORT ACROSS BIOLOGIC MEMBRANES

N.S. BRICKER, Washington University, School of Medicine, *Saint Louis, Missouri* 63130

We propose to continue studies relating to the nature of salt and water movements across membranes of living cells. Specific interest will be directed towards the biophysical mechanisms and the energetics of active transport across polar epithelial cells that are specialized in transcellular salt (and water) movements. Studies also will be performed on transport by red blood cells of the squalus acanthias (dogfish shark). The internal ionic environment of cells of this marine species is unique to elasmobranchs and special problems in maintaining intracellular composition are of considerable interest.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

2.0707, COMPUTER SIMULATION OF THE HYDROLOGIC SYSTEM OF A MOUNTAIN WATERSHED

D.E. DUNN, Montana State University, Graduate School, *Bozeman, Montana* 59715

The proposed work is an attempt to simulate the hydrologic system of a small mountain watershed using digital computer techniques. Both surface and subsurface portions of the system will be included in the synthesis. Parameters in the model will be related to physical characteristics of the system. Initial estimates of the parameters will be based on field observation, and then the parameter values will be improved by trial and error matching of computer and prototype stream-flow rate outputs.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Montana State University

2.0708, INFLUENCE OF SPECIFIC IONS ON GROWTH PATTERN OF PLANTS

E.O. SKOGLEY, Montana State University, Agricultural Experiment Sta., *Bozeman, Montana* 59715

1. To study the influence of nutrient or salt ions on moisture efficiency.

2. To investigate the relative influence of specific ions on the growth pattern and water utilization characteristics of plants.

3. To determine the influence of nutrient or salt ions on physiological and/or anatomical responses related to growth and transpiration.

Description of Work: Selected crop plants will be grown in synthetic ion-exchange media prepared to support plant growth. A specific ion can be varied in amount in this medium without the concurrent variation of other ions in the system. Growth and development of the plants will be measured and the water use by transpiration under various conditions will be monitored. The relative turgidity of the plant leaf tissue will be used as an index to the water condition within the plant. Plant composition data will be gathered as required. Root permeability measurements and physiological studies may be used to help elucidate the mechanisms involved.

SUPPORTED BY U.S. Dept. of Agriculture
Montana State Government

2.0709, MOUNTAIN PRECIPITATION AND DISTRIBUTION

A. SUPER, Montana State University, Graduate School, *Bozeman, Montana* 59715

This research project has as its major objective the acquisition of a continuum of information about Montana alpine snowpacks from autumn origin through winter accumulation to spring wastage. The snowpack is of basic importance in all considerations of water supply. There is also a growing importance in relation to recreational use and safety.

Instrumentation has been installed in the Bridger Research Area. Part of this instrumentation is included in an automated data collection system from which data are transmitted by telemetry to the Computer Center on the Montana State University campus. The resistograph, invented by Dr. Charles C. Bradley of Montana State University, is an important scientific instrument in this research.

Investigations of the accumulation, metamorphism, and wastage of mountain snowpacks will be continued and expanded. Particular attention is being given to the climate near the ground as determined by such descriptive parameters of terrain as slope inclination, elevation and slope orientation. The transfers of radiation and latent and sensible head through the snow-air interface and the factors contributing to snow settlement and snow creep are also being studied.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Montana State University

2.0710, DRAINAGE CORRELATION RESEARCH PROJECT

T.T. WILLIAMS, Montana State University, School of Engineering, *Bozeman, Montana* 59715

There is a shortage of a reliable information regarding flood flow frequencies and magnitudes from small (1 to 100 sq miles) drainage areas in Montana. This study is intended to augment the 'Small-Area Peak-Flow Program' being conducted in Montana by the U. S. Geological Survey, under which peak flow data are being collected by crest-stage gages at over 200 watersheds.

The present study is two-phase: A. Precipitation and other climatological data are being analyzed to determine whether a correlation exists between these data and the crest-stage peak flow data being gathered by the USGS. B. An intensive field study of four watersheds is in progress, with data being collected for a six-year period, on a continuous basis. Precipitation and other climatological data, together with stream flow data, are being obtained and will be analyzed by a variety of hydrologic techniques, including the unit hydrograph method.

SUPPORTED BY Montana State Government

2.0711, INVENTORY & EVALUATION OF THE GROUND-WATER RESOURCES OF SUMMIT VALLEY & UPPER SILVER BOW CREEK DRAINAGE AREA

M.K. BOTZ, Montana Coll. of Min. Science, Graduate School, *Butte, Montana* 59701

The objective of this research project is to develop information regarding water problems of the Butte Metropolitan area. Residential and industrial growth around the perimeter of the city is placing additional water use pressures on individual wells and group well systems. These uncoordinated developments involve pollution problems including the effect of industrial waste. The research on this project is designed to produce a complete inventory of geology, hydrology and water quality of the area.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Montana College of Mineral Science & Tech.

2.0712, TRANSPIRATION RATES OF CONIFERS

M. BEHAN, Univ. of Montana, Graduate School, *Missoula, Montana* 59801

The objective of this research project is to assemble basic data relating to the interaction of various environmental factors as they affect the transpiration rates of Northern Rocky Mountain Conifers. Much of the work during 1965-66 involved the establishment of a laboratory facility and a test area in the Lubrecht Experimental Forest of the University of Montana as a site for field studies.

The work during the 1966-67 fiscal year will (1) construct sampling cuvettes and standardize operation of infra-red gas analyzer for determination of transpiration rates under controlled conditions and in the field, and (2) determine effect of radiation, temperature and humidity on the transpiration rates of western larch, lodgepole pine, ponderosa pine, and Englemann spruce.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Montana

2.0713, GRAVITY INVESTIGATION OF WATER-BEARING STRATA IN SWAN VALLEY, MONTANA

G.W. CROSBY, Univ. of Montana, Graduate School, *Missoula, Montana* 59801

Purposes of the gravity investigation in the Swan Valley, northwestern Montana, are to determine the thickness and configuration of Tertiary and Quaternary water-bearing strata, and to infer their approximate water-bearing capacity, i.e., porosity, from gravitational measurements of bulk density.

Swan Valley is one of many intermontane valleys in western Montana created by Tertiary block faulting. Displacement on the faults, and thickness of valley fill, is generally measured in thousands of feet. Previous gravity investigations in the Basin and Range Province indicate density of the valley fill is about 2.2 grams per cubic centimeter. This density value is in contrast to a value of approximately 2.67 for the Belt rocks exposed in the Swan and Mission Ranges bounding the valley on the east and west sides respectively. Variation in gravity as a result of this large density contrast should readily express position of boundary faults and permit a model computation of the configuration of the valley sediments. Gravity base stations, looped with the absolute gravity base at Missoula airport, have already been established in the valley. Samples of Belt rocks have been collected for laboratory density measurements. Approximately 400 gravity stations will be occupied in the Swan Valley and tied to the base stations, mostly during the 1967 field season. Field data will be processed by computer and mathematical models computed to determine best fit with observed gravity. Results are to be published in a professional journal.

Ground water resources in the Swan Valley will be utilized by industrial, agricultural and recreational facilities in the valley, and, as the need arises, water may be diverted to the more industrialized Flathead and Missoula Valleys which have natural drainages from Swan Valley.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Montana

2.0714, HYDROLOGIC ANALYSIS OF THE NORTH FORK OF ELK CREEK

R. KONIZESKI, Univ. of Montana, Graduate School, *Missoula, Montana* 59801

The first year of work on this research project emphasized the development of a coordinated outdoor laboratory for water resources research on the Lubrecht Experimental Forest of the University of Montana. Metering and measuring devices were installed and measurements were started.

The 1966-67 fiscal year will involve the installation of observation wells driven to bedrock across the mouth of the North Fork of Elk Creek. A study will be made of ground-water fluctuations and velocities in an attempt to measure ground-water discharge from the North Fork of Elk Creek Watershed.

A long-run objective is to automate the instrumentation system on the Lubrecht Experimental Forest on the basis of experience and research results on the Bridger Research Area at Montana State University.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Montana

2.0715, WATER DATING TECHNIQUES AS APPLIED TO THE MISSOULA GROUND-WATER RESERVOIR, MONT.

R.L. KONIZESKI, Univ. of Montana, Graduate School, *Missoula, Montana* 59801

The Missoula valley is a structured trough partly filled to a depth of about 3,500 feet with unconsolidated cenozoic sediments. In these sediments is stored an estimated 30 million acre feet of potable water. The potential offtake is limited by recharge to the deep aquifers in the sediments. In order to estimate the maximum potential development of the deep aquifers it is necessary to determine the age relationships of the included water. A program of radio carbon dating of water samples, in combination with existing geohydrological data, will supply information relative to the rate of recharge and movement of ground water within the deep aquifers.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Montana

2.0716, THE DETERMINATION OF PLANT ROOTING AND WATER ABSORPTION PATTERNS WITH RADIOIODINE

T.J. NIMLOS, Univ. of Montana, Graduate School, *Missoula, Montana* 59801

Rooting patterns and water absorption by understory plants common to the forests of the Northern Rocky Mountains will be determined by injecting radioactive iodine (I-131) into the soil at various depths and measuring the presence of the isotope in the above ground portion of the plant. This study is a continuation of work already in progress and will be conducted on sites at which other environmental and biotic data are being collected. The site to be investigated in the first year is stone-free, which will permit perfecting the techniques used in 1965. The techniques developed at this site will be applied to a stony soil during the second year of the investigation.

These data will be related to soil moisture depletion curves as determined by gravimetric analysis. Rooting patterns have been studied at one site and the patterns obtained on other sites will be compared to the data from the first site.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Montana

2.0717, THE AQUATIC PLANT RESOURCES OF WESTERN MONTANA

S.J. PREECE, Univ. of Montana, Graduate School, *Missoula, Montana* 59801

NO SUMMARY HAS BEEN PROVIDED TO THE SCIENCE INFORMATION EXCHANGE

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Montana

2.0718, A GEOLOGIC, GEOCHEMICAL AND MICROBIOLOGIC STUDY OF FLATHEAD LAKE

A. SILVERMAN, Univ. of Montana, Graduate School, *Missoula, Montana* 59801

The objective of this research project is to construct a topographic map of the Flathead Lake bottom and to make a physical chemical and microbiological analysis of the sediment on the Lake bottom.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Montana

2.0719, NATURAL WATER SYSTEMS IN WESTERN MONTANA

R.A. SOLBERG, Univ. of Montana, Biological Research Station, *Missoula, Montana* 59801

This research project is centered at the Biological Research Station of the University of Montana on Flathead Lake and will study the physical and biological aspects of (1) phyloplankton and Zooplankton of Flathead Lake, (2) plankton of the Swan and Flathead Rivers above the Lake and of Flathead River below the lake, (3) Aquatic entomological aspects of the Flathead Basin area, especially of the order of Pleciptera, and (4) phycology of the Lake, especially diatomes and desmids.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Montana

2.0720, LIMNOLOGY OF NEBRASKA

D.B. MCCARRAHER, Hastings College, Undergraduate School, *Hastings, Nebraska* 68901

Specific Objectives: 1. Development of a physio-chemical index for surface waters of Nebraska. 2. A general assessment of biological production in 14 natural lakes and impoundments. 3. The limnology of the alkaline lakes of Nebraska. 4. Windmill tank ecology. 5. Limnology of the Northern Great Plains. 6. Publication of: Occasional Papers on Nebraska Limnology. 7. Phyliopod shrimp ecology. 8. Preparation of an analogous set of water criteria to provide an insight into applicable physical, chemical, and biological conditions necessary for the protection and development of Nebraska's aquatic resources.

SUPPORTED BY Nebraska State Government
Hastings College

2.0721, ENERGY SOURCES FOR EVAPOTRANSPIRATION IN THE PLAINS REGION

N.J. ROSENBERG, State Water Resour. Res. Inst. , *Lincoln, Nebraska*

Two weighing lysimeters of the type described by Van Bavel and Myers (Agr. Eng. 43:580-583, 586-588, 1962) will be constructed and filled with soil to a normal bulk density. The lysimeters will be placed within a field uniformly leveled for frequent and precise application of irrigation water. The field will be large enough to insure adequate fetch for representative aerodynamic conditions in the area of the lysimeters.

Meteorological parameters as wind movement, total hemispherical and net radiation, soil thermal flux, air and soil temperatures and atmospheric humidity will be monitored during periods of evaporative and transpiration loss of water from the lysimeters. The relative contribution of radiative and advected energy to the evapotranspirational demand created will be studied. Relationships to predict evaporation and transpiration from well watered soil based upon meteorological conditions will be developed.

Means of modifying evapotranspirational flux will be tested. These will include wind shelter, anti-transpirant and evaporation suppressant chemicals and plastic and vegetative mulches.

The work will be performed at the University of Nebraska Field Laboratory at Mead, Nebraska.

The project was first funded in Fiscal 1965. Equipment will be operational by the end of Fiscal 1966. It is anticipated that the first studies described above will be completed by the end of Fiscal 1969 but that the facilities established will continue in use beyond that time.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Nebraska

2.0722, INTERNAL WATER STATUS OF PLANTS

E.J. KINBACHER, Univ. of Nebraska, School of Agriculture, *Lincoln, Nebraska* 68508

Instrumentation available to monitor the status of internal plant water leaves much to be desired. Improved instrumentation is of interest in order that the influence of various degrees of moisture stress on rate levels of key physiologic processes might be studied more adequately. Currently a project is underway to adapt microwave refractometry to the measurement of internal plant water status. Water vapor pressure in air equilibrated with internal plant water is of interest. Dielectric constant measurements of air in equilibration chambers are being attempted. As instrument construction is completed this project will involve a comparison of the new method with other methods for characterizing internal plant water status such as the Beta guaging, relative turgidity procedures, electrical conductivity, and some of the old and new diffusion pressure deficit procedures.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Nebraska
U.S. Dept. of Agriculture

2.0723, DETACHABILITY OF SOIL PARTICLES

A.P. MAZURAK, Univ. of Nebraska, Agricultural Experiment Sta., *Lincoln, Nebraska* 68508

Objectives: 1. To determine the effect of raindrops on the detachability of soil particles in the principal soil groups in Nebraska. 2. To determine the physical and chemical properties of soil associated with detachability of soil particles. 3. To evaluate the effects of soil and land use management practices on detachability of soil particles.

Principal bench-mark soils in Nebraska will be studied. The range of soils selected for the study will be determined from the K-values (0.49 to 0.10) in the universal erosion equation. Soil surfaces will be exposed to simulated uniform raindrops in a 3-story rainshaft. The amount of soil detached in a 30-minute storm will be measured. Chemical and physical properties of soil associated with the detachment of soil particles will be measured and related to the K-values in the erosion equation.

Field studies will be related to the laboratory study. Five sampling periods of the field conditions during the year will be taken. Soil samples will represent disturbed and non-disturbed conditions. Effect of mulches and vegetative canopy on detachability of soil particles will be determined.

SUPPORTED BY U.S. Dept. of Agriculture
Nebraska State Government

2.0724, AGROCLIMATIC PARAMETERS

R.E. NEILD, Univ. of Nebraska, Agricultural Experiment Sta. , *Lincoln, Nebraska* 68508

Objectives: (1) To determine climatic adaptability and length of growing and harvest season for a series of vegetable crops in Nebraska. (2) To evaluate the effects of climatic events on yield and quality of vegetables within their respective growing seasions. (3) To define and apply probability estimates to the climate of Nebraska in terms of its current and future effects on agricultural operations.

Procedure: (1) Most favorable dates for planting and harvest will be determined by comparative climatology for those crops found to be adaptable to the region. (2) Yield, quality and phenological measurements of selected vegetables at different locations will be analyzed in relation to climate and season. (3) Climatological data will be processed electronically with particular attention to agroclimatic parameters and the growth season.

SUPPORTED BY U.S. Dept. of Agriculture
Nebraska State Government

2.0725, MEASURING EVAPOTRANSPIRATION AND PHOTOSYNTHESIS OVER SHORT PERIODS OF TIME IN THE FIELD

N.J. ROSENBERG, Univ. of Nebraska, School of Agriculture, *Lincoln, Nebraska* 68508

In a large field of alfalfa with essentially an undisturbed windfetch from all directions are located instruments for measuring radiation, wind, humidity, soil moisture, precipitation (and irrigation), and evapotranspiration from a precision lysimeter.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.0726, A LEGAL-ECONOMIC ANALYSIS OF ADMINISTRATIVE AND MARKET PROCEDURES USED IN THE TRANSFER OF WATER RIGHTS

C. YEUTTER, Univ. of Nebraska, School of Agriculture, *Lincoln, Nebraska* 68508

This study will analyze and evaluate, both from a legal and from an economic standpoint, the varying means by which water is now being allocated in the United States. Specific objectives include: 1) Determining the degree to which efficiency criteria are being applied by both courts and administrative agencies. 2) Determining the extent to which market forces are permitted and encouraged to function and the extent to which equi-marginal principles are evident in such markets. 3) Determining whether state statutes are impeding water development because of rigidities and inflexibility.

The investigation will: (a) Appraise the allocation of water in Nebraska in terms of conformance with an economic model to be devised. (b) Determine the effectiveness of water law administration in Nebraska and other selected states with dissimilar legal systems. (c) Develop methods and techniques for electronic retrieval of water law, state and federal.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Nebraska

2.0727, MAXIMUM PRODUCTION OF CROPS UNDER IRRIGATION IN WESTERN NEBRASKA

L. HARRIS, Univ. of Nebraska, Agricultural Experiment Sta. , *Mitchell, Nebraska*

Objectives: A study to determine maximum production of crops under irrigation in Western Nebraska.

Description: The maximum production and best judgement rotations were established on the level basins in Field K. Bulk soil samples were taken for chemical and other analyses. Undisturbed soil cores were taken for moisture release and determinations. Differential fertilizer and irrigation practices were initiated. Yields of crops were excellent except in some areas where soil compaction by construction machinery appears to have impeded root penetration. Installation of the underground irrigation pipeline was completed on July 10.

SUPPORTED BY Nebraska State Government

2.0728, WATER REQUIREMENTS OF MAJOR CROPS IN SOUTHERN NEVADA

R.K. PETERSEN, Univ. of Nevada, Agricultural Experiment Sta. , *Logandale, Nevada*

Objectives: 1. To determine peak and seasonal water use by the more important crops grown in Southern Nevada. These requirements will be obtained for crops grown during the cool season as well as for those grown in the hot season. 2. To compare above results with various empirical relationships between climate and water use (Thornthwaite, Penman, Blaney-Criddle, etc.). 3. To determine leaching requirements for keeping salt out of the root zone.

Description of work proposed: Plots containing some of the more important crops to Southern Nevada will be established and maintained under optimum soil moisture conditions, as well as under irrigation practices common to the area. Different methods will be used to obtain periodic soil moisture readings to determine peak and seasonal water use. Soil samples will also be taken periodically to determine any possible build-up in salts. If need arises, leaching requirements will be studied under different irrigation practices.

SUPPORTED BY U.S. Dept. of Agriculture
Nevada State Government

2.0729, MOVEMENT OF WATER AND AIR TO AND INTO PLANT ROOTS IN SOILS OF THE GREAT BASIN

W.F. SPENCER, U.S. Dept. of Agriculture, *Reno, Nevada*

Objective: To measure the oxygen diffusion rate and other physical and chemical properties of problem soils of the Great Basin and relate these factors to crop response. To devise physical and/or chemical treatments to improve soil physical condition, soil water movement, and crop yield.

Plan of Work: Continue development and testing of instrumentation for measuring oxygen diffusion rate in soils in the laboratory under a variety of moisture contents, salinity levels, and other variables, such as soil texture, and volume weight. Measure oxygen diffusion rate, soil water movement, and related physical and chemical properties in laboratory soil samples and field plots. Correlate results with crop response.

Cooperation: Agricultural Experiment Stations, SCS, U. S. Bureau of Reclamation, State Engineers, State Water Resources Agencies, and other irrigation, water management, or soil conservation district agencies.

SUPPORTED BY U.S. Dept. of Agriculture

2.0730, CLIMATE AND PHENOLOGICAL PATTERNS FOR AGRICULTURE IN THE WESTERN REGION

R.O. GIFFORD, Univ. of Nevada, Agricultural Experiment Sta. , *Reno, Nevada* 89507

Objectives: 1. To record and tabulate Nevada weather data on coded punch cards in a form available for research. 2. To describe the climatic patterns of Nevada by statistical analyses of long-term weather data.

Description of Work Proposed: A network of weather stations will be selected to represent the various climatic types in Nevada. In cooperation with the U. S. Weather Bureau, missing data will be interpolated. All data will be placed on standard Weather Bureau punch cards. Statistical analyses of the data will be made following the pattern established by the NC-26 Climate Project. Probability of precipitation and temperature extremes will be computed initially.

SUPPORTED BY U.S. Dept. of Agriculture
Nevada State Government

2.0731, NORTH SIERRA OROGRAPHIC, CONVECTIVE CLOUD STUDY - ATMOSPHERIC WATER RESOURCES PROGRAM

W.A. MORDY, Univ. of Nevada, Desert Research Institute, *Reno, Nevada* 89507

To make a study of the physics and dynamics of orographic and convective cloud systems of the Humboldt River and Lake Tahoe drainage basins of Nevada. Also, lee wave lenticular clouds of supercooled droplets are being studied. Precipitation from these clouds frequently does not occur naturally due, in part, to short transit time through the clouds. Using instrumented aircraft and radar, nuclei and drop spectors will be studied with and without seeding to test the modification of the precipitation processes.

Theoretical studies of cloud physics to actual weather modification research, and the development of instrumentation and data acquisition systems will be made. Special emphasis will be given to the development of a data acquisition system which will coordinate radars, instrumented aircraft, balloon probes and telemetered ground networks to provide real-time display of meteorological and hydrological data. Applied Research 100 percent.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0732, FACTORS RESTRICTING INFILTRATION RATES ON DECOMPOSED GRANITIC SOILS

R.J. MORRIS, Univ. of Nevada, Desert Research Institute, *Reno, Nevada* 89507

Accelerated runoff from the Sierra Nevada has produced erosion, flood and pollution problems. This study investigates the physical and chemical nature of changes in infiltration capacity that may result from combinations of organic hydrophobic substances, fire, and soil frost for sandy soils. Analytic procedures include controlled field and laboratory fires, infiltration tests, chemical analyses using spectrophotometric techniques, and physical analyses of soil properties.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Nevada

2.0733, EFFICIENT ESTABLISHMENT AND PRODUCTION OF FORAGE CROPS ON IRRIGATED LANDS

J. OLDHAM, Univ. of Nevada, Agricultural Experiment Sta. , *Reno, Nevada* 89507

Objectives: 1, to determine the effects of row spacing of legume- grass mixtures and fertility levels on ease of establishment, yield; botanical and chemical compositions of forages; 2, to compare methods of irrigation during establishment in relation to soil properties; 3, to evaluate methods of establishing winter annuals in Bermudagrass sod and achieving maximum yearly production of forage.

Procedure: Grasses and legumes will be seeded in a mixture, in alternate rows and with two rows of grass and one of legume. Fertilizer involving variables in P, K and N will be evaluated. Forage yield and botanical composition of all treatments will be determined. Consumptive use of water will be calculated from neutron probe and water application data.

A number of forage species seeded in a saline-sodic soil will be irrigated by flood and sprinkler irrigation during establishment. Records of amounts and dates of water application will be kept. Number of plants established and forage yields will be determined. Winter annual legumes and grasses will be seeded at different dates in Bermudagrass sod that has been mowed, mowed plus scarification, or mowed plus paraquat. Fertilizer variable will be included, yield and composition of the forage will be determined.

SUPPORTED BY U.S. Dept. of Agriculture
Nevada State Government

2.0734, DISSOLVED CONSTITUENTS OF NATURAL WATERS - CONTRIBUTIONS FROM MINERALIZED AREAS

J.V. SHARP, Univ. of Nevada, Water Resources Research Ctr. , *Reno, Nevada* 89507

Geologic terranes where ore metals and substances occur in abundance relative to usual occurrence are possible sources of unusually high concentrations of trace constituents and certain gross constituents in natural waters. These constituents may be harmful for human consumption or for agricultural or industrial use. Ground and surface waters will be sampled from selected mineralized areas and analyzed for gross and trace constituents. Spatial and temporal occurrence of dissolved constituents will be related to sources in mineralized rock, thermal waters, and mine and mill disposals. Transport of constituents will be interpreted in light of hydrodynamic and geochemical characteristics of flow systems. Results will be related to water uses in the areas investigated, particularly situations where deleterious constituents may be a limiting factor on water use. Information and generalizations will be extended to other mineralized localities in the western United States.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Nevada

2.0735, STATISTICAL TREATMENT OF HYDROGEOLOGIC DATA - PART II, WATER QUALITY ASPECTS

J.V. SHARP, Univ. of Nevada, Desert Research Institute, *Reno, Nevada* 89507

This research effort is directed toward development of improved methods for statistical treatment of time-and spatial series of water quality data.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Nevada

2.0736, CHEMICAL AND FLOW REGIMES OF GREAT BASIN SPRINGS

J.V. SHARP, Univ. of Nevada, Desert Research Institute, *Reno, Nevada* 89507

Spring flow is an important water resource in the Great Basin. Little systematic knowledge exists of the chemical and flow regimes of the springs. This investigation will document chemical and flow characteristics of selected springs and will attempt to relate these characteristics to geologic, hydrologic, geochemical and meteorological parameters of the environment.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Nevada

2.0737, THE WATER RELATIONS OF DESERT PLANTS

N.M. STARK, Univ. of Nevada, Desert Research Institute, *Reno, Nevada* 89507

The proposed research plan will complete work on the water relations of desert plants which is already in progress. The study is investigating the sources of water available to desert plants including soil moisture, and soil and atmospheric humidity. The influence of water available in the field is followed by comparing the changes in osmotic pressure, percent moisture, and relative turgidity of plant parts. Fluorescent dyes and tritiated water are being used to determine if water from various sources is able to enter the plant tissues. Water up-take is compared to water loss from transpiration which is correlated with seasonal changes in soil and air moisture, soil and air temperatures, and phenology. The study is projected to continue with monthly sampling for another year to develop a clearer understanding of plant responses at different times of the year. Three common warm desert species are being studied intensively.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Nevada

2.0738, AN ATMOSPHERIC ENERGY BUDGET STUDY

C.K. STIDD, Univ. of Nevada, Desert Research Institute, *Reno, Nevada* 89507

This research effort consists of developing daily energy budget for ground and atmosphere in the Great Basin for a two year period. Output from the study will be monthly averages of various forms of heat exchange and analysis of the role of heat exchange in individual storm situations.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Nevada

2.0739, PRECIPITATION AND RUNOFF DISTRIBUTIONS - ANALYSIS AND COMPARISONS

C.K. STIDD, Univ. of Nevada, Desert Research Institute, *Reno, Nevada* 89507

This project is designed to test a new plotting method for hydrologic data distributions, develop theoretical explanations for observed time-distributions of precipitation data and consequent distributions of stream-flow data, and improve methods for estimating hydrologic statistics from minimum amounts of observed data.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Nevada

2.0740, AN ANALYSIS OF THE VEGETATION AND SOIL CHARACTERISTICS OF RANGE WATERSHEDS IN NEVADA

P.T. TUELLER, Univ. of Nevada, School of Agriculture, *Reno, Nevada* 89507

Reconnaissance descriptions of the native plant communities have been completed on 12 range watersheds in Nevada. As part of an ecological resource inventory detailed vegetation descriptions have been completed on 4 of the 12 areas. Soil profile descriptions have also been completed at the vegetation plot locations. An additional 4 areas will be studied in the summer and fall of 1965. Vegetation data has been summarized and analyzed for 3 of the areas. Correlations of vegetative and cover characteristics of native plant communities will be made with important soil characteristics. These data will then be available for correlating with infiltration and runoff data as it is accumulated. Infiltration rates will be determined for the principle soil types starting in the fall of 1965. Work on 12 range watersheds in Nevada is to be completed by the fall of 1968. Runoff water production and precipitation data are being collected as parts of other cooperative studies and by technicians of the Bureau of Land Management.

SUPPORTED BY U.S. Dept. of Interior - Bu. Land Mgmt.

2.0741, CLIMATOLOGICAL MEASUREMENTS RELATED TO AGRICULTURE

G.L. BYERS, Univ. of New Hampshire, Agricultural Experiment Sta., *Durham, New Hampshire* 03824

OBJECTIVES: (1) To keep reliable records of temperature and precipitation and to forward these regularly to the U. S. Weather Bureau Office. (2) To keep other environmental records as deemed necessary for research projects that are being conducted on the campus and to make these records available to all parties interested in using the data.

DESCRIPTION OF WORK: Readings will be taken daily between the hours of 5:00 p.m. and 6:00 p.m. of maximum and minimum temperature for the previous 24 hours; temperature at the time of observation and total precipitation (in inches of water) for the previous 24 hours. Particular weather phenomena such as fog, mist, thunderstorms, etc., will be recorded. Daily continuous records of solar radiation - temperature, and atmospheric pressure will be kept. All records will be made available to interested persons.

SUPPORTED BY New Hampshire State Government

2.0742, BASE FLOW ANALYSIS OF SELECTED DRAINAGE BASINS.

F.R. HALL, Univ. of New Hampshire, Agricultural Experiment Sta., *Durham, New Hampshire* 03824

Objectives: 1. To investigate base flow from a few drainage basins in New Hampshire selected to cover a range in area and geographic location. 2. To derive and test equations that describe the base flow with reasonable accuracy and to assess the physical significance of the terms in the equations.

Description: Drought conditions in New Hampshire have shown the need for a better knowledge of stream flow during the summer months. This flow is commonly called base flow and comes mainly from ground water. One way to investigate the problem is to study the stream-flow records from selected small drainage basins. The records will be analyzed by graphical and other techniques, and equations will be derived to describe the amount and distribution with time of the base flow from the basins.

SUPPORTED BY U.S. Dept. of Agriculture
New Hampshire State Government

2.0743, CHEMICAL CHARACTER OF GROUND AND SURFACE WATERS IN RELATION TO SOIL WEATHERING PROCESSES

F.R. HALL, Univ. of New Hampshire, Agricultural Experiment Sta., *Durham, New Hampshire* 03824

Objectives: 1. To determine the chemical character of ground and surface waters with particular attention given to pH, iron, and silica. 2. To investigate the relationship of weathering processes in the soil including mineral cycling by the vegetation and transport of iron, organic matter and silica to the composition of the ground and surface waters.

Under objective 1, samples of water will be collected from the several parts of the system under study including segments of the soil profile, ground water, and surface water. These samples will be characterized chemically with particular attention being given to iron and silica.

Under objective 2, an attempt will be made to identify those organic compounds in the soil and in water which are most closely associated with the movement and deposition of iron. After such compounds have been identified, their mode of action in connection with the weathering of iron-bearing minerals and the movement of iron and silica to surface and ground waters will be studied in both the field and laboratory.

SUPPORTED BY New Hampshire State Government

2.0744, OCCURRENCE AND CHARACTERISTICS OF FRACTURES IN CRYSTALLINE ROCKS OF SOUTHEASTERN NEW HAMPSHIRE AND THEIR RELATIONSHIP TO THE YIELD OF DRIL

G.W. STEWART, Univ. of New Hampshire, Graduate School, *Durham, New Hampshire* 03824

The goal of this research is to map the fracture systems in the crystalline (igneous and metamorphic) rocks of southeastern New Hampshire and attempt to ascertain how the yield of the drilled water wells and the fracture systems are related.

The field work will consist of an examination of the available outcrops. A record of the fracture systems will be prepared as well as other related structural features in the outcrops. The field data will be plotted on base maps and local and regional syntheses will be made to aid in an evaluation of potential water supplies.

Southeastern New Hampshire is growing very rapidly and the domestic use of ground water has increased because the cities and towns have not been able to expand their water systems to all areas of development. Any techniques developed by this investigation might be useful not only to tjhis area but to other parts of New Hampshire underlain by crystalline rocks.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of New Hampshire

2.0745, HYDROLOGIC-MINERAL CYCLE INTERACTION IN SMALL UNDISTURBED AND MAN-MANIPULATED ECO-SYSTEMS

G. LIKENS, Dartmouth College, Graduate School, *Hanover, New Hampshire* 03755

This is a renewal of GB-4169 for continued work in the Hubbard Brook Experimental Forest in New Hampshire. The investigators have been successful in developing an input-output-budget approach to the hydrologic cycle and to the movement of several elements through a watershed. The influence of vegetation cover on both runoff and cycles of elements has been strikingly demonstrated. The investigators now are expanding the work to include consideration of more aspects of the system through the enlistment of the cooperation of seven additional scientists. Continuing work includes studies of both undisturbed watersheds and others that have been modified by cutting, herbicides, and pesticides.

SUPPORTED BY U.S. National Science Foundation

2.0746, DETERMINATION OF THE STAGES OF EUTROPHICATION OF SOME OF NEW HAMPSHIRES LARGE LAKES PHASE II

P.J. SAWYER, Dartmouth College, Graduate School, *Hanover, New Hampshire* 03755

The determination of the stages of eutrophication has been carried out on only one of New Hampshire's lakes, it is proposed to extend this knowledge. Five lakes will be investigated, one of them in two different places. Attempts will be made to gather information on the chemical, physical, and biological characteristics of the lake. The chemical characteristics to be determined will be oxygen, carbon dioxide, alkalinity, phosphates, nitrates, and possibly some ionic determination by atomic spectroscopy. Physical characteristics to be identified will be pH, light penetration, temperature stratification, and conductivity. Finally, primary productivity will be measured by the carbon-14 technique, and the zooplankton and phytoplankton components will be identified. Additional work will be done on the impact of copper sulfate on lake communities.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of New Hampshire

2.0747, SNOW AND ICE COVER INVESTIGATIONS

M.A. BILELLO, U.S. Army, Terrestrial Sciences Center, *Hanover, New Hampshire* 03755

Regional variations of snow cover properties; the formation, growth and decay of lake, rivers, and sea ice and the rate of thaw of seasonal frost in the Arctic and Subarctic are being studied. Seasonal and areal distribution of these conditions to develop forecast schemes for prediction of the time of occurrence are being studied also. Data are acquired through a cooperative program between USA TSC and the following agencies: Weather Bureau, U.S. Soil Conservation Service, U.S. Geological Survey, U.S. Air Force, and Canadian Department of Transport.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0748, FROZEN GROUND INVESTIGATIONS, BARROW, ALASKA

J. BROWN, U.S. Army, Terrestrial Sciences Center, *Hanover, New Hampshire* 03755

An integrated program combining soils, surficial geology and stratigraphy, vegetation and hydrology was initiated in 1962 to characteristic soil and near-surface processes operating in a coastal arctic environment (71 degree 19'N, 156 degree 35'W). Related hydrologic research includes: (1) A continuing hydrology study on a small watershed in which rainfall, runoff, evaporation, and various chemical and soil parameters are determined (data period summers 1963- 1966); (2) Depth of seasonal soil thaw (1962-1966); (3) Ice content of perennially frozen ground including massive ice wedge ice. Findings are related to present and past climates. Chemical gradients in soils and near-surface sediments are determined in order to approximate formational processes.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0749, HYDROLOGIC STUDY OF A SMALL ALASKAN WATERSHED

S.L. DINGMAN, U.S. Army, Terrestrial Sciences Center, *Hanover, New Hampshire* 03755

A forested watershed of Glenn Creek, 8 miles north of Fairbanks, Alaska, is being studied. The vegetation and topography are typical of the Yukon-Tanana Uplands. Runoff through a V-notch weir, precipitation, air and water temperatures, humidity and incoming solar radiation will be recorded from break-up to freeze-up. Periodic water samples for dissolved and suspended solids are taken. A snow survey course provides snowpack information.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0750, CONTROL AND PREVENTION OF CULVERT AND ROAD ICINGS

R.W. HUCK, U.S. Army, Terrestrial Sciences Center, *Hanover, New Hampshire* 03755

The purpose of this cooperative study, begun in FY 1967, is to develop new and improved existing methods for the prevention and control of culvert and road icings, with the initial effort focused on the problem of culvert icings. The scope of this study includes: (1) a literature survey; (2) field reconnaissance of icing problem areas; (3) investigation of several typical icing problem areas, considering topography, surficial geology, hydrology, and meteorology; and (4) field testing new techniques for icing control and prevention.

A literature survey has been completed, resulting in an annotated bibliography. Icing problems have been studied along 800 miles of Alaska's highways. Analysis of meteorological and culvert temperature data from three instrumented icing sites near Fairbanks has been performed, covering the 1966-67 and 1967-68 winters. Hydrologic data acquisition has added to the field program at these sites for the 1967- 68 winter. At one site, controlled testing of electrical heating techniques was performed during the 1967-68 winter.

Three full-scale field tests will be conducted during the 1968-69 winter. These include channel covers to reduce radiative and connective heat losses, electric heating cables to keep the channel open and a channel improvement to carry potential icing down stream of a bridge.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0751, FROST SUSCEPTIBILITY CRITERIA

C.W. KAPLAR, U.S. Army, Terrestrial Sciences Center, *Hanover, New Hampshire* 03755

The purpose of this investigation is (1) to further study and evaluate those factors that cause a soil to be frost susceptible and (2) to develop rapid and more precise frost susceptibility criteria and indicators. The study will be performed principally in the laboratory.

Review and analysis of available literature will be made to take advantage of any new research or demonstrable theories on frost action phenomenon in soils. Previously collected in-house data will be reviewed in the light of newer knowledge and information.

Laboratory effort initially will be concentrated on developing a simpler and more rapid freezing test. The simpler, more rapid freezing technique, if developed and proved effective, will be used as a principal tool in the ensuing studies in this project. Efforts will then proceed to formulation and investigation of hypotheses as indicated under paragraph 2, 'Procedure,' of the basic Instructions and Outline

SUPPORTED BY U.S. Dept. of Defense - Army

2.0752, GROUND WATER PREDICTION STUDIES

C.W. KAPLAR, U.S. Army, Terrestrial Sciences Center, *Hanover, New Hampshire* 03755

The purpose of this project will be to study methods of predicting or estimating ground-water conditions in the upper soil strata and availability of moisture for ice segregation during freezing.

Field observations of climatic, meteorological and ground moisture conditions will be made at 2 or 3 sites in the northern United States over a period of a few years to study methods of predicting soil moisture conditions and probable ice segregation and heaving. Methods of evaluating climatic and other factors for estimating probable field moisture conditions will be studied. Field moisture conditions just prior to and during freezing will be correlated with heave characteristics of various soils. Simplified method(s) will be developed for predicting or estimating soil moisture and possible ice segregation in soils, for use as a design tool.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0753, MOUNTAIN RESEARCH

C.C. LANGWAY, U.S. Army, Terrestrial Sciences Center, *Hanover, New Hampshire* 03755

TECHNICAL OBJECTIVE - To study the environment of a high mountain with particular reference the distribution and properties of snow. Emphasis is placed on snow as frozen precipitation which accounts for large changes in storage in these glacierized drainage basins.

APPROACH - Measure the distribution of precipitation with elevation on a large, high mountain by sampling through the previous year's snow accumulation. Measure as many of the related climatological parameters as possible.

PROGRESS - A traverse from 3300 to 5500 meters was made on Mt. Logan, Yukon Territory, Canada. Mean annual accumulation was measured at 300 meter vertical intervals. Mean annual temperatures were estimated from the 10 meter deep snow temperatures. Two automatic recording weather stations were set up to measure winter temperatures and air pressures in order to correlate with upper air soundings from Yakutat, Alaska and Whitehorse, Canada.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0754, DEEP ICE CORE STUDIES AND ANALYSES FROM GREENLAND AND ANTARCTICA

C.C. LANGWAY, U.S. Army, Terrestrial Sciences Center, *Hanover, New Hampshire* 03755

For the FY 68 period, plans are to study the ionic stable and radioactive isotope concentrations and their variations, and also the variations in composition of the atmospheric precipitation and gases contained in the occluded air bubbles. A study will be made of microscopic dust looking for historically datable horizons such as the 1883 Krakatoa and the 1912 Mt. Katmai eruptions and will provide data on such things as the transporting power of stratospheric and tropospheric winds. Additional studies will be conducted on the extraterrestrial constituents of glaciers. This project was started in 1957. It has branched into more geochemical analyses as indicated.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0755, TEST OF EFFECTIVE SOILS PROPERTIES IN THE ANNUAL FROST ZONE

E.F. LOBACZ, U.S. Army, Terrestrial Sciences Center, *Hanover, New Hampshire* 03755

The purpose of this investigation is to develop a basic mathematical theory relative to the thaw-consolidation problems in soils and to determine effective values of, and relationships between, permeability, thermal conductivity, percentage of freezeable soil moisture, etc., undisturbed soil subject to freeze-thaw cycles.

These studies will include a review and analysis of available literature and data, laboratory cold room studies, hydraulic and of electronic computer investigations, and field studies as necessary to verify theoretical concepts.

This project was to be initiated in FY 69 with a scheduled completion data of 30 June 1972. However, unavailability of funds has resulted in postponement of the project start to a future date.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0756, UTILITIES IN PERMAFROST AREAS

S.C. REED, U.S. Army, Terrestrial Sciences Center, *Hanover, New Hampshire* 03755

It is the purpose of this study to develop design and construction criteria for utility systems in cold regions to satisfy requirements for water conservation and pollution control. The study includes water supply, waste water treatment and fluid transmission systems. Work in progress includes: (1) Intensive performance study of utility pipe system and prototype extended aeration waste water treatment plant installed at the USA CRREL Alaska Field Station in Fairbanks, Alaska. This work is a cooperative effort with the State of Alaska Department of Health and Welfare. (2) A study to develop design and operational criteria for water supply and waste water disposal facilities for permanent and semi-permanent stations on the ice caps of Greenland and Antarctica. Future work will include: Observation of community utility systems in permafrost areas, and an extension of present programs with increasing emphasis on water supply problems.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0757, COLD REGIONS PHYSICAL SCIENCE

Y.C. YEN, U.S. Army, Terrestrial Sciences Center, *Hanover, New Hampshire* 03755

TECHNICAL OBJECTIVE: To obtain information on particle physics, wave propagation and lower atmospheric conditions.

APPROACH: Research is being conducted at the desk, in the controlled conditions of the laboratory and in the field.

PROGRESS: Electron microscopy work on snow, ice crystals and ice fog crystals as well as fog dispersal studies, effects of thermal instability on ice melting, propagation of radiation in visible and IR ranges in Arctic fogs. Reports include: Improving Visibility Near Airports During Periods of Fog, USA CRREL Tech. Report 0181 - Fog Dispersal Experiments Using Propane at Walla Walla, Wash., USA CRREL Tech. Report 0198 - Fog Modification Studies on the Greenland Ice Cap, Proceedings of the First National Conference on Weather Modification, pp. 414-422, 1968 - Hexagonal and Cubic Ice at Low Temperature, J. Glaciology, Vol. 7, No. 49, pp. 95-108, 1968 - Microspherules in Snow and Ice-Fog Crystals, J. Geophysical Research, Vol. 71, pp. 3397-3404, 1966 - Electron Microscope Study of Ice-Fog and Ice Crystal Nuclei in Alaska, J. Meteor. Soc. Japan, Ser. II, Vol. 44, pp. 185-194, 1966.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0758, SOIL-PLANT-WATER RELATIONSHIPS

R.B. ALDERFER, Rutgers The State University, Agricultural Experiment Sta., *New Brunswick, New Jersey* 08903

1) To study the energy status and dynamics of water in soils and plants. 2) To determine the influence of plant and environ-

mental variables upon water extraction from the soil profile. 3) To relate physiological conditions in plants to water stress.

The New Jersey Station will measure the water use rates of plants and the possible contribution of lateral and upward movement of water to the supply of available water in the root zone of the soil. Plastic barriers will be placed on the soil surface to control evaporation losses and additions of water from rainfall. Plastic barriers will also be installed around and/or below 6x3 1/2x 10 foot blocks of soil to control water movement into or out of the block, and confine root development of the crop plants grown in this volume of soil.

New Jersey will study the effects of various combinations of stress on the growth of plants. Yield and quality of harvested plant parts and depletion of available water from the soil occupied by different parts of the root system will be measured in field and greenhouse experiments.

SUPPORTED BY U.S. Dept. of Agriculture
New Jersey State Government

2.0759, USE OF WATER BY LOWLAND VEGATATION IN NEW JERSEY COASTAL PINE REGION

M.F. BUELL, Rutgers The State University, Graduate School, *New Brunswick, New Jersey* 08903

The proposed research involves the measurement of evapotranspiration by units of lowland vegetation. The units of vegetation (1) shrubs, (2) small breadloaf trees, (3) small cedar trees, are placed in tanks in sites and prevailing normal water level maintained. Rainfall records kept at site. Record of pumping necessary to maintain the level in tanks used as record of evapotranspiration. What is relative use of water by these three types of widespread lowland vegetation and may the results suggest desirability of management of lowland vegetation for increased water yield?

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Rutgers The State University

2.0760, INFLUENCE OF SOIL MOISTURE AND SOIL FERTILITY LEVELS ON ASPARAGUS YIELD AND QUALITY

R.L. FLANNERY, Rutgers The State University, Agricultural Experiment Sta., *New Brunswick, New Jersey* 08903

(1) To determine the influence of three soil moisture and three soil fertility levels and their interactions on yield and quality of asparagus grown on Coastal Plain soils.

Moisture levels to be studied: Low, medium and high moisture levels to be maintained by differential irrigation during: (a) cutting season only, (b) brush growing season only, and (c) during both cutting and brush growing season. Soil fertility levels to be studied: Use of one-half of N-P2O5-K2O per acre recommended according to soil tests; use of normal N-P2O5-K2O per acre recommended according to soil tests; and use of two times the N-P2O5-K2O per acre recommended according to soil tests.

SUPPORTED BY New Jersey State Government

2.0761, A STUDY OF THE ECONOMIC IMPACT OF DROUGHT ON WATER SUPPLY SYSTEMS IN THE PASSAIC RIVER BASIN, NEW JERSEY

A.V. HAVENS, Rutgers The State University, Graduate School, *New Brunswick, New Jersey* 08903

1. To investigate the relationship between factors associated with drought, raw and treated water quality, water treatment costs and revenues of water utilities. 2. To establish mathematical models from which costs of water treatment and future revenues of water companies may be predicted from hydrologic, meteorologic and raw water quality data.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.0762, APPLICATION OF CLIMATOLOGY TO NEW JERSEY AGRICULTURE

A.V. HAVENS, Rutgers The State University, Agricultural Experiment Sta., *New Brunswick, New Jersey* 08903

Objectives: To assemble and analyze the climatological data of the Northeast that apply to agriculture; to determine, using phenological measurements, the response of selected plant species to environment; to conclude the present studies of the influence of climatic variables on plant response. Description: An important part of Objective I is the continued analysis of weather records and publication of regional bulletings. The Technical Committee plans continued publication of regional bulletins under the series, The Climate of the Northeast. The committee also encourages the individual cooperators to publish additional results separately. Studies currently in progress will be completed under the revised project. The daily weather data now on cards for the 1926-1956 period will be put on magnetic tape, according to procedures agreed upon by the Technical Committee. Stable, long-record weather stations are particularly important for studying climatic trends and extrapolating the data of short-record station. Long record stations have been designated for 60 percent of the Region. Similar stations will be selected in the remainder of the region with the assistance of the Weather Bureau State Climatologist involved. The selections are made on the basis of the period of record and the completeness of the daily weather data. These data will also be put on magnetic tape. Post-1956 data for the regular network stations are being added to the present record. For a complete analysis and coverage of the climate of the northeast, it is necessary that the weather network be complete and include each state in the region.

SUPPORTED BY U.S. Dept. of Agriculture
New Jersey State Government

2.0763, DROUGHT FREQUENCY, INTENSITY & DURATION - ITS CORRELATION TO STREAMFLOW AND ITS IMPACT UPON SYNTHETIC HYDROLOGY

A.V. HAVENS, Rutgers The State University, Agricultural Experiment Sta., *New Brunswick, New Jersey* 08903

Objectives: To carry out computation of the Palmer Drought Index for long record weather stations in selected watersheds to obtain more complete and reliable data on drought frequency, intensity and duration; to correlate the information obtained from this with streamflow data from selected gaging stations in a chosen watershed. Assuming that sufficiently high correlations between drought index and streamflow will be obtained, it should then be possible to extrapolate our streamflow records backward in time to provide a much longer period of record of information of this kind.

Description of Work Proposed: The data from long record New Jersey climatological stations from selected New Jersey watersheds will be placed on punched-cards. A hydrologic accounting will be computed for entire period of record of these stations and summarized to obtain coefficients of evapotranspiration, recharge, runoff, and loss. From these coefficients, data on the moisture departures, moisture anomaly indices and finally the drought severity index will be computed. The data obtained will be used to compute the frequency of occurrence of droughts of various severities and durations. The same data will be useful for determining the probability of occurrence of the beginning or ending of periods of drought and periods of abnormal wetness. The final drought severity index, (and perhaps some of the intermediate parameters mentioned previously) will be correlated with the streamflow data from the chosen watershed. If the correlations obtained are sufficiently high, regression equations will be computed to predict streamflow. These will be used to extrapolate backward streamflow for period prior to start of flow measurements.

SUPPORTED BY New Jersey State Government

2.0764, THE ECOLOGY OF SELECTED SUBMERSED AQUATIC WEEDS

D.N. RIEMER, Rutgers The State University, Agricultural Experiment Sta., *New Brunswick, New Jersey* 08903

1) To study the growth and development of Myriophyllum, Potamogeton, and Elodea as affected by (a) chemical, (b) physical, and (c) biological variables. 2) To realte the results obtained to the incidence, distribution, management and control of the above mentioned genera.

Myriophyllum, Potamogeton and Elodea will be grown in the laboratory under different levels of water hardness to determine its effect on the growth and development of the plants. Nutrition studies will be initiated in the field in one-tenth acre ponds, where special attention will be given to the effects of sudden large changes in nutrient supply as compared to relatively constant nutrient availability. Laboratory studies will be initiated to determine the effects of photoperiod on germination, shoot growth and development, and flower -ing. Also, laboratory studies will be conducted on the environmental factors, such as temperature, on the germination of seeds.

SUPPORTED BY U.S. Dept. of Agriculture
New Jersey State Government

2.0765, DYNAMIC GROUND-WATER STORAGE

R.J. DEWIEST, Princeton University, School of Engineering, *Princeton, New Jersey* 08540

This research in unsteady state ground water flow will have the following objectives: a. To investigate analytically the dynamic storage and recovery of underground water. The mathematical tool proposed to investigate time dependent flow in aquifers is Dirac's delta function which is represented in its series of eigenfunctions by integrating the Green's function of the problem in the complex plane. When aquifers are finite, as they are all in nature, the proposed technique offers great advantages over the method of images used by Hantush and Jacob. Moreover, when the aquifer is wedge shaped, the angle of the converging boundaries may assume arbitrary values, unlike those required for the application of the method of images. In particular, the response of the system to sudden changes in required yield will be examined. b. To construct electric R-C analog models: To test the analytical work and to expand the results where analysis becomes unwieldy. c. Field work: A hydrogeologic map will be prepared and aquifer pumping tests made in the field. Part (c), which is an important part of the work, will be supported from state funds and not from NSF funds.

SUPPORTED BY U.S. National Science Foundation

2.0766, FLUVIAL SEDIMENTATION IN STONY BROOK WATERSHED

P.W. ANDERSON, U.S. Dept. of Interior, Water Resources Division, *Trenton, New Jersey*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of New Jersey.

The objective is to develop improved technology for measurement of peak runoff from small acres. Peak runoff rates of small watersheds are difficult and often impossible to measure by conventional methods. Use of a pond or small lake to capture and temporarily store most or all of such runoff from a given storm offers a direct volumetric solution. This solution requires that the capacity of the pond at different levels and the outflow, if any, be accurately known. It also requires that the change in level of the pond be observed or recorded frequently during the period of maximum runoff.

A digital-recording water level gage is being evaluated for this purpose. The research includes required frequency of data recording, required accuracy in recording of water levels, a program for processing data through a digital computer and final presentation of results, and a study of the various sources and degrees of error.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
New Jersey State Government

2.0767, HYDROLOGY OF CONSOLIDATED ROCK AQUIFERS NEAR PENNINGTON, NEW JERSEY

L.D. CARSWELL, U.S. Dept. of Interior, Water Resources Division, *Trenton, New Jersey*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of New Jersey.

Purpose: To determine the effects of small stream impoundments on ground-water recharge; to define the thickness of the zone of fresh- water circulation, and lateral changes in porosity, permeability, and gradients within this zone; and to determine chemical changes in the water as it moves through the zone of fresh-water circulation. To evaluate well-development techniques in wells tapping water filled joints and fractures in consolidated rock.

Methods: Aquifer characteristics are to be determined by a series of pumping tests made before and after filling an impoundment. The local geohydrologic system is to be defined by head measurements of individual aquifers using an inflatable packer. Variations in yield are to be determined throughout the zone of fresh-water circulation by borehole geophysical techniques. Response of the basin to natural- and man-induced changes or events is to be monitored by a gaging station below the impoundment, water-level measurements in wells, and meterological observations.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
New Jersey State Government

2.0768, GEOHYDROLOGY OF THE POTOMAC-RARITAN-MAGOTHY AQUIFER SYSTEM

H.E. GILL, U.S. Dept. of Interior, Water Resources Division, *Trenton, New Jersey*

This research is part of the program of water resources investigations conducted by the U.S. Geol. Survey in cooperation with the state of New Jersey. The purpose of this project is to aid in our understanding of the geologic, geochemical, and hydrologic controls on ground water in the various aquifers within the Magothy-Raritan Potomac sediments of New Jersey and Pennsylvania. The primary purpose is to determine the mineralogic controls on the chemistry of ground water by evaluating such factors as the clay mineralogy, the gross mineralogy, and flow patterns in order to determine the departure from equilibrium of the water with respect to selected minerals in the aquifer, primarily siderite. In addition to determining the distribution of selected constituents within the natural system, a laboratory study is being made to re-evaluate the stability of natural and synthetic siderite through solubility measurements at 25-30 degrees C.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
New Jersey State Government

2.0769, TIDAL DISCHARGE RESEARCH, NEW JERSEY

A.C. LENDO, U.S. Dept. of Interior, Water Resources Division, *Trenton, New Jersey*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of New Jersey, the Corps of Engineers, and the Federal Water Pollution Control Administration.

Purpose: To develop and improve techniques for the collection of tidal stage, discharge, quality of water, and sediment data.

Methods: Synchronous records of tidal stage have been collected by digital recorders at estuary stations, computer programs are used to compile these records. Discharge equations have also been programmed and calibration has been based on observed discharge by diographs and other parameters by field measurement. Suspended-sediment, particle- size, and other water-quality information is collected during discharge calibration measurements to define changes during tidal cycles.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
New Jersey State Government
U.S. Dept. of Interior - F. Water Pol. Ctl
U.S. Dept. of Defense - Army

2.0770, INTERCEPTION AND WATER LOSSES FROM A FOREST FLOOR-SHRUB LAYER

E.C. RHODEHAMEL, U.S. Dept. of Interior, Water Resources Division, *Trenton, New Jersey*

This research is part of the program of water resources investigation conducted by the U. S. Geological Survey in cooperation with the State of New Jersey. This project is designed to determine the effects of the forest floor on interception and evapotranspiration by operation of an automatic recording lysimeter designed during the course of this study for use in the deep sandy soils of the study area (McDonalds Branch in New Jersey.) The hydrologic effects of the forest floor are of fundamental importance to water-resources evaluation in areas where prescribed burning programs are carried out because this aspect of the forest is most drastically altered by the burning programs.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
New Jersey State Government

2.0771, FLOW AND SEDIMENT TRANSPORT, RIO GRANDE CONVEYANCE CHANNEL

J.K. CULBERTSON, U.S. Dept. of Interior, Geological Survey, *Albuquerque, New Mexico*

The objective of this project is to utilize known techniques and to develop new techniques to obtain field measurements of hydraulic and sediment variables in a natural alluvial channel, and the analysis of the data relative to all aspects of flow in alluvial channels. The study reach is in the area of a control structure that has been constructed on the Rio Grande Conveyance Channel near Bernardo, New Mexico.

The project is designed to obtain accurate and complete field data for the entire range of bed configurations and flow regimes found in a sand-bed channel for a range of discharges, depths, and concentrations not heretofore available. The results of this investigation will supplement previous and current studies of hydraulics and sediment transport in sand-bed streams, and will be useful in extrapolating the results of flume studies.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0772, FLOOD FREQUENCY STUDY

UNKNOWN, U.S. Dept. of Interior, Geological Survey, *Albuquerque, New Mexico*

Basic flood-frequency relations in the Rio Grande Basin, are to be defined. Variations in frequency and magnitude of flood peaks in terms of causative factors, both topographic and meterologic are to be explained. The findings are expected to make it possible to design bridges, culverts and other hydraulic structures more economically and to minimize flood damage. The flood-frequency study for the greater part of New Mexico) the Rio Grande and the San Andres and Orgam mountains excluded) has been completed and sent to the Washington Office of USGS for review. Work is continuing in the Washington research section of USGS on determination of relations between floods and various measurable parameters.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
New Mexico State Government

2.0773, IRRIGABILITY CLASSIFICATION OF NEW MEXICO SOILS AS A GUIDE FOR WATER IMPORTATION

J.U. ANDERSON, New Mexico State University, School of Agriculture, *Las Cruces - University Park, New Mexico* 88001

The objectives of this study are to classify the soils of Eastern New Mexico according to irrigability classification based on basic soil surveys, and to identify distribution of the irrigable lands and those having limitations for irrigation.

The Pacific Southwest Inter-Agency organized a committee which met in July, 1967, and drew up and recommended the following classifications: Class 1 - None to slight soil limitations for sustained use under irrigation. Class 2 - Moderate soil limitations for sustained use under irrigation. Class 3 - Severe soil limitations for sustained use under irrigation. Class 4 - Very severe soil limitations for sustained use under irrigation.

Published and unpublished soil survey information from the Soil Conservation Service and the Agricultural Experiment Station, plus field observations and aerial photo interpretations will be used in this research project.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
New Mexico State University

2.0774, A HISTORY OF WATER UTILIZATION IN THE SOUTHWEST, WITH PARTICULAR REFERENCE TO NEW MEXICO

I.G. CLARK, New Mexico State University, Graduate School, *Las Cruces - University Park, New Mexico* 88001

Effective utilization of its meager water resources has been a dominant problem in the Southwest from the time of its earliest known inhabitants. The present project is directed towards tracing historically the approaches to this problem, with emphasis on the period since its acquisition by the United States. Essentially it will be a history of the way in which water has been utilized in New Mexico. The project will deal with as many facets as possible, including the search for and husbanding of water, customs and laws controlling water rights, technical advances, divergent views regarding the most economic use to which water should be put, and conflicting opinions respecting the implementation of policies. Inescapably it will touch on such related themes as the administration of the public domain and conservation in general, but will not depart from the central theme of water use.

The method will be primarily one of examining documentary evidence: extracts from accounts of travelers, scientists, army officers and others who observed the country at various periods; Congressional hearings, documents, and debates; reports of Federal and State agencies charged with water administration; judicial decisions; records of private agencies; and the writings of authorities on the subject.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
New Mexico State University

2.0775, FARM IRRIGATION EFFICIENCY AS INFLUENCED BY DESIGN, CONSTRUCTION, AND OPERATION OF IRRIGATION SYSTEMS IN SOUTHWESTERN NEW MEXICO

E.G. HANSON, New Mexico State University, Agricultural Experiment Sta., *Las Cruces - University Park, New Mexico* 88001

Objective: 1. To determine how efficiently water is being used on New Mexico farms under different a) designs of irrigation systems; b) operation practices; c) stages of plant or root growth; d) conditions or degrees of land preparation. 2. To determine relationships among the variables involved and to develop design and operation procedures by which these variables may be adjusted or combined to improve present irrigation practices and future irrigation systems.

Description of Work Proposed: On selected farms determinations will be made of the total quantity of water diverted, the source and magnitude of losses, and percentage of irrigation water delivered and effectively stored in the soil as available moisture. Soil moisture will be determined under cropped land before and after irrigation mainly by equipment using the neutron scattering method. Hydraulic characteristics of conveyance structure will be measured and physical features of the land and irrigation layout drawn on appropriate plans and profiles. Relationships between size of stream, time rate of advance, and unifromity of distribution in the root zone will be plotted with respect to the length of irrigation runs. These data will be evaluated to determine recommended adjustments in operation practices and desirable design features which will increase farm irrigation efficiency.

SUPPORTED BY New Mexico State Government

2.0776, USE OF RADAR FOR HYDROLOGICAL STUDIES

M. BROOK, New Mexico Inst. Min. & Tech. , Graduate School, *Socorro, New Mexico* 87801

A comprehensive interdisciplinary water program of raindrop growth, storm trejectories, precipitation patterns, run-off, evaporation, and underground water migration will be undertaken, incorporating the radars now being used in the cloud physics research program.

Two complete 3-cm radars are now in operation by New Mexico Institute of Mining and Technology personnel; one located about 1 mile west of the campus, the other at the Langmuir Laboratory on Mount Baldy Ridge, 16 miles west-southwest of Socorro. Both radars are capable of surveillance of rainfall over an area of approximately 20,000 square miles. A 10-cm radar capable of 30,000 square mile rainfall surveillance is on hand and will be used in the projected program.

A small suitable area of hydrologic interest, such as the Snake Ranch Flats area near the Institute facility, will be selected as a test area for an intensive study of the hydrologic parameters, involving atmospheric, surface, and underground phenomena.

The atmospheric physics group at the Institute is now actively engaged in complementary studies of natural rain formation and methods of induced precipitation growth and rainfall. For example, the role of electric forces in hindering and accelerating precipitation growth has been under intensive study for the past five years.

SUPPORTED BY New Mexico State Government

2.0777, ANALYSIS OF RECHARGE BASINS

R.J. WEAVER, State Dept. of Transportation, *Albany, New York* 12226

Recharge basins are used extensively in the Long Island, New York area to dispose of surface runoff from highways. It is proposed to develop rational criteria, methods and procedures for the design, construction and maintenance of recharge basins, by reviewing all available information on existing basins, and performing a detailed field and laboratory study of selected basins with a wide range of performance. Some aspects of deep diffusion wells also will be studied.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
New York State Government

2.0778, LAKE EFFECT STORM STUDY

V.J. SCHAEFER, State University of New York, Graduate School, *Albany, New York* 12203

Abnormal snowfalls occurring to the lee of Lakes Erie and Ontario produce a classical 'lake effect' similar to the local heavy snowfall that occurs independently of cyclones or fronts over the coast of the Japan Sea. These storms cannot be explained by usual meteorological means. ASRC has constructed a dynamic laboratory model, which includes the various parameters of the lake effect storm including warm water, cold air, a land barrier and means for controlling each separately. The Japanese have done the same.

During the winter of 1967-1968 a group of Japanese scientists will come to the U.S. to make cooperative simultaneous observations of the Great Lake Storms and during the winter of 1968-1969 U.S. scientists will visit Japan to observe the storms over the Japan Sea. The investigation of the mechanisms of 'lake effect' storms should contribute to more exact forecasting methods and a meteorological (as opposed to geophysical) study in this field.

SUPPORTED BY U.S. National Science Foundation

2.0779, THE ROLE OF LANGMUIR CIRCULATIONS IN MIXING OF LAKE GEORGE

J.T. SCOTT, State University of New York, Graduate School, *Albany, New York* 12203

An investigation of the role of Langmuir circulations in mixing of epilimnion water is proposed. The experiments are also designed to determine the specific mechanism which generates this organized type of circulation, and to test methods of observing these circulations. The field program will be closely allied with the development of workable theoretical models which are intended to apply in general to this circulation type.

The field program will include the following studies: 1. A correlation of foam line spacing with meteorologic parameters. 2. A refinement of methods of observing Langmuir circulations. 3. Measurement of currents within Langmuir circulations.

These field observations will be tied to an investigation of the heat transport caused by Langmuir circulations.

The results of this investigation will be applied directly to water resource problems. If Langmuir circulations produce a significant mixing in the epilimnion and the generation mechanism is well known, then steps may be taken to alter the heat balance of reservoirs or lakes and thereby influence evaporation from their surface.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
State University of New York

2.0780, THE ROLE OF LANGMUIR CIRCULATIONS IN MIXING OF LAKE GEORGE

J.T. SCOTT, State University of New York, Graduate School, *Albany, New York* 12203

Results from two years of study indicated that Langmuir circulations may be the most important cause of mixing in epilimnion water because they are able to transport heat to much deeper levels than ordinary turbulence.

The specific aims of the proposed second phase of this project are: (1) measurement of the current field in Langmuir circulations, (2) wave-interaction as a possible mechanism of Langmuir circulations, (3) thermal structure, spectra, and heat transport of Langmuir circulations, (4) laboratory experiments on the properties of air over surface films and, (5) field studies of the mechanism of Langmuir circulations.

These field experiments have direct application to water resource problems. If the mechanism of Langmuir circulations and the amount mixing they produce are known, steps may be taken to modify the effect they exert upon epilimnion properties such as temperature and concentration of gases, pollutants or other constituents. For example, by modifying the epilimnion circulation one modifies the heat balance and therefore also evaporation.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
State University of New York

2.0781, FLOW AND SALINITY IN THE HUDSON ESTUARY, NEW YORK

M.W. BUSBY, U.S. Dept. of Interior, Water Resources Division, *Albany, New York* 12201

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of New York.

Purpose: To define the physical and chemical characteristics of the water in the estuary in order to provide a basis for management of this resource.

Method: River stage at each end of a reach (Poughkeepsie to Clinton) is continuously recorded. These time-synchronized stages are used with the power series method developed by Baltzer and Lai to compute tidal volumes. Water conductivity and temperature are continuously recorded at Poughkeepsie, Beacon, Peekskill and Peirmont. The conductivity data (a measure of salinity) will be related to tidal volume and movement and to fresh-water inflow as measured by several gaging stations on tributaries to the estuary.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
New York State Government

2.0782, FORM, PROCESSES AND DEPOSITS OF THE KNIK RIVER, ALASKA

R.K. FAHNESTOCK, State University of New York, Graduate School, *Fredonia, New York* 14063

The Knik River of Alaska is a braided glacial stream which in most years experiences a catastrophic flood when Lake George bursts through its ice-dam. We propose to study the changing behavior and deposits of this gravel bearing river before, during, and after the flood. An understanding of the Knik will contribute to an understanding of the flood processes of 'normal' rivers which experience a catastrophic flood only occasionally, and to the interpretation of ancient fluvial deposits. This proposal covers the second year of a two year grant, NSF GA 696, originally made to the University of Texas.

A considerable amount of data was collected during the summer, in spite of the failure of Lake George to fill and break out, and difficulties with equipment. To establish a reference for comparison before and after the flood, a variety of plane table maps of bars and bar features, and water surface and bottom profiles were made. Bar materials were painted. Surveys to establish a water surface profile based on Corps of Engineer temporary bench marks have largely been completed. Significant differences from the profile that could be developed from topographic maps of the area have been determined.

A large number of determinations of pebble size, shape and lithology have been taken in order to develop an understanding of the sorting and alteration of valley train gravel by the flood transport. Grain size tends to decrease in a down valley direction, although this trend is also influenced by local source rocks. Shape-studies suggest that shape-sorting may be important. A second summer of observations will furnish details in sediment-transport picture.

Several different bar types occur in the Knik Valley. Although their distribution in not clearly understood at this point, it appears to be systematic. Further observations are planned for the second field season.

SUPPORTED BY U.S. National Science Foundation
State University of New York

2.0783, LAKE ERIE ENVIRONMENTAL STUDIES PROGRAM

J.A. JONES, State University of New York, Lake Erie Environ. Stud. Prog., *Fredonia, New York* 14063

The Lake Erie Environmental Studies program has been established to support and coordinate environmental research focused on the lake at Fredonia. A lakeside laboratory is available for use by investigators from Fredonia and other interested institutions. A program of continuous environmental data monitoring has been initiated to provide support for investigations. Data gathered include meteorological, physical, chemical, biological, and geological. These data will be compared with conditions in the eastern basin of Lake Erie.

In addition to standard environmental data monitoring, several pilot studies are to be conducted annually to provide basic information necessary for requesting outside support. This year such programs include delta sedimentation from a lake shore stream, distribution of aquatic insects along the New York shoreline, fish mortality cycles, algal metabolism, utilization of products of eutrophication, and a survey of near-shore aquatic organisms.

SUPPORTED BY State University of New York

2.0784, STUDY OF SNOW CRYSTAL TYPES IN GREAT LAKES SNOWSTORMS

R.G. LAYTON, State University of New York, Graduate School, *Fredonia, New York* 14063

For the past two winter seasons some small efforts have been made at Fredonia to look at the snow crystal types in lake effect storms. In the coming winter we hope to expand this effort and attempt to take systematic replications in a variety of storms, both of the lake effect and the non-lake effect types. In addition we propose to do some exploratory work in evaluating the iodine content of the snow using neutron activation analysis.

To accomplish this we propose to set up three permanent stations and instruct an observer at each in the proper observational techniques and in rough preparation of the data. These same observers will also take snow samples for analysis. By utilizing people who live at the observation site, it is hoped to obtain a high degree of reliability in the observations, and we expect to recover a good precentage of the possible data. The location of the proposed stations is shown on the map. At each station we propose to put a continuous replicator and such other equipment as finances allow.

SUPPORTED BY State University of New York

2.0785, HETEROGENEOUS NUCLEATION OF ICE

R.G. LAYTON, State University of New York, Graduate School, *Fredonia, New York* 14063

In the past decade there has been rapid progress in our understanding of the heterogeneous nucleation of ice (Fletcher, 1962; Mason, 1957). There is still, however, a gap between theory, laboratory experiments, and field experiments. Part of the problem has been that the experimental conditions are in many cases not well known. Studies of nucleation and growth of ice under more carefully defined conditions of the surfaces of single crystals should provide information which will help close these gaps in our knowledge. The goal of the proposed research is to provide experimental facts which will increase our fundamental understanding of the heterogeneous nucleation of ice. The research will be directed toward the study of the effects of radiation of various wavelengths together with the effects of addition of various impurities on the nucleation of ice by silver and lead iodide.

The photolytic decay of silver iodide and its effect on ice nucleation have been the object of several recent studies, several of which indicated an increase in nucleating ability of silver iodide upon first being exposed to light. This effect was predicted by Papee (1962) on the assumption that the increase in dislocation density caused by the decomposition would result in an initial enhancement of the ice forming capacity of the salt. Further study of the details of the effect of this on ice nucleation is needed.

Observations of this kind can be carried out very effectively by observing the temperature and vapor pressure at which ice grows on the faces of a single crystal as it is exposed to light of different wavelengths and intensities for different times.

A cold chamber will be constructed and so designed to give good control of the temperature and the vapor pressure at which the crystals of ice are to be grown. The growth will be observed by means of a microscope.

SUPPORTED BY State University of New York

2.0786, AQUATIC BIOLOGY INVESTIGATIONS

M.M. ALEXANDER, New York State Agric. Sta., *Geneva, New York* 14456

Objective: To study various physical and biotic problems in lakes and streams as related to fish, waterfowl and furbearers.

Progress: 1) A comparative field study of the ecology of the three forest ponds on the Tully Forest was conducted. 2) Planning was carried out for an ecological study relating aquatic invertebrates to aquatic vegetation. This is an important basic study in waterfowl management. 3) A study was completed on the ecology and movements of muskrats on marginal habitat of the Adirondacks. A paper was given at the Northeast Wildlife Conference. 4) A study of the trout and their movements in the tributaries of Wolf Lake on the Huntington Forest was conducted this year, and will be continued through next year. 5) Brook trout in Tully Forest ponds are growing very rapidly and a plan to open some of these ponds for fishing under a permit system has been completed in cooperation with Mr. Engleken. A new supply of brook trout has been ordered. Rainbow trout are present, but not doing very well. Bass, sunfish and bullheads are doing very well in the headquarters pond.

Plans: To complete sub-projects 1 and 3 above in 1965, and continue 2,4 and 5. Also to institute one new project.

SUPPORTED BY New York State Government

2.0787, A STUDY OF SNOW INTERCEPTED BY CONIFEROUS TREE CROWNS AND ITS DISPOSITION UNDER THE CLIMATIC CONDITIONS OF CENTRAL NEW YORK

A.R. ESCHNER, New York State Agric. Sta., *Geneva, New York* 14456

Objective: Exploratory study of quantity of snow intercepted by coniferous tree crowns of commonly planted species.

Progress: Devising methods of supporting and weighing small conifers; developing equipment to measure snow in crowns.

2. WATER CYCLE

SUPPORTED BY New York State Government

2.0788, TREE NUTRITION AND FOREST FERTILIZATION

A.L. LEAF, New York State Agric. Sta. , *Geneva, New York* 14456

Objective: Determine moisture and/or nutrient element effects on soil fertility as expressed by growth and development of, and nutrient element uptake and distribution in trees. Work confined to Pack Forest plain.

Progress: Initiation of irrigation system for moisture-nutrient interaction study. Detailed investigation of site variability, a confounding factor in interpreting responses to fertilizer additions.

Plans: Further work on irrigation - fertilization study, determining effect of fertilizers and/or water treatments on tree growth and development.

SUPPORTED BY New York State Government

2.0789, SOIL MOISTURE AND FRUIT GROWTH IN RELATION TO WEATHER CHECKING OF MCINTOSH APPLES

E.F. TASCHENBERG, New York State Agric. Sta. , *Geneva, New York* 14456

Fruit growth, soil moisture, and the incidence and severity of weather checking are compared under four treatments designed to alter the normal seasonal patterns of available soil moisture in an effort to determine the role of fluctuations in soil moisture in the development of weather checking.

SUPPORTED BY New York State Government

2.0790, SOIL-PLANT-WATER RELATIONSHIPS

M.T. VITTUM, New York State Agric. Sta. , *Geneva, New York* 14456

Objective: To determine the influence of plant and environmental variables upon water extraction from the soil profile.

Work Proposed: The main and interactive effects of irrigation, variety, spacing and other variables upon extraction of water from the soil profile will be measured on a number of crops, including tomatoes, snap beans, lima beans, cabbage, broccoli and peas. Most of these crops will be harvested sequentially in order to determine the effects of treatments on maturation and quality as well as yield.

SUPPORTED BY U.S. Dept. of Agriculture
New York State Government

2.0791, CLIMATE OF THE NORTHEAST - ANALYSIS AND RELATIONSHIP TO PLANT RESPONSE

M.T. VITTUM, New York State Agric. Sta. , *Geneva, New York* 14456

Objectives: 1. To determine, using phenological measurements, the response of selected plant species to environment. 2. To conclude the present studies of the influence of climatic variables on plant response.

Work proposed: 1. Persian lilacs will be planted at 50 or more locations in New York State. Dates when leaf bud scales break, first flowers open and last flowers open will be correlated with the weather data obtained at each location. 2. The present study comparing actual ET, as measured from changes in soil moisture, with calculated ET, as obtained from various formulas, will be continued and concluded. Various formulas will be compared and development of a new formula using multiple correlation techniques will be explored.

SUPPORTED BY U.S. Dept. of Agriculture
New York State Government

2.0792, APPLICATION OF AERIAL PHOTOGRAPHS FOR THE INVESTIGATION OF THE DISCHARGE PROPERTIES OF DRAINAGE BASINS

D.J. BELCHER, Cornell University, School of Engineering, *Ithaca, New York*

This project proposes to develop methodology which would give estimates of the yield pattern of water from a basin where stream flow records are non-existent or incomplete. Planning can rarely wait until our data is truly adequate. Indeed, our capacity to conceive of ways to use more and better data is usually far ahead of our capacity to generate it. This project is a step toward correcting this imbalance. It would provide a better basis than we now have while waiting for precise discharge statistics to be generated over the years.

Stream flow measurement stations have increased rapidly in recent years, but this still means that we often must rely upon long-term discharge data from only a few stations. Statistical techniques for extending the data we have are far better than they were. But this project will provide a technique through air photo interpretation for making estimates where measurements don't exist or are too scanty to be adequate.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Cornell University

2.0793, A THREE-DIMENSIONAL APPROACH TO THE EXCHANGE OF HEAT AND WATER VAPOR BETWEEN A LARGE WATER BODY AND THE ATMOSPHERE

W. BRUTSAERT, Cornell University, School of Engineering, *Ithaca, New York*

The investigation involves the study of the physical and mathematical foundations underlying simultaneous turbulent heat and water vapor exchange between a large open water body and the surrounding atmosphere for various conditions of local atmospheric advection and of solar and other energy input into the water body. This will be accomplished by analyzing the solvability of the partial differential equations describing turbulent diffusion in the atmosphere subject to the appropriate boundary conditions.

The main objective of the proposed research is to gain a better understanding of these phenomena in order to assess and improve the presently available theoretical models. This will then in turn allow the development of practical engineering procedures to better predict cooling and evaporation from water reservoirs, especially in connection with thermal power station design than is possible at present.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Cornell University

2.0794, STUDY OF GEOLOGIC STRUCTURAL CONTROL ON THE FLOW AND DISCHARGE OF GEOTHERMAL WATERS

G.A. KIERSCH, Cornell University, Graduate School, *Ithaca, New York*

This research is intended to study the effect of geologic structure on the underground movement and discharge of groundwater, heated by the earth's natural heat. A typical geothermal area was selected in the Southwestern sector of Iceland where the Research Assistant has already completed five months of field work necessary for this project.

Laboratory investigations will now be conducted on the rock samples collected during the field work to establish the geologic structure, correlation and analysis of all the data leading to interpretations and preparation of maps and cross-sections to be included in the final report.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Cornell University

2.0795, WATER SUPPLY-DEMAND

D.J. ALLEE, State University of New York, School of Agriculture, *Ithaca, New York* 14850

Generally, the objective of the project is to provide improved methodology and new or improved knowledge about the supply of water available to New York State and the adjoining states in the Northeast region, including ultimately the influence of Canada, and the demands that will be made on such supplies for domestic, municipal, industrial, agricultural and recreational purposes; for the propagation of fish, aquatic life and wildlife; and for other purposes.

Specifically, the objective of the project is to review planning methodology including hydro-meteorological and engineering analyses, socioieconomic investigations and data processing and programming studies that (a) estimate present water use, potential supply and capacity of existing development on a comparable and uniform basis; (b) estimate the supply functions for water (i.e., what each successive increase in developed capacity might cost); (c) construct projections of water use by each water function; and finally match the demand data to the water supply data. Subsequent approximations would aim at refining information with particular emphasis on water supply data and on improving the evaluation of water demand projections, considering the cost of meeting such demands.

This project was started in Fiscal Year 1965 and the completion date is indefinite at present.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Cornell University

2.0796, MAJOR FACTORS INFLUENCING PRODUCTION OF PHYTOPLANKTON IN NEW YORK LAKES

J.P. BARLOW, State University of New York, Agricultural Experiment Sta., *Ithaca, New York* 14850

Objective: The objectives of this study are to determine the levels of nutrients that limit phytoplankton production and radiant energy available as a function of sea and depth in various New York Lakes.

Description of Work: Initially the study will include an intensive investigation of effect of nutrient levels and radiant energy on production of limnetic phytoplankton in Cayuga Lake, and more extensive studies of the characteristics of radiant energy as related to water quality in a wide range of New York lakes.

SUPPORTED BY U.S. Dept. of Agriculture
New York State Government

2.0797, DIFFUSION OF OXYGEN ACROSS THE MUD-WATER INTERFACE IN AQUATIC ENVIRONMENTS

D.R. BOULDIN, State University of New York, Agricultural Experiment Sta., *Ithaca, New York* 14850

Objective: To develop procedures for measuring oxygen consumption by aquatic muds under a variety of laboratory and field conditions, and to relate the measured oxygen consumption to the various hypotheses presented in Appendix I.

Work Proposed: Two procedures are proposed for measuring oxygen consumption in the aquatic muds. In one procedure the amount of oxygen required to maintain predetermined concentration of oxygen in a thin layer of water above a core of mud is measured over a period of several hours. This is accomplished by using an oxygen electrode to control an infusion pump fitted with an oxygen-filled syringe. In the other procedure the drop in concentration of oxygen across a membrane of known permeability in conact with the mud is measured. Measurements of oxygen consumption in the laboratory by cores taken in the field will be made under a variety of conditions. The relationship between oxygen consumption and such variables as temperature, oxygen concentration, past history of the core, chemical characteristics of the core and productivity of the water. The pattern of oxygen consumption will be studied in relation to the models which have been derived from diffusion theory. Measurements of oxygen consumption will be made in the field in order to verify the inferences made from the laboratory studies.

SUPPORTED BY U.S. Dept. of Agriculture
New York State Government

2.0798, A STUDY OF TECHNIQUES FOR INCREASING EFFICIENCY OF IRRIGATION WATER APPLIED TO POTATOES

E.E. EWING, State University of New York, Agricultural Experiment Sta., *Ithaca, New York* 14850

To determine at which stage (s) of development of the potato plant moisture stress is most harmful; and to learn whether the measurement of cell sap concentration by refractometer offers a superior method of discoving at what point the potato plant is being adversely affected by soil moisture stress.

In order to pursue the first objective it will be necessary to control the water reaching plants. Therefore emphasis will first be placed upon developing techniques for performing irrigation research under plastic covers (developed by Dept. of Agricultural Engineering) and learning whether plants under covers respond to irrigation in the same way as do plants in the open field. If results indicate that the covered plot technique is valid for studying responses to irrigation under field conditions, covered plots will be used to provide a controlled moisture regime for investigating the effects of moisture stress at different stages of development of the potato plant.

Determinations will be made of the effects of various environmental conditions and cultural practices on cell sap concentration (as measured by refractometer) and on changes in cell sap concentration following irrigation. Results will be evaluated from the point of view of learning whether cell sap concentration measurements would be helpful in predicting when to irrigate potatoes.

SUPPORTED BY New York State Government

2.0799, THE PHYSICAL AND CHEMICAL PROPERTIES OF WATER AND SOILS AS RELATED TO THE SUCCESSFUL GROWTH OF WATERFOWL FOOD AND COVER PLANTS

D.J. LATHWELL, State University of New York, Agricultural Experiment Sta., *Ithaca, New York* 14850

1) To obtain specific information on the factors affecting the development of waterfowl foods and cover plants as influenced by soil and water conditions. 2) to define these requirements for the successful growth of waterfowl foods and cover plants on soils flooded from a depth of one foot to three feet, at intervals of six inches.

Description of Work Proposed: Studies will be made of aquatic plant growth and soil and water characteristics associated with their growth. Special attention will be given to oxygen level in water and the concentration in the soil of elements which might be toxic to plant growth.

SUPPORTED BY New York State Government

2.0800, EVALUATION OF SOIL AND WATER CONSERVATION DESIGN

G. LEVINE, State University of New York, Agricultural Experiment Sta., *Ithaca, New York* 14850

To evaluate the performance of soil and water conservation practices and to relate this performance to the design procedures for the purpose of improving the efficiency of these procedures. Subproject 1. Stone center drains. The performance of a representative group of stone-center drains in Central N. Y. will be evaluated. Designs based upon tractive force theory will be prepared for each drain. Constructed design will be compared with tractive force design and related to performance. Subproject 2. Contour row lengths and operational efficiency of selected farm machines. Subproject 3. Debris basin design capacity. To determine expected rates of debris accumulation, as influenced by precipitation, runoff, and geomorphological conditions. Debris accumulation in existing debris basins will be measured and correlated with local precipitation and runoff records.

SUPPORTED BY U.S. Dept. of Agriculture
New York State Government

2.0801, PHYLLOSILICATE WEATHERING IN UNCONSOLIDATED MATERIAL OF WISCONSIN AGE IN A HUMID TEMPERATURE ENVIRONMENT

M.H. MILFORD, State University of New York, Agricultural Experiment Sta., *Ithaca, New York* 14850

a. Characterization of the weathering sequences and weathering rates of inherited phyllosilicates in relation to pedogenic sequences of soil morphology as affected by differences in drainage and water movement within the soils of a catena. b. Characterization of the pedogeochemical reactions which occur in the interfacial zone between the eluvial and illuvial horizons during soil formation to produce a thickened eluvial horizon at the expense of the illuvial horizon.

Soils formed in glacially derived parent materials and representing at least three degrees of wetness within each of three lime levels (parent material) will be selected for this investigation. A study of water table fluctuation at each site will be initiated. Each soil will be described and sampled in as much detail as possible. Laboratory analyses of the samples will involve thin section studies, mechanical analysis, preparation for and conduction of mineralogical analyses, and some chemical analyses. The relationships between the data thus obtained and the observed soil-water relationships will determine the course of further investigations.

SUPPORTED BY U.S. Dept. of Agriculture
New York State Government

2.0802, MECHANISM OF FROST HEAVING

R.D. MILLER, State University of New York, School of Agriculture, *Ithaca, New York* 14850

Research has been conducted on the mechanisms of soil freezing and frost heaving in three phases. Phase I was a theoretical consideration of the mechanisms, while Phase II was an experimental study of certain predictions achieved in Phase I. During this research, it was discovered that gypsum was apparently effective in reducing frost heaving. Phase III was an independent study concerned with alleged interactions between waxes and silicone surfaces, involving studies of phase equilibria, film flow studies (of a liquid-like layer which apparently exists between ice and soil particles) and closed system heaving studies of soil particles in a moist soil without ice lens formation. Rate of heaving can be predicted although computations are rather lengthy and involved. Water movement in finely divided ice at temperatures between O degrees and -10 degrees has been shown to be quite small; approximately at the rate one would expect from vapor diffusion. This work was initiated in FY 64 and final payment made in FY 68. The final report (lettter report referring to 13 CRREL research reports authorized by letter) was submitted 24 June 1965 to the C.O. U. S. Army Cold Region Research and Engineering Laboratory, Hanover, N. H.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0803, BASIC RESEARCH IN THE AQUATIC ENVIRONMENT EFFECTS OF EUTROPHICATION ON PLANKTON ALGAE AND BENTHIC PLANTS COMMUNITIES

H.F. MULLIGAN, State University of New York, School of Agriculture, *Ithaca, New York* 14850

The composition of submerged and planktonic aquatic plant communities will be examined to determine the effects of different levels of enrichment over a period of 3 years. Six species of submerged aquatic plants will be established in the bottoms of twenty, one-quarter acre earthen ponds containing 200,000 gallons of water. Species selected include Potamogeton pectinatus, P. crispus, Myriophyllum exalbescans, Chara Vulgaris, Ceratophyllum demersum and Elodea canadensis. These plants have world wide distributions and commonly occur in abundance in the local aquatic plant flora.

Three levels of a mixture of soluble organic and inorganic fertilizers containing nitrogen and phosphorus will be added to the water of specific ponds weekly for a period of twelve weeks during the summers of 1968 and 1969. The growth of each plant species will be observed under the different enrichment regimes. The movement of the fertilizer within the aquatic ecosystem will be followed.

By beginning with an unmodified environment and adding known quantities of enrichment material, it will be possible to isolate the effects of eutrophication on planktonic and benthic plant populations and make predictions of the effects of current cultural practices.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Cornell University

2.0804, IRRIGATION STUDIES WITH TOMATOES

G.J. RALEIGH, State University of New York, Agricultural Experiment Sta., *Ithaca, New York* 14850

To evaluate the cell sap concentration method for determining the need for irrigating tomatoes, to determine the requirements for big acre yield of high quality fruit as they are affected by moisture level and regulation of the nitrogen supply and to observe the relationship between moisture, nitrogen and blossom-end rot.

Previous work on an Arkport fine sandy loam soil gave yields as high as 32 tons of Glamour tomatoes to the acre in 1962 a year of low temperatures especially in September. Yields in 1963 were somewhat lower due partially to nitrogen deficiency. An average yield of 40 tons to the acre should be a possibility on such a soil type. Excessive nitrogen delays maturity and greatly reduces yields of a variety such as Glamour if frost comes early. Inadequate nitrogen reduces yields. These relationships need additional experimentation. Several years of work with the cell sap concentration method of determining need for irrigation suggests that the method has merit but the effect of varying nutrient levels, time of making the test, and the interpretation of the deficiency index require more work. Blossom-end rot wtill remains a little known physiological disorder.

SUPPORTED BY New York State Government

2.0805, THE ECOLOGY OF SELECTED SUBMERSED AQUATIC WEEDS

E.L. STONE, State University of New York, Agricultural Experiment Sta., *Ithaca, New York* 14850

To study the growth and development of Myriophylluna, Potamogeton, Elodea, and Naias, and algae as affected by (a) chemical variables, such as nutrients and other dissolved solids, pH, and dissolved gasses, (b) physical variables, such as light, temperature, water depth and flow and turbidity, and (c) biological variables, including competition, predation, and stimulation; and to relate the results obtained to the incidence, distribution, management, and control of the above-mentioned genera. The New York station will undertake to (a) establish inorganic nutrient requirements, and optimum pH levels following chemistry of water in ponds. Single effects and interactions of light, temperature, water depth, turbidity and soil conditions on the named species will be studied. Effects of photoperiod on germination, shoot growth and flowering, as well as effects of other environmental factors on germination will be studied under controlled conditions. Effects of competition among the named genera will be investigated in the greenhouse and under field conditions. Organisms feeding on the named genera will be identified and collected. Promising leads will be investigated further as the project progresses, utilizing 1/10-acre ponds, greenhouse, and growth chamber as appropriate.

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SUPPORTED BY U.S. Dept. of Agriculture
New York State Government

2.0806, IN SITU STUDY OF FACTORS CONTROLLING NUTRIENT REGENERATIONS IN THE BOTTOM SEDIMENTS

D.A. WEBSTER, State University of New York, School of Agriculture, *Ithaca, New York* 14850

The proposed study will deal with the physical, chemical, and biological factors influencing nutrient regeneration in the sediments of four Adirondack ponds, selected for differences in water chemistry, sediment characteristics, and abundance of rooted aquatic vegetation. The relation between water chemistry, sediment chemistry, and rates of microbiological decomposition in the sediments will be used to elucidate mechanisms and rates of phosphorus regeneration. Investigation in situ by using polyethylene enclosures of selected areas of pond bottom and overlying water, makes possible the alteration and control of water and sediment chemistry, permitting simultaneous observations in the four ponds of the effects of varying organic matter levels, pH exchange capacities, and Fe, Mn, and Al concentrations on rates of microbiological activity and phosphorus regeneration.

SUPPORTED BY U.S. National Science Foundation

2.0807, INVESTIGATION OF PHOSPHORUS AVAILABILITY IN OLIGOTROPHIC LAKES

D.A. WEBSTER, State University of New York, School of Agriculture, *Ithaca, New York* 14850

The main objective of the project will be to determine the effects of lime application to sediments in an infertile lake as measured by the following factors: 1. Phosphorus fixation and distribution in the sediments. 2. Phosphate retention capacity and rate of adsorption. 3. Phosphate exchange capacity and equilibrium concentrations maintained in the interstitial water and free water over the sediments. 4. Bacterial activity in the sediments. 5. Production of benthic algae, periphyton, and phytoplankton. 6. Phosphorus content of the above forms. 7. Zooplankton standing crops and composition. 8. Development of the macro flora. 9. Fish growth and standing crop.

Additional information that will be obtained to complement the field program consists of: 1. Determining the relative significance of bacterial and inorganic phosphate transfer between sediments and water. 2. Comparative contributions of phosphorus to the lake from the bottom sediments allochthonous sources will be evaluated by determining phosphate exchange rates, exchange capacity, and diffusion coefficients of the mud-water system and monitoring phosphorus inputs and losses.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Cornell University

2.0808, THE ENERGY BUDGET AT THE EARTHS SURFACE

E.R. LEMON, U.S. Dept. of Agriculture, *Ithaca, New York*

Object: To measure, understand, and control the plant, soil, and meteorological interaction involved in the partition of energy at the earth's surface.

Plan of work: (1) Experimental and theoretical methods will be employed to increase the understanding of carbon dioxide and water vapor transfer by turbulent processes near the ground in agricultural crops. (2) Methods of crop management to increase the turbulent transfer of carbon dioxide will be investigated. (3) Controlled experiments in an aerophytotron (wind tunnel) will be aimed at further understanding of facts controlling heat and water vapor exchange directly from the soil. (4) The effect of soil moisture, ambient temperature, humidity, radiant energy (quantity and quality), and other factors on transpiration and stomatal behavior under different controlled conditions will be evaluated. (5) Methods will be explored for controlling transpiration and stomatal behavior.

SUPPORTED BY U.S. Dept. of Agriculture

2.0809, QUANTITATIVE WATER-BUDGET ANALYSIS OF WESTERN LONG ISLAND, NEW YORK

O.L. FRANKE, U.S. Dept. of Interior, Water Resources Division, *Mineola, New York* 11501

This research is part of the program of water resources investigations carried on in cooperation with the Counties of Nassau and Suffolk, New York.

The purpose of this research is to review the continuity principle (hydrologic-budget concept) as it applies to the entire hydrologic system and to the ground-water subsystem of western Long Island.

This will be based on a hydrologic budget estimated for predevelopment (natural) conditions; and on hydrologic budgets for the entire project area and for subareas, designated on the basis of the degree of development (or overdevelopment), for selected subsequent time intervals. These budgets will demonstrate quantitatively the impact of man's activities on the hydrologic regimen and how those activities have affected the perennial yield of the system. The relation of the continuity principle to virtually all quantitative management decisions will be sought by means of specific evaluations of the hydrologic effects of proposed alternative methods of development -- especially those proposed for managing the ground-water resources of Nassau County.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Nassau County Government - New York
Suffolk County Government - New York

2.0810, STUDY OF INFLUENCE OF STRATIFICATION ON CURRENT STRUCTURE

G. NEUMANN, New York University, School of Engineering, *New York, New York* 10003

This research proposal is concerned with the study of the circulation of Lake Michigan. Rotary currents with the local inertial period have been found to be very prominent in the data and frequently mask other long and short term current variations. In order to obtain more definitive clues as to their nature, it is proposed to separate these currents from the data by a least squares technique. This will enable us to study not only the vertical and horizontal structure of these rotary currents but also the residual circulation that remains after the rotary current has been subtracted.

SUPPORTED BY U.S. National Science Foundation

2.0811, MEASUREMENT OF WATER VAPOR FLUX ABOVE A LAKE SURFACE BY MEANS OF OPTICAL TECHNIQUES

E.E. CHERMACK, State University of New York, Graduate School, *Oswego, New York* 13126

The substance of this project is to measure the humidity profile in the atmosphere above an evaporating surface by means of infrared transmission measurements. Transmission of radiant energy through an atmosphere is determined primarily by attenuation due to scattering and absorption, both of which are wavelength dependent. If the transmission over a known physical distance is measured for two beams of light, closely separated in wavelength, the transmission of a wavelength within an absorption region of water vapor will be appreciably lower than the transmission of a wavelength just outside the absorbing spectral region. The variation in the ratio of the two transmissions should then be an indication of the variation in total water vapor along the physical transmission path.

The research effort here is to determine the feasibility of such an experiment, particularly with regard to the problems engendered by molecular and aerosol scattering losses. If such can be overcome by judicious choice of wavelength interval and scheduling of subsidiary experimental measurements, selection and design of the transmitter, receiver and recording apparatus will get underway, with field experiments over the surface of Lake Ontario near Oswego to follow.

SUPPORTED BY State University of New York

2.0812, CHAMPLAIN VALLEY PRECIPITATION STUDY

M.H. TOURIN, State University of New York, Graduate School, *Plattsburgh, New York* 12901

This project is a pilot study to determine the effects, if any, of the Plattsburgh industrial area (mainly wood pulp processing) on precipitation characteristics in the Champlain Valley. To achieve the objectives of the study, a rain gauge network has been set up over a portion of the Valley and the variation of rainfall intensity and sulfur content is being documented. These variations are being correlated to wind speed and direction. In addition, Lake temperature, air temperature above the Lake, and dew point above the Lake are being determined in the vicinity of the industrial area, and also at a distant control location. These parameters, combined with wind and temperature data on land, are also being used to determine evaporation anomalies and an objective lake breeze index.

SUPPORTED BY State University of New York
U.S. National Science Foundation

2.0813, FISH MOVEMENTS IN THE NORTH INLET OF WOLF LAKE, HUNTINGTON FOREST

R.W. BERNHARDT, State University of New York, Graduate School, *Syracuse, New York* 13210

Objective: To study the movement behavior of brook trout and other fish in a small Adirondack stream. To correlate these movements with environmental factors such as water flow, water temperature, cover, time of spawning, and presence of other species of fish.

Progress: 1) The installation of recording thermographs, water level recorder, two-way fish trap at the mouth of the stream, and numerous portable fish traps in the stream. 2) The tagging of several hundred brook trout and the subsequent capturing of many of them.

Plans: Intensive trapping of the fish population, tagging and recapture, to determine movement patterns.

SUPPORTED BY New York State Government

2.0814, A COMPARATIVE STUDY OF THE MACROSCOPIC BENTHIC FAUNA OF TWO CENTRAL ADIRONDACK LAKES

R.W. BERNHARDT, Syracuse University, Graduate School, *Syracuse, New York* 13210

Objective: 1. Determine what species make up the benthic fauna of Catlin and Wolf Lakes. 2. Study the benthic animal communities, their species composition, distribution and seasonal change.

Progress: The species composition of the bottom fauna is at present (1964) being determined. The taxonomic groups, Ephemoroptera, Odonata, and Trichoptera have been worked over. The order Diptera is being worked on at present.

Plans: 1. The continuance of the taxonomic work on the rest of the groups. Have the species identifications checked by specialists. 2. Begin the final report in 1965.

SUPPORTED BY New York State Government

2.0815, FOREST TREE NUTRITION AND FOREST FERTILIZATION

A.L. LEAF, Syracuse University, Graduate School, *Syracuse, New York* 13210

Objective: To determine nutrient element effects on soil fertility and their interaction with soil moisture as expressed by growth and development of, and nutrient element uptake and distribution in trees. To gain an understanding of the fundamentals of the nutritional aspects of tree growth and development, research continues on coniferous species in fertilized and/or irrigated and unfertilized plantations supported by nutrient element deficient, deep sandy soils.

Research Program: 1) Irrigation-fertilization study to determine moisture - potassium fertilization effects on growth and development, and uptake and distribution of nutrient elements of Pinus resinosa Ait. plantations on soils of various degrees of potassium deficiency. 2) Total tree analysis study of nutrient uptake and distribution in various treated and control plots of various coniferous species. 3) Root growth and development of 35-year-old Pinus resinosa on potassium deficient and nondeficient plots on deep outwash sandy soil. 4) Chemical analysis of various tree components for N,P,K,Ca,Mg,Na,A1,B,Co,C ,Fe, Mn,Si,Zn by spectrophotometric, flame spectrophotometric and atomic-absorption spectrophotometric techniques. All research conducted on the Charles Lathrop Pack Forest in southeastern Adirondack Region of New York.

SUPPORTED BY U.S. National Science Foundation

2.0816, DIATOM POPULATIONS CHANGES IN LAKE GEORGE

N.L. CLESCERI, Rensselaer Polytechnic Inst. , School of Engineering, *Troy, New York* 12181

The proposed research is directed towards characterizing and measuring the diatom populations in the plankton and periphyton found over an extended period of time at various depths and locations in Lake George, New York. This work is expected to provide the biological data needed to establish the pattern and rate of eutrophication in this popular recreational lake and is an essential part of a comprehensive interdisciplinary study of a limnological model for Lake George being conducted by the Rensselaer Polytechnic Institute. The identification and measurement of the principal diatom species by light and electron microscopy along with the measurement of total plankton and periphyton by microscopy, gravimetry and extraction- spectrophotometry, when correlated with the other detailed measurements (temperature, light intensity, water quality) which will be made at the same depths and locations can be utilized to identify the causative factors for the biological changes taking place.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

2.0817, ESTUARINE BIOLOGY--RESPONSE OF LARVAE TO TEMPERATURE AND SALINITY

R.M. LICHTENHEK, U.S. Dept. of Interior, Biological Laboratory, *Beaufort, North Carolina* 28516

Atlantic menhaden hatch in the ocean and migrate into shallow estuarine nursery areas as larvae. The effect of temperature and salinity on survival may be a determining factor in year class size. Field observations have shown that low temperatures delayed entry of larvae into the estuary from the ocean and after establishment in the nurseries, caused massive mortalities. Laboratory experiments were conducted to determine the lethal temperatures. Preliminary findings confirmed the field observations that 3 degrees C. may be the lower limit at estuarine salinities.

Plans are underway to continue the laboratory work when larvae become available in January 1964. Methods consist of holding larvae at various temperatures and salinities, with and without acclimatization to lower temperatures, to determine the lethal limit of chilling.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

2.0818, PRODUCTIVITY OF ESTUARINE AND MARINE ECOSYSTEMS (A COOPERATIVE AGREEMENT WITH THE ATOMIC ENERGY COMMISSION)

R.B. WILLIAMS, U.S. Dept. of Interior, Radiobiological Lab. , *Beaufort, North Carolina* 28516

All life ultimately depends on autotrophic organisms. Therefore, knowledge of primary production in estuaries is required for evaluation of their potential to produce commercially important fish and shellfish and for elucidation of the movement of radionuclides through estuarine food chains into edible species. The primary production of phytoplankton and benthic algae, two groups of autotrophs important in the characteristically shallow southeastern estuaries, is being measured at regular intervals in inshore waters near Beaufort, N. C. Phytoplankton production is estimated by the light and dark bottle technique. Bottles of seawater (with zooplankton removed by filtration) are incubated for 24 hours at several fractions of surface illumination, and changes in dissolved oxygen are determined by titration. To estimate benthic production, areas of bottom are enclosed (in situ) for 24 hours beneath clear and opaque plastic bell jars, and changes in dissolved oxygen within the jars are obtained by titration of water samples withdrawn from them. In addition, measurements of standing crop accompany the measurements of production.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

2.0819, MEASUREMENT OF RADIONUCLIDES IN ESTUARINE AND MARINE ENVIRONMENTS (A COOPERATIVE AGREEMENT WITH ATOMIC ENERGY COMMISSION)

D.A. WOLFE, U.S. Dept. of Interior, Radiobiological Lab. , *Beaufort, North Carolina* 28516

Many scientists have been concerned with the potential effects on marine organisms of low-level radioactive wastes from nuclear reactors on land as well as those on ships and submarines. Additionally, fission products from nuclear weapons are now found in the biosphere. To evaluate the ecological effects of radionuclides on organisms of commercial importance, it is necessary to know the quality, quantity, and form of radionuclides in estuarine and marine environments. These data are needed now so they can be utilized to establish base lines for existing levels of radioactivity in various components of estuarine and marine ecosystems, and so the mechanisms of uptake in the passage of radionuclides through food chains can be investigated.

Large samples of biological materials (1 kg.) are collected for analyses. These samples are either dry ashed or wet ashed to reduce the volume and to provide homogeneous samples. The gamma activity of the samples is then measured with a low background detection system consisting of a multichannel analyzer and a 4 x 4-inch sodium iodide crystal-detector housed in a 7-ton shield. The data for each sample are stored on binary-coded punched tapes which can be used in a computer for comparisons with the radioactivity of future or past samples.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

2.0820, OPTIMUM ECOLOGICAL DESIGNS FOR ESTUARINE SYSTEMS OF NORTH CAROLINA

H.T. ODUM, Univ. of North Carolina, Inst. of Marine Science, *Chapel Hill, North Carolina* 27514

This project will provide information on the feasibility of establishing associations of organisms in estuaries which can process man's wastes, metabolize inflow, develop the missing loops of the mineral cycles, and channel the fertility into one or more populations with food potential. Nine marine ponds will be constructed in a high marsh area along the coast of North Carolina. Three of the ponds will be continually seeded with mixtures of marine organisms (larvae, adults, plankton, micro-organisms, etc.) and will receive a steady flow of urban waste mixed with sea water. Three ponds will be seeded, but will be supplied only with sea water, i.e., no wastes. The remaining three ponds will receive the wastes mixed with sea water, but will not be seeded artificially.

Principal populations, some principal nutrient cycles and the total photosynthetic production and system respiration will be measured. Those populations of larger organisms which develop in large mass will be studied for growth rate and not production per area of meat potential.

SUPPORTED BY U.S. National Science Foundation

2.0821, COMPUTER SIMULATION OF AQUIFERS OF COASTAL PLAIN OF NORTH CAROLINA

J.K. SHERWANI, Univ. of North Carolina, School of Public Health, *Chapel Hill, North Carolina* 27514

Ground water management in the Coastal Region of North Carolina is the foremost water resource problem in the State due to the massive impact of large concentrated withdrawls by the existing and proposed phosphate mining operations. The limestone artesian aquifer involved (Castle Hayne) is the most important source of fresh water for agricultural, municipal, and industrial use in the area. Salt water intrusion poses a potential threat. The objective of the project is to investigate the dynamic behavior of the Castle Hayne aquifer. Three stages of the study are envisioned: (1) System identification through a specification of the aquifer characteristics at different locations and of the boundary configuration. General purpose analog and digital computers will be used in this phase; (2) Direct Analog model; a passive resistance-capacitance network will be constructed to model the ground water system in greater detail; (3) Prediction of Response; i.e., to forecast the water level changes under different assumed conditions of replenishment and extraction. Passive analog and digital computers will be used in this phase. The project will be started in FY 1968 and is anticipated to be completed by the end of FY 1970.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of North Carolina

2.0822, COMPUTER SIMULATION OF AQUIFERS OF COASTAL PLAIN OF NORTH CAROLINA

J.K. SHERWANI, Univ. of North Carolina, School of Public Health, *Chapel Hill, North Carolina* 27514

Ground water management in the Coastal Region of North Carolina is the foremost water resource problem in the State due to the massive impact of large concentrated withdrawals by the existing and proposed phosphate mining operations. The limestone artesian aquifer involved (Castle Hayne) is the most important source of fresh water for agricultural minicipal, and industrial use in the area. Salt water intrusion poses a potential threat. The objective of the project is to investigate the dynamic behavior of the Castle Hayne aquifer. Three stages of the study are envisioned: (1) System identification through a specification of the aquifer characteristics at different locations and of the boundary configuration. General purpose analog and digital computers will be used in this phase; (2) Direct Analog model: a passive resistance-capacitance network will be constructed to model the ground water system in greater detail; (3) Prediction of Response; i.e., to forecast the water level changes under different assumed conditions of replenishment and extraction. Passive analog and digital computers will be used in this phase.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of North Carolina
North Carolina State Government

2.0823, MULTIPURPOSE RESERVOIRS AND URBAN DEVELOPMENT

S.F. WEISS, Univ. of North Carolina, Graduate School, *Chapel Hill, North Carolina* 27514

The proposed research seeks to develop the foundations of a forecast model which may be utilized to predict the pattern of development surrounding large multipurpose reservoirs. The research plan is based on a conceptual framework and approach to the study of land development that has evolved at the Center for Urban and Regional Studies, in Chapel Hill, during the past ten years. This approach views land development as the result of the interaction between environmental influences flowing from physical characteristics on the site, location of the site relative to activity nodes and the spatial pattern of social values, and institutional factors (such as the matrix of federal, state, and local policies) and a chain of key primary and supporting decisions made by various agents in the development process.

By focusing on the chain-like nature of the land development process, attention is drawn to the set of factors which influence decisional behavior -- the decision of the predevelopment land owner to sell to a developing agent; the decision of the development entre- preneur to consider the site, purchase and develop it; and the consumer's decision to utilize the finished product. By isolating influences on these decisions which are affected by public policies, the formulation and testing of alternative policy mixes for their effectiveness in promoting desirable land development patterns contiguous to large multipurpose reservoirs.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of North Carolina
North Carolina State Government

2.0824, ATLANTIC COASTAL PLAIN - PERMEABILITY DISTRIBUTION STUDY

P.M. BROWN, U.S. Dept. of Interior, Water Resources Division, *Raleigh, North Carolina* 27607

Examination of sediments along the Atlantic Coast Plain indicates a pulsating sedimentary environment characterized by cyclic transgressive, regressive, and static stages. Determination of some of the axes of the transgressive stages within the basin indicate that they each have a preferred orientation in relation to their position on the flank of the basin. For example, the axis line of a transgressive stage, located in the northwest quadrant, is N. W. E. whereas, the axis line of a transgressive stage, located in the southwest quadrant, is S. W. applies to regressive stages, which, depending upon their location within the mobile basin, have axes that coincide with or that deviate as much as 90o from the axes of related transgressive stages.

The shift in depositional axes results from differential mobility of structures transverse to the long axes of the Atlantic Basin. The objective is to study the depositional controls and environment on a regional scale and relate the depositional controls and environment on a regional scale and relate the depositional history to spatial changes in the primary permeability of successive stratigraphic units.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0825, HYDROLOGY OF THE CRYSTALLINE ROCK SYSTEM IN SOUTHEASTERN STATES

H.E. LEGRAND, U.S. Dept. of Interior, Water Resources Division, *Raleigh, North Carolina* 27607

To determine relationship between the geohydrologic factors and occurrence and movement of water in crystalline rocks in unglaciated areas in Piedmont and Blue Ridge Provinces between Maryland and Alabama. Particular attention is being given to the factors governing the yields of wells in these rocks and to factors relating to ground- water contamination in the region.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0826, SALT-WATER ENCROACHMENT IN NORTH CAROLINA ESTUARIES

H.B. WILDER, U.S. Dept. of Interior, Water Resources Division, *Raleigh, North Carolina* 27607

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of North Carolina.

Purpose: To determine the variations in flow and chemical quality of water in North Carolina sounds and estuaries so that decisions may be made regarding industrial utilization of the water.

Methods: Collect and analyze water samples, plot dispersion pattern compile and collate hydrologic information from various sources and prepare an interpretive report on the estuaries.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
North Carolina State Government

2.0827, SOD AND STUBBLE MULCH PLANTING - VEGETATION CONTROL

G.C. KLINGMAN, Univ. of North Carolina, Agricultural Experiment Sta. , *Raleigh, North Carolina* 27600

Sod planting and stubble mulch planting has the potential of reducing soil eroision, reducing water loss in the form of both run- off and surface evaporation, reducing silting of rivers, streams and dams, making crop production possible on relatively steep, rocky soils not now suitable for crop production. It is believed that the above can be done without sacrificing crop yields.

Feed costs constitute a major cost in the production of beef, dairy and poultry products. With the long growing season found in the Southeast United States, it would appear that the program is especially well sutied to North Carolina. Full development of this potential could tremendously increase the south's advantage over the Cornbelt and Northeastern States.

More specifically the objectives are as follows: 1. To synthesize and develop dynamic ecological systems for efficiently producing grain and forage while maintaining continuous soil mulch cover, and 2. To reduce soil erosion and water loss through runoff and evaporation.

SUPPORTED BY North Carolina State Government

2.0828, WATER TABLE CONTROL AND SUBSURFACE IRRIGATION IN MINERAL AND HIGH ORGANIC COASTAL PLAIN SOILS

G.J. KRIZ, Univ. of North Carolina, School of Agriculture, *Raleigh, North Carolina* 27600

There is approximately 3 million acres of mineral and high organic soils in the Lower Coastal Plains of North Carolina. Much of this area is being cleared and drained for agricultural and forestry purposes. In order to prevent excessive subsidence, criteria for efficient water management must be developed. The objectives of this project are to determine the water table fluctuations in a given area or land, to determine the vertical and lateral water movement within the soil profile and control and water table by ditch and tile subirrigation.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
North Carolina State University

2.0829, INTERRELATIONSHIPS OF SOIL PHYSICAL PROPERTIES AND SOIL WATER MOVEMENTS

J.F. LUTZ, Univ. of North Carolina, Agricultural Experiment Sta. , *Raleigh, North Carolina* 27600

Determine draw-down patterns of water table by use of electric analogue. Attempt to measure hydraulic conductivity of undisturbed soil cores and relate it to soil properties. Study nature and magnitude of forces holding water films on clays and relate these to hydraulic conductivity.

Description of Work (a) Further work will be done on the effects of phosphate on the colloidal-physical-chemical properties of clays especially on the hydration of the clay particles and on micro aggregation, or flocculation. (b) Soil moisture tension studies will be made on a number of North Carolina soils with emphasis on field capacity and wilting percentage determinations. This will be a continuation of some of the work which has been done during the past year. (c) Soil moisture and bulk density determinations will be made on soils under a number of different cultural management and tillage practices to determine the effects of these different practices upon the properties mentioned.

SUPPORTED BY U.S. Dept. of Agriculture
North Carolina State Government

2.0830, COOPERATIVE RESEARCH PROJECT IN WESTERN NORTH CAROLINA

P.C. SPATH, Univ. of North Carolina, School of Agriculture, *Raleigh, North Carolina* 27600

Research begun in January 1949 to determine water-land relationships for some of the principal soils and important crops used for agricultural purposes in western North Carolina, to provide basic information needed to know how best to utilize these lands for agricultural purposes, with proper consideration for conservation of both land and water resources.

Four watersheds of 3 to 5 acres in area were treated with four different covers rotated under a statistical Latin square design. Covers are improved clover-grass pasture, overgrazed heavily trampled improved pasture, wheat with lespedeza for summer cover, and corn.

Hydrologic determinations are being made to evaluate detailed physical relationships between soils, land use, and water. The effects upon the hydrologic characteristics of the four watersheds under the different covers are being determined. Hydrologic observations include precipitation, surface-water and ground-water runoff, ground-water levels, soil temperature, evaporation, wind velocity, evapotranspiration, dewfall, air temperature, sunshine, and relative humidity.

Electronic computers are used in evaluating equations to determine the significance of hydrologic changes. Detail study of project data is resulting in new concepts of runoff that are proving useful not only for achieving project objectives but also in other hydrologic studies. Results to date are summarized in annual reports. Work is in the twentieth year. Field work has been completed.

Two of the four watersheds were discontinued in 1966 as part of the basic study. One of these was instrumented as part of a short-term but intensive investigation into evapotranspiration and interflow. The two watersheds were instrumented in 1968 as part of an investigation of pesticide dispersion.

SUPPORTED BY U.S. Tennessee Valley Auth.

2.0831, WEATHER MODIFICATION IN NORTH DAKOTA

A.F. BUTCHBAKER, North Dakota State University, Agricultural Experiment Sta. , *Fargo, North Dakota* 58102

Objectives: 1. To characterize the climatology of hail storms in southwestern North Dakota. 2. To determine whether seeding convective storms causes a reduction in intensity of hail and impact energy of hailstorms and causes changes in other hail parameters in seeded areas as compared with adjacent nonseeded areas. 3. To determine whether seeding clouds with silver iodide causes a precipitation increase in seeded areas and a possible 'rain shadow' downwind from commercial weather modification areas.

In North Dakota, hail and drought losses amount to about 50% of all Federal Crop Insurance payments for crop losses due to natural hazards. A group of farmers in southwestern North Dakota are seeding storms with silver iodide in an effort to suppress hail. In addition, a weather modification firm seeds clouds in the north-central part of the state for precipitation increase.

Crop loss and precipitation records will be analyzed. Hail impact energy will be determined from dents on aluminum foil. Storm information will be collected from hail indicators, rain gauges, radar data, daily weather maps, and questionnaires. This data will be analyzed to statistically determine the seeding effects.

SUPPORTED BY U.S. Dept. of Agriculture
North Dakota State Government

2.0832, EFFECTS OF GROUNDWATER SEEPAGE ON STREAM REGIMEN
L. CLAYTON, North Dakota State University, State Water Resources Inst, *Fargo, North Dakota* 58102

The proposed research will be a study of the quantitative and qualitative influence of groundwater seepage pressure on the various erosive and transport characteristics of streams. The research will consist of both laboratory and field studies.

In previous laboratory studies using stream flumes, the influence of groundwater has been largely ignored; many empirical hydrologic relationships have been established in flumes lacking any groundwater control. For the proposed study, two stream flumes with groundwater control will be constructed. The threshold velocity of grain transport with various groundwater seepage pressures in various bed materials will be measured in a small flume with constant cross-section. The relation between seepage and channel characteristics will be observed in a larger flume.

In the field study, the channel and bed-material characteristics of several small drainage basins in western North Dakota will be mapped. These characteristics will be compared with measured groundwater characteristics, including the seepage pressure and the amount and direction of flow. Relationships established in the flumes will be tested in the field streams, and problems encountered in the field will be studied in the laboratory flumes.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
North Dakota State University

2.0833, A LIMNOLOGICAL STUDY OF SPIRITWOOD, NORTH DAKOTA - WATER QUALITY AND SEASONAL CYCLES
G.W. COMITA, North Dakota State University, Graduate School, *Fargo, North Dakota* 58102

It is proposed to study Spiritwood Lake, N. D. by measuring temperature, transparency, pH, conductivity, and take appropriate water samples for analysis of NH3, NO2, PO4, O2, Fe and alkalinity, phytoplankton and zooplankton at weekly intervals during the colder part of the year and semi weekly during the warm part of the year. Primary production will be measured at appropriate intervals. An analysis of these data will provide the basis for lake management by the North Dakota State Game and Fish Department for recreational purposes. These data will provide the basis for comparison of the cyclical events in nutrients, phytoplankton and zooplankton between this lake and another much shallower and smaller which sustains similar organisms but less total dissolved solids.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
North Dakota State University

2.0834, DROUGHT INJURY AND RESISTANCE IN PLANTS
K.L. LARSON, North Dakota State University, Agricultural Experiment Sta., *Fargo, North Dakota* 58102

Objectives: 1. To determine the association between plant water stress and various nitrogenous fractions and sulfhydryls in plant parts of alfalfa and barley at different stages of maturity. 2. To determine how and to what degree the water status of plants is (a) related to growth and development, (b) influenced by physical factors of the environment. 3. To determine what stages of growth are most critical for water utilization.

Plants of Vernal alfalfa and Trophy barley will be grown in the greenhouse and growth chambers at low and high plant moisture stresses, initially at uniform temperatures. As moisture stress increases, simulating drought conditions, changes in nitrogenous fractions, RNA and SH groups within the roots and tops of alfalfa and roots, stems and leaves, and grain of barley will be determined by standard biochemical procedures. These determinations will be made at 4 stages of growth. Additional plants will be subjected to drought conditions at various stages of growth to determine the critical times for efficient water utilization. The effect of these moisture stresses on the above constituents will be determined.

SUPPORTED BY U.S. Dept. of Agriculture
North Dakota State Government

2.0835, IRRIGATION AND WATER CONSERVATION
H.M. OLSON, North Dakota State University, Agricultural Experiment Sta., *Fargo, North Dakota* 58102

Location of the Carrington Irrigation Substation is in, and representative of, the area to be irrigated from the Garrison Dam when that project is funded. Water is now obtained by pumping from an aquifer with water quality reasonably comparable to that of the Missouri River. Initial studies are designed to determine the effects of supplemental irrigation on crop production and the possibility of introducing specialty crops not now grown because of inadequate rainfall. Expanded program calls for research on improved irrigation techniques, control of water evaporation, moisture-fertility relationships. As the station program expands, livestock will be incorporated into the research program and a broad study of dryland and irrigation farming involving both crop and livestock production will be developed.

SUPPORTED BY North Dakota State Government

2.0836, THE EFFICIENCY OF WATER USE UNDER VARYING CONDITIONS OF PLANT WATER STRESS
G.E. WILKINSON, North Dakota State University, Agricultural Experiment Sta., *Fargo, North Dakota* 58102

1. To measure the plant moisture characteristics of selected crops relative to soil moisture conditions. 2. To evaluate the influence of soil and atmospheric environment on plant water stress. 3. To relate plant performance to variations in (a) plant water stress and (b) the soil and climatic environment.

Greenhouse studies will test the methods for evaluating plant water stress. Methods which may be suitable for field use will be related to the energy level of water in the plant. Then barley will be grown in field plots and lysimeters from which evapotranspiration can be measured. Plant leaf sections will be tested periodically to anticipate predetermined plant water stress levels at which water will be applied to the soil. Yields will be related to the water stress history and to soil and climatic conditions under which the crop will be grown to determine the optimum environmental conditions which produce the highest yield per unit of water used.

SUPPORTED BY U.S. Dept. of Agriculture
North Dakota State Government

2.0837, GEOLOGY AND GROUND WATER RESOURCES OF TRAILL COUNTY
W.M. LAIRD, State Geol. Survey, *Grand Forks, North Dakota*

This report is in three parts. Part I describes the geology. Part II presents ground water basic data and Part III describes the ground water resources.

Part I involves surface mapping of the glacial and/or bedrock deposits. Part II includes a survey of existing wells and information obtained from a test hole drilling program. Part III describes the aquifers in terms of areal extent, chemical quality and water-bearing characteristics.

SUPPORTED BY North Dakota State Government
U.S. Dept. of Interior - Geological Survey

2.0838, GEOLOGY AND GROUND WATER RESOURCES OF WELLS COUNTY
W.M. LAIRD, State Geol. Survey, *Grand Forks, North Dakota*

This report is in three parts. Part I describes the geology. Part II presents ground water basic data and Part III describes the ground water resources.

Part I involves surface mapping of the glacial and/or bedrock deposits. Part II includes a survey of existing wells and information obtained from a test hole drilling program. Part III describes the aquifers in terms of areal extent, chemical quality and water-bearing characteristics.

SUPPORTED BY North Dakota State Government
U.S. Dept. of Interior - Geological Survey

2.0839, GEOLOGY AND GROUND WATER RESOURCES OF GRAND FORKS COUNTY
W.M. LAIRD, State Geol. Survey, *Grand Forks, North Dakota*

This report is in three parts. Part I describes the geology. Part II presents ground water basic data and Part III describes the ground water resources.

Part I involves surface mapping of the glacial and/or bedrock deposits. Part II includes a survey of existing wells and information obtained from a test hole drilling program. Part III describes the aquifers in terms of areal extent, chemical quality and water-bearing characteristics.

SUPPORTED BY North Dakota State Government
U.S. Dept. of Interior - Geological Survey

2.0840, GEOLOGY AND GROUND WATER RESOURCES OF WILLIAMS COUNTY
W.M. LAIRD, State Geol. Survey, *Grand Forks, North Dakota*

This report is in three parts. Part I describes the geology. Part II presents ground water basic data and Part III describes the ground water resources.

Part I involves surface mapping of the glacial and/or bedrock deposits. Part II includes a survey of existing wells and information obtained from a test hole drilling program. Part III describes the aquifers in terms of areal extent, chemical quality and water-bearing characteristics.

SUPPORTED BY North Dakota State Government
U.S. Dept. of Interior - Geological Survey

2.0841, GEOLOGY AND GROUND WATER RESOURCES OF WARD COUNTY
W.M. LAIRD, State Geol. Survey, *Grand Forks, North Dakota*

This report is in three parts. Part I describes the geology. Part II presents ground water basic data and Part III describes the ground water resources.

Part I involves surface mapping of the glacial and/or bedrock deposits. Part II includes a survey of existing wells and information obtained from a test hole drilling program. Part III describes the aquifers in terms of areal extent, chemical quality, and water-bearing characteristics.

Part II published; Parts I and III in progress.

SUPPORTED BY North Dakota State Government
U.S. Dept. of Interior - Geological Survey

2.0842, GEOLOGY AND GROUND WATER RESOURCES OF BURKE COUNTY
W.M. LAIRD, State Geol. Survey, *Grand Forks, North Dakota*

This report is in three parts. Part I describes the geology. Part II presents ground water basic data and Part III describes the ground water resources.

Part I involves surface mapping of the glacial and/or bedrock deposits. Part II includes a survey of existing wells and information obtained from a test hole drilling program. Part III describes the aquifers in terms of areal extent, chemical quality and water-bearing characteristics.

SUPPORTED BY North Dakota State Government
U.S. Dept. of Interior - Geological Survey

2.0843, GEOLOGY AND GROUND WATER RESOURCES OF RENVILLE COUNTY
W.M. LAIRD, State Geol. Survey, *Grand Forks, North Dakota*

This report is in three parts. Part I describes the geology. Part II presents ground water basic data and Part III describes the ground water resources.

Part I involves surface mapping of the glacial and/or bedrock deposits. Part II includes a survey of existing wells and information obtained from a test hole drilling program. Part III describes the aquifers in terms of areal extent, chemical quality, and water-bearing characteristics.

Part II published; Parts I and III in progress.

SUPPORTED BY North Dakota State Government
U.S. Dept. of Interior - Geological Survey

2.0844, GEOLOGY AND GROUND WATER RESOURCES OF PEMBINA COUNTY
W.M. LAIRD, State Geol. Survey, *Grand Forks, North Dakota*

This report is in three parts. Part I describes the geology. Part II presents ground water basic data and Part III describes the ground water resources.

Part I involves surface mapping of the glacial and/or bedrock deposits. Part II includes a survey of existing wells and information obtained from a test hole drilling program. Part III descirbes the aquifers in terms of areal extent, chemical quality and water-bearing characteristics.

SUPPORTED BY North Dakota State Government
U.S. Dept. of Interior - Geological Survey

2.0845, GEOLOGY AND GROUND WATER RESOURCES OF NELSON COUNTY
W.M. LAIRD, State Geol. Survey, *Grand Forks, North Dakota*

This report is in three parts. Part I describes the geology. Part II presents ground water basic data and Part III describes the ground water resources.

Part I involves surface mapping of the glacial and/or bedrock deposits. Part II includes a survey of existing wells and information obtained from a test hole drilling program. Part III describes the aquifers in terms of areal extent, chemical quality and water-bearing characteristics.

SUPPORTED BY North Dakota State Government
U.S. Dept. of Interior - Geological Survey

2.0846, GEOLOGY AND GROUND WATER RESOURCES OF WALSH COUNTY
W.M. LAIRD, State Geol. Survey, *Grand Forks, North Dakota*

This report is in three parts. Part I describes the geology. Part II presents ground water basic data and Part III describes the ground water resources.

Part I involves surface mapping of the glacial and/or bedrock deposits. Part II includes a survey of existing wells and information obtained from a test hole drilling program. Part III describes the aquifers in terms of areal extent, chemical quality and water-bearing characteristics.

SUPPORTED BY North Dakota State Government
U.S. Dept. of Interior - Geological Survey

2.0847, GEOLOGY AND GROUND WATER RESOURCES OF CAVALIER COUNTY
W.M. LAIRD, State Geol. Survey, *Grand Forks, North Dakota*

This report is in three parts. Part I describes the geology. Part II presents ground water basic data and Part III describes the ground water resources.

Part I involves surface mapping of the glacial and/or bedrock deposits. Part II includes a survey of existing wells and information obtained from a test hole drilling program. Part III describes the aquifers in terms of areal extent, chemical quality and water-bearing characteristics.

SUPPORTED BY North Dakota State Government
U.S. Dept. of Interior - Geological Survey

2.0848, RAINWASH AND SOIL CREEP IN WESTERN NORTH DAKOTA

L. CLAYTON, Univ. of North Dakota, Graduate School, *Grand Forks, North Dakota* 58202

The proposed research involves the field and laboratory investigation of slope processes, of rates of slope erosion, and of the drainage basin characteristics of two drainage areas in the badlands of western North Dakota. The field work will involve the study of types of slope processes, their intensity, their rates, and their relationship to climate and lithologic conditions. Direct observation and observation through time will be made to record changes in landscape features. Procedures to be followed are: 1. Direct observation of slope processes. 2. To observe and study the microclimatic factors of the area, its influence on slope processes, and landform development. 3. To measure rates of hillslope erosion through time. 4. To establish transverse level profiles of valley walls and to record the profile variation through time. 5. To establish permanent photo stations of valley walls. 6. To establish rain gages throughout the drainage basins.

The laboratory work involves a quantitative study of the 'form' factors of the drainage basin following Horton's and Strahler's work. Parameters to be considered are drainage density, stream frequency, hypsometric integral, Horton's number, basin shape, constant of channel maintenance, and ruggedness.

The research will be of importance to future agricultural and conservational projects in this area of North Dakota.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of North Dakota

2.0849, REGIMEN OF THE MARTIN RIVER AND SIOUX GLACIERS, ALASKA

J.R. REID, Univ. of North Dakota, Graduate School, *Grand Forks, North Dakota* 58202

NO SUMMARY HAS BEEN PROVIDED TO THE SCIENCE INFORMATION EXCHANGE

SUPPORTED BY U.S. National Science Foundation

2.0850, LIMNOLOGICAL INVESTIGATIONS OF PRAIRIE POTHOLES

G.A. SWANSON, U.S. Dept. of Interior, Northern Pr. Wlfe. Res. Ctr., *Jamestown, North Dakota*

Objectives: To initiate, on the prairie pothole area of North Dakota, a limnological investigation to study the relationships that exist between organisms comprising the plant and animal communities and their relative contribution to waterfowl production. The initial phase of this investigation will be devoted to developing techniques to sample the varying habitats of prairie potholes.

Procedures: A literature survey will be conducted to compile information on limnological equipment, sampling techniques and previous limnological investigations of waterfowl habitat.

Equipment will be developed to quantitatively sample aquatic invertebrates associated with the benthos, plankton and aquatic macrophytes of prairie potholes.

Statistical procedures will be utilized to determine the sampling intensity required to obtain a precision that is economically feasible. Potholes selected for intensive sampling will be screened by dominant cover type and water chemistry.

Waterfowl will be collected on intensively sampled potholes and their esophageal, proventricular and gizzard food contents will be examined and related to food availability as determined by limnological sampling.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

2.0851, GROUND WATER BASIN DYNAMICS

H.C. PREUL, Univ. of Cincinnati, School of Engineering, *Cincinnati, Ohio* 45221

The specific aim of this research plan is to study the dynamics of ground water basin by mathematical analysis, laboratory studies and field investigations, and to develop methods for the optimum use of the ground water resources in a river basin.

The Great Miami River Basin will be used as a prototype because of its excellent aquifers which are largely recharged by the river.

Over the past several years, extensive studies relative to unsteady ground water recharge have been in progress at the University of Cincinnati in the Division of Water Resources and Hydraulics. In addition, the Division has carried out a number of studies on ground water problems connected with the Great Miami River Basin. The proposed work would utilize this background and develop it into a form which may be applied to any river basin.

Laboratory and field data which are presently available will be used in the development of models for representation of dynamics of a ground water basin.

Final results will be provided in three forms for optimum use of ground water basin. 1. A general mathematical model for basin dynamics. 2. A general digital computer program for ground water basin dynamics. 3. An electric analog model for ground water dynamics in the Great Miami River Basin; general information will be included so that others may use this model as a pattern for other basins.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Cincinnati

2.0852, ENVIRONMENTAL HISTORY OF THE GALAPAGOS ISLANDS

P.A. COLINVAUX, Ohio State University, Graduate School, *Columbus, Ohio* 43210

Sediment cores and related samples were collected on the Galapagos Archipelago in 1966. How present vegetation of the Archipelago is being recorded in the pollen record will be the subject of continued investigation. Efforts will be made to relate the descriptive field notes and surface pollen collection to floristic communities of the islands. Further elucidation of modern pollen spectra should come from a series of surface pollen samples from the Ecuadorian mainland. Further work will be conducted to increase understanding of the variety of the modern lacustrine systems of the Archipelago, and how records of these are being incorporated as fossil traces in the sediments. Finally, efforts will be made to work out the history of several lake ecosystems.

SUPPORTED BY U.S. National Science Foundation

2.0853, EFFECT OF WATER APPLICATIONS TO SOD AND MULCH UPON QUALITY ATTRIBUTES OF APPLE FRUITS

C.W. DONOHA, Ohio State University, Agricultural Experiment Sta., *Columbus, Ohio* 43210

Objectives: (1) To ascertain the effect of water applications to apply trees /// in sod and mulch upon growth, yield and certain quality attributes of the fruit deemed of greatest market acceptability; (2) to ascertain the effect of such treatments upon certain biochemical constituents of the fruit; (3) to assess the nutritional status of leaves and stems with particular reference to the extent to which they are qualitatively affected by changes in the water status of the tree; (4) to ascertain the effect of water applications upon certain major physiological processes occurring in leaves and stems; (5) to determine the effect of such water application on physiological disorders of the fruit and on length of acceptable storage life.

Description of work proposed: Water will be applied by sprinklers to the soil beneath apple trees established in sod and mulch when the available moisture at the 6-18' depth has been reduced by 40 and 60 percent. The effect of such applications as compared with those treatments to which no water has been applied will be recorded in terms of tree and fruit growth, certain biochemical constituents of the leaves, stems and fruits as well as on the rate of photosynthesis and respiration at appropriate intervals during the season. Special attention will be given to the effect of water treatments upon certain fruit quality attributes and storage behavior in view of the emphasis given in this project to this aspect.

SUPPORTED BY U.S. Dept. of Agriculture
Ohio State Government

2.0854, STRONTIUM ISOTOPE COMPOSITION AND TRACE ELEMENT CONCENTRATIONS IN LAKE HURON AND ITS PRINCIPAL TRIBUTARIES

G. FAURE, Ohio State University, Graduate School, *Columbus, Ohio* 43210

Concentrations of the major cations: Na, K, Ca, and Mg and Sr were determined for 64 samples of surface water from Lake Huron and for 17 of its major tributary rivers. For addition, isotopic compositions of strontium were measured for 30 samples of lake water and for 13 of the tributary rivers. Concentrations of dissolved iron and total phospherous were determined for a small suite of lake and river water.

The data documents important differences in the chemical composition of water discharged into Lake Huron by Lake Superior, Lake Michigan and tributary rivers. These differences are related to differences in the chemical and mineralogical composition of the bedrock underlying the Great Lakes drainage basin.

The strontium contributed to Lake Huron by water draining the Canadian Shield along its northern shore is enriched in radiogenic Sr87. The average Sr87/Sr86 ratio is 0.718. The rivers draining sedimentary rocks of Michigan and southwestern Ontario contribute strontium whose isotope composition is similar to that in the modern oceans and has a Sr87/Sr86 ratio of 0.710.

A geochemical model is presented which attempts to represent the chemical composition of water in Lake Huron as a mixture of the different types of water discharged by different sources.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Ohio State University

2.0855, EFFECTS OF TREE ROOTS ON HYDRAULIC CONDUCTIVITY AND POROSITY OF FOREST SOILS IN THE ALLEGHENY-CUMBERLAND PLATEAU

N. HOLOWAYCHUCK, Ohio State University, Agricultural Experiment Sta., *Columbus, Ohio* 43210

The objectives are to develop techniques for (1) measurement of void size and distribution and (2) the determination of soil density differences with distance from the void or root channel in undisturbed forest soil samples. Such techniques would make it possible to determine the sizes, quantity, and distribution with depth of voids and channels through which free water may move in forest soils. The research will be directed to (1) developping techniques for taking of blocks of forest soils in which the roots and the soil will not be disturbed and (2) methods of preparation of thin sections of these blocks of soil for examination under a microscope in the laboratory.

SUPPORTED BY Ohio State Government

2.0856, GLACIOLOGY AND METEOROLOGY OF ANVERS ISLAND, ANTARCTICA

R.A. HONKALA, Ohio State University, Graduate School, *Columbus, Ohio* 43210

During 1967 Antartic winter Honkala, the P.I., and Whillans, his Research Associate, carried out the field glaciological and meteorological research portion of this project on Anvers Island, in the vicinity of Palmer Station, Antarctica, under GA-747. The field research consisted primarily of (1) glaciological observations of snow accumulation, snow and ice ablation, and surface ice movement; (2) further topographic and geodetic control for the construction of base maps of the research area; (3) geophysical observations of the gravity field on the Anvers Island Ice Cap to help determine the thickness of the ice and the shape of the data at Palmer Station and at an inland site, heat-budget studies on the ice surface, and wind-speed measurements.

These data will be reduced and analysed at O.S.U. by Honkala and Whillans to help determine the best balance and mass balance, as well as the dynamics of the Anvers Island Ice Cap.

No further Antarctic field work is contemplated.

SUPPORTED BY U.S. National Science Foundation

2.0857, DROUGHT INJURY AND RESISTANCE IN PLANTS

H.J. MEDERSKI, Ohio State University, Agricultural Experiment Sta., *Columbus, Ohio* 43210

Objectives: (1) To develop field and laboratory methods for measuring the water stress of plants.

(2) To determine how and to what degree the water status of plants is (a) related to growth and development, (b) influenced by physical factors of the environment.

Description of Work: Greenhouse and laboratory studies will be conducted to further develop and refine the beta gauging technique for monitoring internal plant water potential. Distribution of plant water potentials within time and space will be made and used as a basis for applying the gauge for monitoring water stress.

Plant factors affecting the relation between beta ray attenuation and tissue water potential will be investigated.

Greenhouse studies of the relation of photosynthesis and growth to internal plant water stress will be made to determine the critical internal plant water stress level for various aspects of growth and processes affecting growth.

SUPPORTED BY U.S. Dept. of Agriculture
Ohio State Government

2.0858, CONTINUATION OF GLACIOLOGICAL INVESTIGATIONS ON THE CASEMENT GLACIER, ALASKA

D.N. PETERSON, Ohio State University, Inst. of Polar Studies, *Columbus, Ohio* 43210 (AT(11-1))

The purpose of this study is to determine the rate of burial and the trajectory of a given point on the surface of a typical temperate glacier, and to determine the date of its exposure at the lower end of the glacier. To accomplish this, an assessment is being made of the surface velocity and of the mass balance of the casement Glacier in order to better understand the factors upon which these parameters depend.

Objectives: (1) To asses the mass balance by measurement of annual accumulation, ablation, and surface velocity. (2) To determine the trajectories of points on the surface of the glacier by using a formula developed by J. F. Nye. (3) To examine the ice at the bottom of the glacier in order to better understand the machanics of the sliding of a glacier on its bed. (4) To establish meteorological stations at various elevations on the glacier and on the rock adjacent to the glacier in order to relate the ablation studies to the meteoro- logical conditions.

SUPPORTED BY U.S. Atomic Energy Commission

2.0859, FLOW ANALYSIS OF HYDRAULIC CONNECTORS IN ARTIFICIAL RECHARGE SYSTEMS

W. PETTYJOHN, Ohio State University, Water Resources Center, *Columbus, Ohio* 43210

The specific aim of this research plan is to study flow systems of water injected into the subsurface through hydraulic connectors by laboratory and mathematical methods.

Over the past three years, studies relative to the design have been in progress in the Water Resources Division of the U.S. Geological Survey. However, the flow systems associated with hydraulic connectors have not been studied and are of considerable importance for determinating proper artifical recharge system designs.

Laboratory and field data that are presently available will be used to build a laboratory model for representation of the dynamics of an artificial recharge system that consists predominantly of hydraulic connectors. Standard hydraulic formulas will be used to form a mathematical model. Results of the two means of analysis will be correlated, modified if necessary, and used to determine a formula that describes the optimum hydraulic connector size and spacing under conditions of uniform permeability.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Ohio State University

2.0860, EFFECTS OF SOIL MANAGEMENT TREATMENTS ON ERODIBILITY AND INFILTRATION CHARACTERISTICS

B.L. SCHMIDT, Ohio State University, Agricultural Experiment Sta., *Columbus, Ohio* 43210

1. To determine infiltration characteristics for typical Ohio soils. 2. To investigate the factors affecting the relative erodibility of major Ohio soils. To study under controlled, simulated rainfall, the effects of raindrop impact energy and initial surface conditions on the formation of soil surface seals, and the characteristics of these surface seals on various Ohio soils. 4. To study, under field conditions, the effects of soil management treatments on soil surface conditions, and the relationships to water intake and soil loss rates.

Field infiltration data will be collected on three typical Ohio soils using the Purdue sprinkling infiltrometer in accordance with the procedures of Regional Research Project NC-40. After adoption of desirable modifications, further studies will be made on other major Ohio soils. Soil survey data from statistical quarter-section samples will be summarized by soil type, slope group and degree of erosion to calculate average weighted erosion indices for major Ohio soils. The susceptibility to surface sealing on these soils under different surface conditions will be studied under simulated rainfall of known energy, as well as the characteristics of these seals and their relationships to erosion and infiltration. Field experiments will be conducted on the effects of tillage and soil surface conditions on sealing, erosion, and water intake and losses.

SUPPORTED BY U.S. Dept. of Agriculture
Ohio State Government

2.0861, HYDROLOGIC INVESTIGATION OF WATERSHEDS IN OHIO

E.P. TAIGANIDES, Ohio State University, School of Agriculture, *Columbus, Ohio* 43210

The objective of this investigation is to acquire the knowledge necessary in the development and application of mathematical models to simulate the hydrologic phenomenon associated with small agricultural watersheds in Ohio.

The initial phase of work will involve a review of the current mathematical watershed models and a selection of the more successful models to apply to Ohio watershed. Both Analog and Digital Computer versions will be considered.

A prime objective will be to modify the Stanford Streamflow Simulation Model, through the use of the excellent collection of data available at the Coshocton Ohio Hydrologic Station, in order to predict small watershed response.

Secondary objectives will encompass investigations of the Influence of Land Use on Runoff and the Hydrologic Response of Strip-mined Areas.

The culmination of these studies will be a mathematical model, that would predict water yield peak runoff, outflow hydrographs, and residual soil moisture conditions, for inputs consisting of readily obtained basin characteristics and given precipitation sequence.

Use will be made of the $30,000 Analog Computer in the Agricultural Engineering Dept. as well as the University's 7094/360 Digital Computer facilities.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Ohio State University

2.0862, WELL DRAWDOWN IN UNCONFINED AQUIFERS UNDER NON-STEADY CONDITIONS

G.S. TAYLOR, Ohio State University, School of Agriculture, *Columbus, Ohio* 43210

Drawdown around wells in unconfined porous media for transit conditions will be evaluated by numerical analysis. The simultaneous flow of water in both the saturated and unsaturated flow regions will be evaluated for various pumping rates and boundary conditions. Fulfillment of the project objectives will yield computer techniques for handling complicated water flow problems and additional information on inflow into wells.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Ohio State University

2.0863, MANAGEMENT OF STORM RUNOFF AND THE IMPROVEMENT OF WATER YIELD ON FOREST LAND

R.Z. WHIPKEY, U.S. Dept. of Agriculture, *Columbus, Ohio*

Object: To devise ways to manage stormwater runoff and improve the amount, timeliness, and quality of water arising from forest land in the Allegheny, Cumberland plateau and related limestone, sandstone, shale and loessial regions of the Midwest.

Plan of work: This project is concerned primarily with forest soils and the movement of water through them. The staff is measuring subsurface stormflow movement and hydraulic conductivity rates through forest soils. They are also determining the effect of subsoiling and mulching on water movement; the relation of soil moisture to distance from planted coniferous trees; and the characteristics of a coniferous plantation related to tree growth and available water.

SUPPORTED BY U.S. Dept. of Agriculture

2.0864, SEDIMENT SOURCES AND YIELDS IN AGRICULTURAL WATERSHEDS IN CORN BELT STATES

L.L. HARROLD, U.S. Dept. of Agriculture, *Coshocton, Ohio*

Object: To develop procedures for predicting the sources and amount, rate, and character of sediment yield in the principal physio- graphic and climatic regions.

Plan of Work: Information on quantities of sediment carried by streams is obtained by means of reservoir sedimentation surveys and through suspended load sampling on selected watersheds. Records of precipitation, runoff, topography, channel characteristics, soils and geology, land use, conservation practices, and watershed treatment measures are compiled for the areas for which sediment yield records are available. Studies are made to determine and evaluate the processes and rates of erosion on land surfaces including gullies, roadbanks, and stream channels. Radioactive elements and other tracers are used in studying the movement of sediment from erosional sources to points of deposition. Required instrumentation is developed. Data on sediment yield rates and associated causal factors are analyzed and interpreted to derive improved techniques and equations for estimating sediment yield and sources in ungaged watersheds.

SUPPORTED BY U.S. Dept. of Agriculture

2.0865, PRECIPITATION AND SNOW MELT CHARACTERISTICS INFLUENCING RUNOFF FROM WATERSHEDS IN CORN BELT

L.L. HARROLD, U.S. Dept. of Agriculture, *Coshocton, Ohio*

Object: To (1) develop information on amounts, duration, areal and seasonal distribution storm paths and other characteristics of rainfall as affected by geographic location, topographic location, and other factors in relation to runoff from agricultural watersheds; (2) evaluate the factors influencing the disposition of snow and to develop improved methods of estimating stream discharges and water yields for upstream watersheds where the supply is from snow melt; and (3) determine the relationship of frozen soils to runoff from melting snow or rain.

Plan of Work: Studies are currently in progress at the North Appalachian Experimental Watershed near Coshocton, Ohio and on agricultural watersheds in the vicinity of Council Bluffs, Iowa, Fennimore and Madison, Wisconsin, Iowa City, Ia., and Columbia Mo.

SUPPORTED BY U.S. Dept. of Agriculture

2.0866, RUNOFF PRODUCTION BY UNIT SOURCE AREA AGRICULTURAL WATERSHEDS IN CORN BELT STATES

L.L. HARROLD, U.S. Dept. of Agriculture, *Coshocton, Ohio*

Object: To evaluate quantitatively, as one of the important factors in predicting runoff from ungaged watersheds, the runoff producing potential of the major individual soil-cover complexes under typical conditions of use and treatment.

Plan of Work: Studies are currently in progress at the Northern Appalachian Experimental Watershed near Coshocton, Ohio; Columbia, Missouri; and in the vicinity of Council Bluffs, Iowa. Particular attention is being given to investigations of interflow in soil profiles.

SUPPORTED BY U.S. Dept. of Agriculture

2.0867, RELATION OF CLIMATIC AND WATERSHED FACTORS TO STORM RUNOFF IN CORN BELT STATES

L.L. HARROLD, U.S. Dept. of Agriculture, *Coshocton, Ohio*

Object: To identify the climatic and watershed factors influencing the magnitude and frequency of storm flows from agricultural watersheds; to evaluate the factors quantitatively; and to develop procedures by which the magnitude and frequency of storm flows from ungaged watersheds may be estimated.

Plan of Work: Work is currently concentrated on North Appalachian Experimental Watershed near Coshocton, Ohio; on agricultural watersheds in the vicinity of Fennimore and Madison, Wisconsin; Columbia, Missouri, and Council Bluffs, Iowa. Some of the factors required for the analyses and which are measured or otherwise documented for the study are: rates and duration of streamflow; precipitation patterns; antecedent moisture; season; soils; land use; conservation and watershed management practices; ground water elevations; riparian vegetation; geology; gradients and hydraulic roughness of stream channels; and the size, shape and other geomorphic attributes of watersheds.

SUPPORTED BY U.S. Dept. of Agriculture

2.0868, RESERVOIR SEDIMENTATION STUDIES IN CORN BELT STATES

L.L. HARROLD, U.S. Dept. of Agriculture, *Coshocton, Ohio*

Object: To obtain an understanding of reservoir sedimentation phenomena, to develop better procedures for predicting such processes, and to develop better design criteria for reservoirs--including knowledgeable consideration of: (1) characteristic rates of storage depletion by filling of reservoirs with sediment, as affected by various parameters in the principal physiographical and geomorphological regions; (2) volume-weight of deposited sediment; (3) reservoir trap efficiency; and (4) distribution of reservoir sediment.

Plan of work: Primarily field investigations to develop improved procedures for making reservoir sediment deposition surveys; distribution of sediment in floodwater detention type reservoirs; and volume weight of reservoir sediment from measurements with the gamma probe.

SUPPORTED BY U.S. Dept. of Agriculture

2.0869, SOIL MOISTURE REGIMES OF AGRICULTURAL WATERSHEDS IN CORN BELT STATES

K.E. SAXTON, U.S. Dept. of Agriculture, *Coshocton, Ohio*

Object: To determine for agricultural watersheds: basic information on amounts, accretion and depletion, areal and depth of distribution, and the transmission of soil moisture; criteria for the design of sampling programs to define soil moisture within prescribed limits of accuracy; and methods for predicting soil moisture for ungaged areas.

Plan of Work: The work is currently in progress at the North Appalachian Experimental Watershed near Coshocton, Ohio; on watersheds in the vicinity of Fennimore and Madison, Wisconsin; in the vicinity of Council Bluffs, Iowa; and at Columbia, Missouri. Patterns of soil moisture extraction and recharge are determined for different land use and soil conditions including investigations to establish criteria for determining soil moisture status on a watershed basis.

SUPPORTED BY U.S. Dept. of Agriculture

2.0870, NITROGEN FERTILIZATION AND IRRIGATION OF TOBACCO

T.G. ARSCOTT, Ohio Agric. Res. & Dev. Ctr., *Wooster, Ohio* 44691

1. To determine the effect of irrigation on stand and early growth of newly transplanted tobacco. 2. To study the effects of irrigation on yield and quality of tobacco grown at four nitrogen levels. 3. To determine the effect of soil moisture stress at various stages of growth on yield and quality of tobacco.

This experiment is designed to determine the response of tobacco to nitrogen fertilization under various soil moisture conditions. Other objectives are to determine the effects of irrigation on stand and early growth of newly transplanted tobacco and the effect of soil moisture stress at various stages of growth on tobacco production.

Four levels of nitrogen fertilization from 0 to 180 pounds of N per acre are compared at three soil moisture levels. The design is a split plot with three replications. The tobacco is irrigated with a sprinkler type irrigation system. One irrigation level is maintained at 60 percent of available moisture, the second is irrigated only at critical periods during growth, and the third level receives only normal rainfall. Yield, quality, value, and chemical analyses of the leaf are determined. The tobacco is grown in a three year rotation.

SUPPORTED BY Ohio State Government

2.0871, FLOW OF COLLOIDAL SUSPENSIONS IN POROUS MEDIA

R.B. CURRY, Ohio Agric. Res. & Dev. Ctr., *Wooster, Ohio* 44691

To investigate the fundamental principles underlying the flow of colloidal suspensions into or through porous media.

Description of work: The scope of this study will include the use of several granular materials and suspensions of colloidal materials. Initially, carborundum will be used as the porous media and Wyoming bentonite as the suspended material in order that there will be continuity between the present work and past studies. Materials to be used later will include chemically active materials such as zeolite, natural occuring materials, such as soils and filter sands. The natural occuring materials will be used to tie this basic study to practical applications in the field.

Both the porous media and the suspended materials will be characterized completely by determination of various physical and chemical properties.

The granular material will be placed in a permeameter for testing. The actual test procedure will involve four phases: (1) initial flow of de-aired, de-ionized water through the porous media in the permeameter, (2) followed by the introduction of the suspension into the permeaneter in order to determine the effect of the suspension flow in the system, and (4) the amount of colloidal material retained in the column of porous media is determined by the use of radioactive isotope techniques.

SUPPORTED BY U.S. Dept. of Agriculture
Ohio State Government

2.0872, IRRIGATION REQUIREMENTS OF FIELD AND HORTICULTURAL CROPS

R.B. CURRY, Ohio Agric. Res. & Dev. Ctr., *Wooster, Ohio* 44691

Irrigation Requirements and Potentials of Field and Horticultural Crops: 1. To determine the water requirements and evapotranspiration rates of field, fruit, vegetable, and nursery crops. 2. To evaluate the long-time response of these crops to irrigation on fine-textured and coarse-textured soils. 3. To evaluate the drought potential of major soils from long-time weather data and to correlate this information with crop response. 4. To apply the information on evapotranspiration rates and water requirements to the development of design criteria for distribution and application systems for irrigation of these crops. 5. To evaluate the effect of irrigation on drainage system design in fine-textured soils.

Description of Work: The study will cover the investigation of the water requirements and evapotranspiration rates of various field and horticultural crops. Initial studies will be made with a neutron meter. Water application will be initially by overhead sprinklers. Surface methods of irrigation will be investigated. Yield and quality, as determined by co-operating personnel in the particular product area, will be used as the measure of response to irrigation. It is also envisioned that studies under controlled climatic conditions may be needed to provide the desired information. The drought potential of major soils in the state will be evaluated from an analysis of long term weather records. The effect of irrigation on drainage system design in fine-textured soils will be determined by a comparison of the behavior of drainage systems under irrigated and non-irrigated conditions.

SUPPORTED BY U.S. Dept. of Agriculture
Ohio State Government

2.0873, CHEMISTRY OF SUBSURFACE OILFIELD BRINES

A.G. COLLINS, U.S. Dept. of Interior, Petroleum Research Ctr., *Bartlesville, Oklahoma*

Subsurface brine and water samples are obtained from primary production oil wells using standard sampling procedures. The samples are analyzed using standard procedures, and the results are published, thereby providing a standard reference source concerning the types of brines or waters produced simultaneously with petroleum from various geological formations.

SUPPORTED BY U.S. Dept. of Interior - Bureau of Mines

2.0874, ANALYTICAL METHODS - OILFIELD WATER CHEMISTRY

A.G. COLLINS, U.S. Dept. of Interior, Petroleum Research Ctr., *Bartlesville, Oklahoma*

Methods applicable to determining the many constituents found in saline oilfield waters are developed. Existing analytical procedures also are improved to meet the need for a better knowledge of water chemistry.

SUPPORTED BY U.S. Dept. of Interior - Bureau of Mines

2.0875, RUNOFF PRODUCTION BY UNIT SOURCE AREAS IN THE SOUTHERN PLAINS

M.A. HARTMAN, U.S. Dept. of Agriculture, *Chickosha, Oklahoma*

Object: To evaluate quantitatively the runoff producing characteristics of the major soil-cover complexes in the Southern Plains under typical conditions of use and treatment.

Plan of work: The studies are currently in progress on single-soil-cover watersheds in the vicinity of Chickasha and Cherokee, Oklahoma; and Riesel and Sonora, Texas. Correlations are established between the physical characteristics, soils and their runoff producing potential under a variety of land use and treatments.

SUPPORTED BY U.S. Dept. of Agriculture

2.0876, WEATHER RADAR - PRECIPITATION RELATIONSHIP

K.E. WILK, U.S. Dept. of Commerce, Natl. Severe Storm Lab., *Norman, Oklahoma*

Tech. Obj. changes in precipitation intensity patterns which accompany transitory weather systems. To determine the quantitative significance of radar signal return from precipitation in terms of precipitation rate, liquid water content, and other meteorological parameters. To determine the minimum number of parameters needed for characterizing the echo element important for forecasting and communicating precipitation data.

Approach; A standard WSR-57 weather radar has been equipped with data recording equipment to provide systematic weather echo recording. Rain-gage data from USDA mesonetwork is assembled and tabulated. Radar and rain-gage data are processes using semi-automatic and computer programs to prepare precipitation radar echo statistics.

Progress: Computer programs had been written to process the data and several years of data have been collected.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.0877, SOIL EROSION STUDIES IN OKLAHOMA AND SOIL SEDIMENTATION STUDIES IN OKLAHOMA

J.W. KEELEY, Univ. of Oklahoma, School of Engineering, *Norman, Oklahoma* 73069

Several soil erosion studies are in progress. The effects of soil type, slope and discharge on the erosion of roadway ditches and channels are being studied, to optimize methods of preventing scour. Studies of the Froude number, which separates culvert outlet conditions into satisfactory and unsatisfactory conditions, are underway. The soil sedimentation studies are investigating the Froude range separating conditions of silt deposition from channel stability.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Oklahoma State Government

2.0878, SOIL SURFACE MANAGEMENT PROCEDURES FOR SOIL AND WATER CONSERVATION

J.M. DAVIDSON, Okla. St. Univ. of Agr. & Sci., Agricultural Experiment Sta., *Stillwater, Oklahoma* 74075

Objectives: 1. Replace or eliminate as many mechanical tillage operations as feasible for an annual wheat, cotton or sorghum program. 2. Measure water storage efficiency of the soil profile under various surface management practices. 3. Evaluate changes in organic matter, bulk density, aggregation and residue in surface soil owing to various tillage practices. 4. Determine annual operational cost of each soil management techniques for cost plus yield analysis.

Procedure: Treatment for weed control, both during and between growing seasons, will vary from complete mechanical to all chemical with intermediate combinations of the two. Water storage in the soil profile will be monitored frequently during the year using the neutron meter. These values will be compared with annual precipitation and consumptive- use measurements. Particular attention will be given to water retention in the top 18 inches of the soil under the various tillage practices. Field work involving evaporation from bare soil will be supplemented with laboratory work. After harvest each year, samples in the top 18 inches of the soil will be collected to measure organic matter, bulk density, aggregation, chemical residue and general conditions of the soil. This information along with the amount of plant residue on the soil surface will be used to estimate physical and chemical property changes of the soil. Cost per unit of yield will be made for each crop and crop program in order to compare mechanical and chemical methods of weed control.

SUPPORTED BY U.S. Dept. of Agriculture
Oklahoma State Government

2.0879, OVERLAND FLOW ANALYSIS FOR A SIMULATED VEGETATED SURFACE

C.E. RICE, Okla. St. Univ. of Agr. & Sci., School of Agriculture, *Stillwater, Oklahoma* 74075

The objectives of this project will be: 1. To determine the functional relationship between watershed roughness (expressed as some appropriate friction factor such as Manning's n) and the depth of flow, rainfall intensity (raindrop impact), and slope of surface profile for a simulated vegetated surface for spatially varied steady flow and spatially varied unsteady flow (overland flow). 2. An analysis of overland flow using the continuity and momentum equations as the expressions to completely define the time distribution of runoff (hydrograph) from a simulated vegetated surface. 3. Adjustment of the friction factor in the friction slope of the equations until the predicted hydrographs duplicate the experimentally determined hydrographs. This should permit determination of the actual friction factor relationship for the different variable combinations of overland flow from a simulated vegetated surface.

The experiment data will be obtained using a 44-foot variable slope rectangular flume. The flume is about 17 inches wide and will be lined with an artifical grass substance (trade name of PERMA-GRASS) that should approximate a close growing mat type grass such as bermuda. The lateral inflow, designed to approximate natural rainfall, will be applied by spray nozzles located along the longitudinal axis of the flume. Rainfall rates of 2 in. per hour, 4 in. per hour, and 6 in. per hour will be studied.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Oklahoma State University

2.0880, STUDIES OF THE SOIL-MOISTURE-PLANT REGIME FOR THE CONDITIONS OF WESTERN OKLAHOMA

J.F. STONE, Okla. St. Univ. of Agr. & Sci. , Agricultural Experiment Sta. , *Stillwater, Oklahoma* 74075

Objectives: 1. To use Oklahoma weather data in establishing probability values for rainfall. 2. To establish an evapotranspiration equation for Oklahoma through use of weather summary data and evaluation of equation parameters involved, and further, to establish a satisfactory means for estimating the total need for water for crop growth. 3. To study the influence of plant and soil factors on water intake by roots and the subsequent transpiration. 4. To study the efficiency of precipitation in the production of plant growth and use this as a yardstick for water efficiency in dryland areas. 5. To study maximization of water-use-efficiency for irrigation agriculture in Oklahoma.

Procedure: Rainfall probabilities at several stations across the state will be characterized through the year. Weather and ground conditions related to water loss will be studied. The factors and parameters concerned will be used in establishing evapotransmission equations for Oklahoma. Laboratory and field studies will be made to establish the relations between physiological conditioning of the plant and water loss to environmental demands. Electric analog procedures are planned to study movement through the plant. Effects of bedding, water impermeable barriers and vertier wetting on water-use-efficiency will be studied.

SUPPORTED BY U.S. Dept. of Agriculture
Oklahoma State Government

2.0881, BIOLOGICAL FIXATION AND TRANSFORMATION OF NITROGEN IN SMALL IMPOUNDMENTS

D.W. TOETZ, Okla. St. Univ. of Agr. & Sci. , Graduate School, *Stillwater, Oklahoma* 74075

The nitrogen cycle of small impoundments will be studied using the isotope dilution technique. The basic objective of this research is to learn the rate at which nitrogen enters small impoundments by biological fixation and the rate it is transformed there by biological processes. Specific objectives are as follows: (1) to measure rates of nitrogen fixation in small impoundments, (2) to measure rates of assimilation of ammonia and nitrates by the biota, (3) to concurrently measure rates of nitrification in the same environment, and, (4) to relate seasonal changes in nitrate and ammonia to the above rates.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Oklahoma State University

2.0882, SEDIMENT PRODUCTION, MOVEMENT, AND DEPOSITION IN WATERSHEDS IN THE SOUTHERN GREAT PLAINS

W.O. REE, U.S. Dept. of Agriculture, *Stillwater, Oklahoma*

Object: To develop procedures to predict the sources, amount, rate and character of sediment yield and delivery from agricultural watersheds of varying sizes; develop design criteria and other information on trap-efficiency, density and distribution of sediment, and characteristic rates of storage depletion by silting for reservoirs and ponds affected by watersheds; and to determine the effects of upstream watershed protection programs on sedimentation along the main stem of river systems.

Plan of Work: The sediment transport in selected streams is measured and sediment yields related to causal factors. The effect of watershed treatment on the sediment delivery to major streams is studied. Transport load is measured, and records made of precipitation, runoff, topography, channel characteristics, soils and geology, land use and cover, and conservation practices and watershed treatment. Information on reservoir sedimentation is obtained, including characterization of the contributing basins, measurement of water and sediment inflow, outflow, and movement; characterization of basins as to shape and size, and capacity-watershed ratios; variations in the density and texture of deposited sediment and processes of delta formations within basins and their extension upstream beyond the backwater of the reservoir.

SUPPORTED BY U.S. Dept. of Agriculture

2.0883, CLASSIFICATION OF DEEP SUBSURFACE WATERS BY CHEMICAL COMPOSITION AND GEOLOGY

P.A. DICKEY, Univ. of Tulsa, Graduate School, *Tulsa, Oklahoma* 74104

This is a renewal of NSF Grant GP-5051. Data from deep oil and gas wells indicate that there is a normal increase in salinity of subsurface water with depth to a certain point, below which the relationship no longer holds and the waters are less concentrated. In the same areas and at about the same depths it has been shown that shales are under-compacted. The normal processes of compaction and expulsion of water have apparently been arrested by normal faults which were active during sedimentation, and which interrupted the paths of water migration along the bedding planes. The pressures in the interstitial water in under-compacted shales approach the weight of the overburden.

To establish these interesting relationships it will be necessary to choose several oil fields whose geology and pattern of reservoir pressures are well known. Water samples will be especially collected and the U.S. Bureau of Mines has agreed to supply chemical analyses. It is expected that much entirely new information on both physical and chemical processes of diagenesis and on tectonics will be obtained.

SUPPORTED BY U.S. National Science Foundation

2.0884, A RUN TIMING STUDY IN THE LOWER COLUMBIA RIVER BY MEANS OF A TESTFISHING PROGRAM

A. OAKLEY, State Fish Commission, *Clackamas, Oregon* 97015

This program is conducted to determine the time of migration of spring-run chinook salmon through the lower Columbia River and provide a means of estimating the size of the population. The program is conducted at two sites. Fish Commission personnel supervise fishing operations at Woody Island, which is 28 miles above the mouth of the Columbia River, while the Washington Department of Fisheries is responsible for conducting the fishing at Corbett located 22 miles below Bonneville Dam. Gill nets are drifted over a standard area on alternate days at each site. Fish captured in suitable physical condition are tagged and released, and later observed at various fishways, hatcheries, and in spawning tributaries. Stream of destination, migration rates, and growth patterns as determined by scale analysis are also learned from this work.

SUPPORTED BY Oregon State Government

2.0885, PREDICTION OF WATER MOVEMENT IN UNSATURATED SOILS

L. BOERSMA, Oregon State University, Agricultural Experiment Sta. , *Corvallis, Oregon* 97331

Objectives: To devise and test methods for predicting water transmission characteristics from measurable soil properties for known temperature conditions.

Work Proposed: Previous work done at the Oregon station has indicated that numerical techniques based on hthe diffusion equation can be used to predict unsaturated water movement. The accuracy of the prediction depends upon the ability to establish the exact relationship between transmission characteristics and moisture content. Soil columns will be packed for the determination of the relationship between the soil-moisture diffusivity and the soil moisture content. The columns will be made up of soils of predetermined mineral composition, apparent density and texture. The range of soil textures to be studied will be selected such that the relationship between texture and diffusivity can be accurately described and possibly predicted.

SUPPORTED BY U.S. Dept. of Agriculture
Oregon State Government

2.0886, WATER-SOIL PLANT RELATIONS

L. BOERSMA, Oregon State University, Agricultural Experiment Sta., *Corvallis, Oregon* 97331

Objectives: Investigate relationships between water stress in root medium and internal water status of plants as affected by environment and plant development.

Description of Work: The initial work is to develop on a practical basis a method to maintain a constant moisture content in a body of soil in which plants are growing. The study will then proceed with studies of the quantitative effects of different air temperatures, relative humidities, soil temperature and soil moisture tensions on growth and transpiration. Additional work will attempt to evalute the link between moisture stress and ion uptake and between transpiration and ion uptake.

SUPPORTED BY U.S. Dept. of Agriculture
Oregon State Government

2.0887, CHARACTERIZATION OF WATER TABLES IN OREGON SOILS WITH REFERENCE TO TRAFFICABILITY

L. BOERSMA, Oregon State University, Agricultural Experiment Sta., *Corvallis, Oregon* 97331

(a) Quantitatively describe and compare the water-table regimes of selected Oregon soils to determine whether particular water-table regimes are associated with specific soil types. (b) Study the relations and associations of soil morphological characteristics, soil moisture regimes, soil trafficability, and other static and dynamic features of soil, terrain, and weather to water-table regimes of the several soils to achieve the capability for appraising water -table regimes from morphological information. (c) To gain background knowledge needed in development of prediction methods for water-tables, soil moisture, and trafficability strength.

Instruments and techniques have been developed for measuring the trafficability characteristics of soils by USA-WES, Vicksburg, Miss. Capabilities for estimating trafficability conditions without the opportunity to measure them and for predicting changes in conditions with time are also needed. Three near-model test sites will be established on each of five soil series of the Willamette Catena in Western Oregon. Sites will be designed and instrumented to allow the collection of data satisfying the needs for fulfilling the stated objectives. The data-collection phase of the program will last for a period of one year after which the following information will have been obtained. (a) Daily records of air temperature, rainfall, water- table depth, soil moisture at several depths, and pertinent changes in vegetation, soil conditions, etc. (b) Data for developing trafficability strength-soil moisture relations. (c) Complete descriptions of soil physical properties, soil morphological features, and terrain features, (d) Other data necessary for the completion of research studies by OSU graduate students who are directly associated with the program.

SUPPORTED BY Oregon State Government

2.0888, IRRIGATION FEASIBILITY ON THE DAYTON, AMITY, WOODBURN, WILLAMETTE AND RELATED SOILS OF THE WILLAMETTE VALLEY

L. BOERSMA, Oregon State University, Agricultural Experiment Sta., *Corvallis, Oregon* 97331

Objectives: 1. To determine the suitability and the production potential of selected crops under irrigation on the Dayton, Amity, Woodburn, Willamette and related soils of the Willamette Valley under different levels of management. 2. To determine the irrigation water requirement of selected crops grown on the above named soils under different systems of management. 3. To determine the economic feasibility of irrigation based on the results obtained under objectives 1 and 2.

Description of Work Proposed: A range of promising crops will be grown under different management and cultural practices in replicated field experiments to assess their production capacity under irrigation. The main variables in the experiments ill be frequency and amount of irrigation, fertilizer application, date of planting and stand density. Experiments will be included to evaluate different soil management practices in relation to the production of crops on these soils. Water usage, yield, and in some cases quality of the product will be measured. In addition a range of crops will be grown in an exploratory manner to obtain an indication of the suitability of specific crops to production under irrigation on these soils. The crops which appear most promising may be further explored in some comprehensive experiments.

SUPPORTED BY Oregon State Government

2.0889, THE PREDICTION OF UNSATURATED FLOW RATES FROM PHYSICAL PROPERTIES OF THE POROUS MEDIUM

L.L. BOERSMA, Oregon State University, School of Agriculture, *Corvallis, Oregon* 97331

The development of the unsaturated flow theory leads to the determination of several parameters necessary for the prediction of water movement in porous media. Little investigation has been done to determine these parameters as a function of easily measured physical properties of the medium. The flow parameters have been related to characteristic functions obtained from experiments. The theory has been successful in some cases under special conditions. When experimental data do not match with the values predicted using the characteristic functions, only assumptions about the discrepancies between theory and experience can be presented. The objective of the proposed study is to establish a relationship between water transmission coefficients and properties of the porous medium by a series of systematic measurements performed on a range of materials.

The need for fundamental information about unsaturated flow parameters obtained in a systematic manner is urgent. Unsaturated water movement is a basic aspect of many studies related to water treatment, movement of chemicals (pesticides) and movement of water as part of the hydrologic cycle. This project was initiated in fiscal 1966 and will be completed in 1969.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Oregon State University

2.0890, UNSATURATED FLOW RATES

L.L. BOERSMA, Oregon State University, Agricultural Experiment Sta., *Corvallis, Oregon* 97331

1. To establish a relationship between water transmission coefficients and soil physical properties by a series of systematic measurements. 2. To compare values of water transmission coefficients calculated from pore size distributions with experimentally obtained values. 3. To establish the possible use of a mercury intrusion porosimeter as a tool for a fast and routine measurement of pore size distribution.

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2. WATER CYCLE

SUPPORTED BY Oregon State Government

2.0891, A CLASSIFICATION OF THE LAKES OF THE STATE OF OREGON

J.R. DONALDSON, Oregon State University, School of Agriculture, *Corvallis, Oregon* 97331

The primary objective of the proposed research is to begin an accurate appraisal of the quantity and quality of the lakes of the State of Oregon in order to document for posterity the existing conditions and to serve as an aid to the present and future water use manipulations.

The specific project objectives are as follows: (1) Assemble information presently available concerning the lakes of the State of Oregon. (2) Begin to sample selected lakes by differing geological areas and/or drainage basins in order to accumulate limnological data essential for a statewide classification. (3) Set up a format for recording and processing the collected information with the eventual purpose of making the results available in published form. The field work will involve the collection of information on the morphological features, thermal and optical properties, major chemical features (oxygen, pH, alkalinity, major cations, total solids and specific conductivity) andthe qualitative and quantitative features of the biota of each lake visited.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Oregon State University

2.0892, HYDROLOGY OF WATER YIELD PREDICTION

J.T. KRYGIER, Oregon State University, Water Resources Research Inst., *Corvallis, Oregon* 97331

Object: To predict water yields from meteorological parameters for watersheds composed of heterogeneous vegetation, and to measure changes in water yield caused by logging.

Plan of Work: The long-range goals of the project will be to estimate measured water budgets on plots and watersheds for meteorological parameters. Small watersheds will be utilized in the Coast Province for prediction purposes and to observe the magnitude of change in water yield caused by clearcut logging.

Water budget measurements will be made weekly or biweekly throughout the year on plots of Douglas fir and oak near Corvallis. Freely fluctuating plots and two functioning as open-ended lysimeters will be utilized. The measurements will consist of gross rainfall, net rainfall, soil moisture change (neutron probe) and measured unsaturated flow. The latter will be organized as a separate research project. Water budgets on the plots will be estimated from incoming solar radiation, net radiation and air temperature, as measured above the forest stands.

The watersheds are located in the coast range approximately 60 miles west of Oregon State University at Corvallis.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Oregon State University

2.0893, SEASONAL WATER USE BY FOREST VEGETATION

J.T. KRYGIER, Oregon State University, Graduate School, *Corvallis, Oregon* 97331

Objectives: The overall purpose is to establish the role of foliage transpiration in causing water loss from streamflow or loss of soil water available for growth and survival of plants. Determination of comparative uses by important local forest vegetational species especially trees during the four seasons of the year will be attempted. Amount of use will be related to soil and air temperature, air humidity, rainfall and solar radiation.

Assessment of the water economy for important forest species will allow interpretation of their effect on flood peaks and low water levels. Control of cover species on a watershed offers one means of controlling quality, quantity and regularity of stream waters.

SUPPORTED BY Oregon State Government

2.0894, TESTS OF DOUGLAS-FIR PLANTING STOCK FOR SURVIVAL UNDER DROUGHT STRESS

D.P. LAVENDER, Oregon State University, Graduate School, *Corvallis, Oregon* 97331

Objectives: 1. To examine the physical and physiological characteristics of root systems of seedlings growing on unfavorable sites. 2. Establish techniques for identifying drought resistance.

Description of Work Proposed: Work with seedlings from Provenance Study. Study seedlings taken from severe sites. Study parents of seedling growing on droughty soils. Work with Ernest Wright on mycorrhiza and its relationship to survival on difficult sites.

SUPPORTED BY Oregon State Government

2.0895, VEGETABLE CROPS FERTILIZER, PLANT NUTRITION, AND IRRIGATION PROBLEMS

H.J. MACK, Oregon State University, Agricultural Experiment Sta., *Corvallis, Oregon* 97331

(1) To evaluate the effect of fertilizers and lime on growth, yields, and quality of major vegetables grown in Oregon (2) to relate the growth and yield response from fertilizer and lime treatments to chemical composition of plants and soil test values, (3) to evaluate the comparative response of different varieties to application of fertilizers and lime, (4) to evaluate the growth, yields, and quality of vegetable crops as influenced by amount and frequency of irrigation, and (5) to evaluate the relationship of growth and yield response to irrigation-fertilizer-stand levels.

Major emphasis in these studies will be on field trials to evaluate effects of fertilizer and lime treatments and irrigation on vegetable crops. When feasible and practical, greenhouse experiments will be conducted to supplement field data and to study the more fundamental aspects of certain problems.

SUPPORTED BY Oregon State Government

2.0896, BIONOMICS OF FISHES AND SHELLFISHES

C.E. WARREN, Oregon State University, Agricultural Experiment Sta., *Corvallis, Oregon* 97331

To: obtain bionomic information of important fishes and shellfish species of Oregon bays in relation to ecological factors (temperatures, salinities, currents and tidal phases, pH, dissolved oxygen, carbon dioxide, turbidity, edaphic conditions, folds, industrial and domestic sewage wastes, etc.); continue development of aqua-culture procedures for oysters, clams and other marine species of importance, particularly rearing of free-swimming larval stages of oysters and clams to seed stage; and, obtain reliable biological information as to resistance and susceptibilities of marine organisms to various pollutional conditions occurring in marine waters and provide methods and scientific data for predicting effects on marine organisms and for establishments of water quality criteria for marine areas.

Description of Work: Perform bioassays with various toxic effluents commonly discharged into marine waters using fishes and the several life stages of oysters and other marine organisms as test animals; and perfect the mussel embryo-larval bioassay techniques for quickly assessing the toxic components of effluents discharged by wood- processing industries into bays and estuaries.

Continue oyster culture studies, particularly the rearing of pelagic larvae of the Kumamoto oyster to 'seed' stage under controlled laboratory conditions; and begin preliminary studies on the damages and control of mud-shrimps to oysters.

SUPPORTED BY U.S. Dept. of Agriculture
Oregon State Government

2.0897, PERFORMANCE CHARACTERISTICS OF SOLID COVERAGE SPRINKLER IRRIGATION SYSTEM

J.W. WOLFE, Oregon State University, Agricultural Experiment Sta., *Corvallis, Oregon* 97331

Objectives: 1. To determine the functional relationships among uniformity coefficients, nozzle size, spacing, pressure, and wind velocity for very small sprinklers used in solid sets. 2. To determine the adaptability, limitations, and efficiency of solid coverage systems for certain specialized tasks.

Procedures: Numerous measurements of uniformity coefficient will be made from several sprinklers discharging less than two gallons per minute under varying conditions of pressure, spacing, and wind velocity. An analysis will be made on all available measurements to determine the functional relationships among the variables by multiple regression techniques. If possible, the data will be presented in such a way that it will permit designers to select the maximum possible uniformity for a given set of operating conditions.

Other performance characteristics will be investigated only as opportunities become available, especially in conjunction with other field research projects.

SUPPORTED BY Oregon State Government

2.0898, ECOLOGY AND PHYSIOLOGY OF THERMORPHILIC BLUE-GREEN ALGAE

R.W. CASTENHOLZ, Univ. of Oregon, Graduate School, *Eugene, Oregon* 97403

This proposal is concerned with algae that live at temperatures which would be lethal to most organisms. Ecologically, a hot spring provides a very simple system for study, because of its constancy and the paucity of species present. By a comparison of field and laboratory experiments it is possible to understand how other environmental factors operate to limit a population that is adapted to unusually high temperature. The ecological consequences of physiological processes will be revealed by this combination of field and laboratory work.

SUPPORTED BY U.S. National Science Foundation

2.0899, NUTRITIONAL AND SOIL MOISTURE REQUIREMENTS OF PEAR ORCHARDS OF SOUTHERN OREGON

P.B. LOMBARD, Oregon State University, Agricultural Experiment Sta., *Medford, Oregon* 97502

Objectives: Nutritional and soil moisture requirements of pear orchards of southern Oregon will be investigated so to improve the tree yields and fruit quality by the most efficient methods.

Description of work proposed: 1. Field experiments will be conducted to determine the combination of nutrient applications to give optimum levels of growth, yield, fruit quality and leaf content of pear trees. 2. Experiments to determine the most efficient use of soil moisture by pear trees will be conducted. 3. The methods of soil management which incorporate optimum levels of nutrients and soil moisture in the field will be evaluated.

SUPPORTED BY Oregon State Government

2.0900, GENERALIZED SOIL - MOISTURE RUNOFF-RELATIONS

J.A. ANDERSON, U.S. Army, Corps of Engineers, *Portland, Oregon* 97205

It is becoming generally accepted by hydraulic engineers that the soil moisture condition of the upper soil layer is the primary factor controlling the amount of runoff from a given rainfall. The purpose of the proposed study is to develop a procedure to evaluate the soil complex of a drainage basin and arrive at the relationship that would permit computation of runoff from rainfall data.

The scope of the study would include the refinement of rainfall - runoff relationships using soil moisture as the primary parameter for typical basins throughout the United States where adequate basic data on rainfall and runoff are available. Data on soil characteristics would be obtained by field surveys and appropriate sampling procedures. Correlations of the field data and the empirically derived soil - moisture functions would then be made. Rainfall - runoff relations could then by synthesized for basins without runoff records. Such procedures could then be used to compute runoff data for river basins in similar areas of the earth where only rainfall data are available.

SUPPORTED BY U.S. Dept. of Defense - Army

2.0901, SEDIMENTATION IN SMALL FORESTED DRAINAGE BASINS

D.D. HARRIS, U.S. Dept. of Interior, Water Resources Division, *Portland, Oregon* 97208

Purpose is to relate changes in sedimentation patterns due to logging operations in a group of three watersheds in the Alsea River system. A comparison of similar basins which are ultimately subjected to extensive logging operations will provide the basis for correlating runoff and sediment discharge as recorded from numerous measurements made at controlled weirs and backwater pools.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Oregon State Government

2.0902, MOVEMENT OF RADIONUCLIDES IN THE LOWER COLUMBIA RIVER

W.L. HAUSHILD, U.S. Dept. of Interior, Water Resources Division, *Portland, Oregon* 97208

The objective of this project is to quantitatively determine the concentrations and loads of specific radionuclides that are solutes and sorbed on sediments in the Columbia River from Hanford, Washington to the estuary. The spatial and temporal variation and distribution of the radionuclide concentration and loads are to be studied, and an approximate budget of the radionuclides is to be determined.

The physical, chemical and mineral properties of the suspended and streambed sediments are being studied; and these properties, insofar as is possible, will be related to sediment transport, sorbed radionuclides, and the equilibrium balance between the solute and sorbed radionuclide phases.

The extent and characteristics of sediments deposited on the streambed and sorption of radionuclides by these sediments in the natural channel, reservoir, and tidal-affected reaches are being surveyed.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0903, THE MOVEMENT OF RADIONUCLIDES IN THE COLUMBIA RIVER ESTUARY

D.W. HUBBELL, U.S. Dept. of Interior, Water Resources Division, *Portland, Oregon* 97208

Certain radionuclides enter the Columbia River from the Hanford installation of the U. S. Atomic Energy Commission. Part of the radionuclides remain in solution in the water, part are sorbed on the fluvial sediment, and part are taken up by the biota. As a result, each medium, by virtue of its motion, affects the distribution of the radionuclides.

Objectives of this project are to define the disposition and movement of radionuclides in the Columbia River estuary; to study the processes that influence the movement of radionuclides, particularly the sedimentation, flow and chemical processes; and to contribute to estuarine technology.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0904, RESEARCH IN ATMOSPHERIC SCIENCES AS RELATED TO INCREASING WATER SUPPLY

A. KAHAN, U.S. Dept. of Interior, Bonneville Power Admin. , *Portland, Oregon*

This program is designed for developing techniques for augmentation of precipitation to increase snowpack by experimenting with the artificial nucleation of orgraphic and semi-orographic clouds. The increased snowpack resulting from the nucleation of winter-time orographic storms would be of great value in increasing water supply to the Bureau of Reclamation, Hungry Horse Reservoir, for release during periods of power needs.

SUPPORTED BY U.S. Dept. of Interior - Bonnvl. Pwr. Adm.
U.S. Dept. of Interior - Bonnvl. Pwr. Adm.

2.0905, HYDROLOGY OF THE COLUMBIA RIVER BASALT

R.C. NEWCOMB, U.S. Dept. of Interior, Water Resources Division, *Portland, Oregon* 97208

Studies are in progress to determine the effect of geologic structure and texture of basalt upon such hydrologic factors as runoff, weathering and erosion, infiltration, occurrence and movement of ground water, and quality of water. Compilation of a regional map of the tectonic structures of the Columbia River Basalt is underway. Data on well construction and such quantitative hydrologic factors as runoff and infiltration are being collected.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0906, SCHUYLKILL RIVER SURVEY

C.H. MCCONNELL, E.H. Bourquard & Associates, *Harrisburg, Pennsylvania*

To conduct a general survey along the Schuylkill River to determine the extent of existing water related problems and make recommendations for a plan of development to be undertaken that would offer benefits in the form of flood control, water supply, recreational and other water related projects at critical locations.

SUPPORTED BY Pennsylvania State Government

2.0907, HYDROGEOLOGY OF PUBLIC GROUND WATER SUPPLIES IN PENNSYLVANIA

G.H. EMRICH, State Dept. of Health, *Harrisburg, Pennsylvania*

This study is to critically evaluate the ground water yields and chemistry of the ground water from all public ground water supplies in the Commonwealth of Pennsylvania.

The information in the file of the Pennsylvania Department of Health will be compiled and completed in a readily usable form. Work will be done cooperatively with the regional staff of the Pennsylvania Department of Health, State Geologists, Department of Forests and Waters and the U. S. Geological Survey. Initial work will be limited to public water supplies in the Susquehanna and Potomac River Basins. The data will be analyzed in order to categorize the yields and the water chemistry of ground water for each hydrostratigraphic unit. Trends in water chemistry changes will be analysed to provide information for water management programs and specific programs to abate ground water pollution.

SUPPORTED BY Pennsylvania State Government

2.0908, DELAWARE ESTUARY SEDIMENTATION STUDY

D.W. MOODY, U.S. Dept. of Interior, Water Resources Division, *Harrisburg, Pennsylvania* 17104

Sediment transport processes in the Delaware estuary are being studied to determine the rate of shoal development. Measured sediment loads delivered to the Delaware estuary by Coastal Plain streams are much less than the annual estimated volume of estuarine sedimentation. Therefore, other sources of sediment must be identified to balance the sediment budget.

Salinity, sediment concentration, turbulence, and many other parameters are known to affect the rate of sediment flocculation. However, little is known about the quantitative effects of the environment upon sedimentation rates. Through field and laboratory experiments the most significant parameters will be identified; these parameters will then be related to rates of sedimentation measured in the field. Results of this study will be used to estimate changes in the present shoaling pattern due to man-made modifications of water quality and the physical geometry of the estuary.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0909, REMOTE SENSING OF DELAWARE ESTUARY

R.W. PAULSON, U.S. Dept. of Interior, Water Resources Division, *Harrisburg, Pennsylvania* 17104

Purpose: To determine effectiveness and feasibility of remote sensing devices in estuarine hydrologic investigations.

Methods: A series of remote sensing data collection missions will be flown over the Delaware estuary by NASA and USGS aircraft. Sensitivities of sensors to water quality variations will be treated initially. Subsequent missions will be based on initial findings.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0910, COORDINATION OF ESTUARINE REMOTE SENSING IN ATLANTIC COAST REGION

R.W. PAULSON, U.S. Dept. of Interior, Water Resources Division, *Harrisburg, Pennsylvania* 17104

Purpose: To provide an overview of Atlantic Coast estuaries, now that it is practical to photograph or sense at frequent and regular intervals large areas of the earth's surface from space. To develop a program and modi operandi for studying estuaries and groups of estuaries from space.

Methods: Photographs, remote sensing data and other information from individual remote sensing projects will be compiled, collated, and coordinated to formulate an optimal synoptic approach to the study of the hydrology of estuaries from space.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.0911, DIVERSITY AND ECOLOGICAL NICHES IN MULTI-SPECIES ASSOCIATIONS OF CHYORID CLADOCERA (CRUSTACEA)

C.E. GOULDEN, Acad. of Nat. Sci. of Phila. , *Philadelphia, Pennsylvania* 19103

The proposed research is designed to study the structure of multi species associations of chydorid Cladocera (Crustacea) in different types of natural habitats and to relate the presence of individual species with substrates and other physical and chemical features of the environment.

Quantitative collections of chydorids will be made, using a modified Gerking Model B sampler, in a specified number of littoral habitats from April to October in 1967 and 1968 in order to study population changes of individual species of chydorids and seasonal changes in diversity related to the growth of vegetation and accumulation of organic material in each habitat. In addition, a series of different habitat types and different lakes in New England will be sampled for analysis of the diversity of chydorid associations as related to habitat and lake types. These data for each lake will be compared with data obtained from analysis of chydorid microfossils in sediments from the same lake.

Microhabitats within each habitat will be sampled to determine substrate preferences for individual species. Substrate preferences and swimming behavior of individual species will be studied in laboratory experiments. Gut analyses will be made on freshly killed specimens to identify major food items consumed by each species.

SUPPORTED BY U.S. National Science Foundation

2.0912, RESEARCH INITIATION-ADSORBED WATER AND SOIL PLASTICITY

E.J. DOHENY, Drexel Institute of Technology, School of Engineering, *Philadelphia, Pennsylvania* 19140

This research seeks to achieve a better understanding of the role of adsorbed and free water in generating plastic properties of soils and will attempt to provide a more quantitative basis for the Atterberg limits by relating the thickness of the adsorbed water layer at specific moisture contents. Techniques to be used in detecting and measuring the thickness of the adsorbed layer are: rates of evaporation; dielectric loss; infrared absorption spectra. Each method will be used to determine the moisture content at which all soil water is adsorbed and the thickness of the adsorbed layer will be calculated by relating total particle surface area to the volume of water in the soil sample.

SUPPORTED BY U.S. National Science Foundation

2.0913, HYDROLOGIC MODELS FOR PREDICTING THE EFFECTS OF URBANIZATION

I. REMSON, Drexel Institute of Technology, School of Engineering, *Philadelphia, Pennsylvania* 19140

The conversion of large rural areas into urban and suburban complexes is an outstanding feature of the national development. Severe hydrologic effects will result from the ensuing conversion and development, yet the resultant effects or their remedies are neither understood or well defined. This study will include mathematical modeling to help appraise these hydrologic changes, their magnitudes, their effects and possible remedial actions.

The investigation, which will complement an initial study employing modeling for soil-moisture and ground water movement, includes as specific objectives: 1. Completion of the entire model by extending it to include overland flow, ground-water discharge to streams, stream flow and other hydrologic phenomena. 2. Testing of the validity of the model against a prototype watershed. Presently, it is planned to do this in conjunction with a study of urbanization and regional planning in the Brandywine Watershed by personnel of the Institute For Environmental Studies at the University of Pennsylvania and the Regional Science Research Institute. Use of the model to determine the hydrologic effects of different urbanization growth patterns.

SUPPORTED BY U.S. National Science Foundation

2.0914, DEVELOPMENT OF A COULOMETRIC METHOD FOR THE MEASUREMENT OF DISSOLVED OXYGEN IN SEA WATER

E.J. GREEN, Carnegie Mellon University, Graduate School, *Pittsburgh, Pennsylvania* 15213

This is a project for the development of a method of analysis for dissolved oxygen in aqueous solutions and particularly in sea water. The method is to be the indirect cathodic reduction of the oxygen by an electrode held at controlled potential. Upon completion of the reduction, measurement of the total charge passed through the solution gives the oxygen concentration directly without further calibration. Preliminary investigations suggest the possibility of a practical shipboard analyzer to replace the currently widely-used Winkler titration.

SUPPORTED BY U.S. National Science Foundation

2.0915, SYSTEMS APPROACH TO FLOW PREDICTION IN WATER RESOURCE PLANNING

C.L. CHIU, Univ. of Pittsburgh, School of Engineering, *Pittsburgh, Pennsylvania* 15213

The proposed research covers the systems analysis of hydrologic systems with a minimum of dependence on historical data, and without the unrealistic assumptions of linearity and stationarity which have rendered the application in most studies impractical.

The main approach in the investigation is:

a. To model the structural behavior of the input-output processes in the hydrologic systems. This involves the determination of the statistical characteristics of rainfall and runoff, using regression techniques, spectral and cross-spectral analysis, harmonic techniques, and Monte Carlo simulation methods.

b. To analyze 'black box' relationship between input and output processes of hydrologic systems. The mathematical technique involves the use of functional polynomials, orthogenal functions, Fourier transformations and analysis of non-stationary time series. Problems concerning the non-linearity and non-stationarity of hydrologic systems will be investigated. Empahsis will be placed on both non-linerar analysis and analysis of time-varying systems.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

2.0916, ANALYSIS AND SYNTHESIS OF BEDLOAD FORMULAS

R.P. APMANN, Penn. State University, U.S.D.A. Ne. Watersh. Res. Ct., *University Park, Pennsylvania* 16802

Object: To evaluate the usefulness, reliability, and applicability of about 17 bedload formulas; and to recommend a research program either to resolve their differences or to provide new formulas.

Plan of work: This research project on sedimentation includes the following aspects: (1) collect original publications including the basic data dealing with the different bedload formulas; (2) collect published comments on the reliability and applicability of bedload formulas; (3) critically compare formulas either graphically or in dimensionless form, or both, and limit comparisons to the ranges of the basic measured laboratory or field data; (4) synthesize the bedload formulas into one or more and develop their ranges of utility and their limitations, particularly for field use and application; and (5) recommend laboratory and field research program to (a) fill in gaps of knowledge in existing or adapted bedload formulas, (b) expand the range of the latter, and (c) provide new bedload formulas if evaluation investigation reveals (a) and (b) would not be satisfactory.

SUPPORTED BY U.S. Dept. of Agriculture

2.0917, NATURAL CONVECTION IN WATER-SATURATED POROUS MEDIA

D.A. DONOHUE, Penn. State University, School of Engineering, *University Park, Pennsylvania* 16802

Using a parallelopiped model filled with a water saturated porous medium, constant temperatures will be applied to the upper and lower faces of the model. The temperature of the lower face will be greater than that of the upper. A number of temperature sensing elements will be placed at appropriate points within the rock-fluid medium and a continuous, multipoint recorder will be used to record temperatures. Fluid movement will be calculated from the temperature-time distributions at the measurement points. The effects of the geometric shape of the model, the macroscopic physical properties of the porous medium, and the viscosity of the fluid will be obtained experimentally at temperature levels of physical significance. The experimental results will be compared with proposed theoretical models and these models will be reformulated if necessary.

SUPPORTED BY U.S. National Science Foundation

2.0918, NUMERICAL SIMULATION OF GROUNDWATER FLOW SYSTEMS

D.A. DONOHUE, Penn. State University, Inst. For Res. on Land & Water, *University Park, Pennsylvania* 16802

The purpose of the proposed study is to apply the numerical techniques developed by the petroleum industry to the simulation of groundwater flow systems. The use of variational methods will be investigated as this approach has been shown to require considerably less computer time than the more conventional techniques. Initial studies will consist of two-phase, two-dimensional systems but the extension to three dimensions will be considered.

A generalized computer program will be written using the most efficient numerical technique. This program may then be applied to a specific groundwater system to be used as a tool in water resource management studies. Each of the various numerical techniques will be reviewed so that the efficiencies of each may be evaluated. An IBM System 360-Model 67 will be used to perform the simulations.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Pennsylvania State University

2.0919, THE RELATION OF RAIN, SNOW, AND FROZEN SOILS TO THE HYDROLOGY OF AGRICULTURAL WATERSHEDS

E.T. ENGMAN, Penn. State University, U.S.D.A. Ne. Watersh. Res. Ct., *University Park, Pennsylvania* 16802

Object: To develop basic information and evaluate factors influencing the areal and geographic location, topography, vegetal cover, frozen soils, snowpack, and melting snow influence runoff from agricultural watersheds in the Northeast.

2. WATER CYCLE

Plan of Work: Studies are carried out on the Sleepers River Experimental Watershed near Danville, Vermont; the Northeast Watershed Research Center, University Park, Pennsylvania, and on other agricultural watersheds in Virginia. The investigations include: development of methods for expressing storm patterns in relation to frequency and seasonal occurrence; deposition and distribution of snow in relation to factors such as topography, wind, watershed aspect, and cover; methods of estimating snow on a watershed by sample measurements; physics of snowmelt; disposition of snow and snowmelt by sublimation, evaporation, runoff, and infiltration; relations between cover, snow, frozen soils, runoff; effects of freezing and thawing of soils on infiltration and runoff; development of methods for obtaining an average depth of precipitation on a watershed; and influence of topography and evaluation on individual seasonal and annual precipitation.

SUPPORTED BY U.S. Dept. of Agriculture

2.0920, TIME DISTRIBUTION OF RAINFALL INTENSITIES

L.A. HIEMSTRA, Penn. State University, Inst. For Res. on Land & Water, *University Park, Pennsylvania* 16802

The proposed research involves the finding of a suitable descriptive mathematical function for the time distribution of rainfall intensities in a rainstorm. The parameters of this mathematical function will be studies to find a seasonal distribution, if it exists, and also to find the serial correllations in the sequence of storms if possible.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Pennsylvania State University

2.0921, SHORT-DURATION CONVECTIVE RAINFALL - DEPTH-DURATION AND INTENSITY-DURATION RELATIONSHIPS AND VARIATIONS

E.B. JONES, Penn. State University, Inst. For Res. on Land & Water, *University Park, Pennsylvania* 16802

Under this project, the following information will be sought: 1) The variation of rainfall depth and intensity with time, encompassing periods of rainfall of a convective nature. 2) Depth-duration and intensity-duration characteristics of the 'average thunderstorm,' and the spatial distribution of these parameters.

Two tipping-bucket rain gages with recorder-indicator units are installed at suitable locations in the general vicinity of State College, Pennsylvania. Two additional gages are located on the Mahantango watershed which is operated by the Northeast Hydrology Laboratory of the A.R.S. (U.S.D.A.).

SUPPORTED BY Pennsylvania State University

2.0922, HYDROLOGIC BEHAVIOR OF SELECTED WATERSHEDS IN THE NORTHERN APPALACHIAN REGION

E.B. JONES, Penn. State University, Inst. For Res. on Land & Water, *University Park, Pennsylvania* 16802

Several watersheds that as a group are generally representative of watersheds in the ridge and valley region of the northern half of the Appalachian Mountains are to be selected for this hydrologic study. Hydrologic, climatic, physiographic and other pertinent data for these watersheds will be collected.

Existing mathematical watershed models will be utilized to simulate hydrologic conditions on these watersheds, for a wide range of historic and synthesized rainfall events.

Based on results from the simulation model, estimates will be made as to what increases in runoff could be attributed to an increase in rainfall by weather modification. Objective criteria for determining opportunities for weather modification will be utilized.

SUPPORTED BY Pennsylvania State Government
U.S. Dept. of Interior - Bu. Reclamation

2.0923, SOIL - PLANT - WATER RELATIONSHIPS

L.T. KARDOS, Penn. State University, Agricultural Experiment Sta., *University Park, Pennsylvania* 16802

Objectives: 1. To study the energy status and dynamics of water in soils. 2. To determine the influence of plant and environmental variables upon water extraction from the soil profile.

Procedures: Using the single probe neutron attenuation method, the two probe, gamma radiation, pulse height analyzer system, and porous resistance blocks, the dynamics of water movement will be studied as it occurs in response to tension gradients induced by root systems and by evaporative removal of water in the absence of vegetation. Plastic canopies will be used in the field to assure the attainment of continuous tension gradients. Data will also be secured on temperature gradients within the soil profile in order to evaluate the contribution which thermal gradients may make to inter-horizonal movements of water.

SUPPORTED BY U.S. Dept. of Agriculture
Pennsylvania State Government

2.0924, THE HYDROLOGIC SIGNIFICANCE OF CHEMICALLY DERIVED MEAN BASIN TEMPERATURES

R. LEE, Penn. State University, Graduate School, *University Park, Pennsylvania* 16802

Many aspects of the regional and local climate can be studied to best advantage if mean air, soil, and water temperatures are available for many different sites. The utility and hydrologic significance of a chemical method of measuring mean temperatures in the field (see e.g., Schmitz, W. and E. Volkert, Zeiss-Mitteilungen 1.Band, 8/9. Heft : 300-337) is to be evaluated.

The procedure will involve the instrumentation of climatological stations and two experimental watersheds at University Park with sugar- inversion sensing elements. The exponential mean temperatures obtained will be used to estimate vaporization losses based on conventional prediction models. The estimates will be compared with those obtained in the same manner using the ordinary arithmetic mean temperatures. Both series of estimates will be related to the observed difference between precipitation and stream-flow from the experimental catchment areas.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Pennsylvania State University

2.0925, AN EVALUATION OF THE SUGAR-INVERSION METHOD OF MEASURING MEAN TEMPERATURE IN A CLIMATOLOGICAL NETWORK

R. LEE, Penn. State University, Graduate School, *University Park, Pennsylvania* 16802

The sugar-inversion, or Pallmann-method of measuring exponential mean temperatures, and some of the difficulties involved in its use are described in WB/T-110 and WB/T-112, U. S. Department of Commerce, 1966. The Pallman-method and recent modifications of the method are to be evaluated.

The non-linearity of the reaction constant of sucrose hydrolysis as a function of temperature is a major obstacle to the use of the method since temperatures obtained in this manner do not correspond to the usual arithmetic means of a climatological network. The possibility of reducing the exponential mean temperatures to arithmetic means will be evaluated, as will the feasibility of employing the method in conjunction with regional phenological observations, or in local studies of the microclimate or topoclimate.

SUPPORTED BY Pennsylvania State University
U.S. Dept. of Commerce - E.S.S.A.

2.0926, RAINFALL FREQUENCY RELATIONS FOR PENNSYLVANIA

C.H. MCCONNELL, Penn. State University, Graduate School, *University Park, Pennsylvania* 16802

To analyze the records of all recording raingages in the Commonwealth to attain improved large maps of Pennsylvania depicting the maximum rainfall expected for various durations from fifteen minutes (if it can be discerned from the data) or thirty minutes through twenty- four hours with return periods of from two years through one hundred years to return periods associated with 'probable maximum precipitation' for use in the design of dam spillways, bridge openings, culverts, and flood control works.

SUPPORTED BY Pennsylvania State Government

2.0927, ANOMALOUS FLOOD RESPONSE IN REGIONS OF SIMILAR GEOMORPHIC CHARACTERISTICS

B.M. REICH, Penn. State University, School of Engineering, *University Park, Pennsylvania* 16802

Statistical parameter of flood series for recorded streams in Pennsylvania draining less than 200 square miles will be analysed. Regional patterns will be sought. Particular attention will be devoted to anomalies in these extreme values. Air-photo interpretation soils maps, and geomorphological considerations will be used to interpret the computer output.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Pennsylvania State University

2.0928, FLOOD PREDICTION METHODS FOR PENNSYLVANIA HIGHWAY CROSSINGS

B.M. REICH, Penn. State University, School of Engineering, *University Park, Pennsylvania* 16802

The purpose is to make maximum use of observations on floods from small-and intermediate-sized watersheds, up to 200 square miles. The end products will include maps subdividing Pennsylvania into regions of homogeneous flood response, and others delineating the values of various flood parameters from place to place. Design methods will be developed for predicting flood peaks and hydrographs.

A keypoint in the philosophy is that flood anomalies should be related to features with which field engineers are familiar. To meet this need detailed geomorphological and soils studies will be included. In the systems analysis feedback will be considered between the latter two and conventional hydrologic studies of extreme value series, synthetic hydrographs, separation of delayed flow, rise times, and triangular approximation.

SUPPORTED BY Pennsylvania State Government

2.0929, CHARACTERISTICS OF STREAM FLOW OF SMALL WATERSHEDS IN PENNSYLVANIA AND INFLUENCING FACTORS

W.E. SOPPER, Penn. State University, Inst. For Res. on Land & Water, *University Park, Pennsylvania* 16802

Watershed research programs are usually developed around experimental watersheds. The establishment and operation of such watersheds, however, is expensive and it is doubtful whether enough experimental watersheds will ever be established to adequately sample the watershed population. Therefore, the application and extension of research results from a limited number of experimental watersheds would be greatly facilitated if more information were available relative to regional streamflow regimens and the relation of streamflow from experimental watersheds to average regional water yield values.

Streamflow data published by the U. S. Geological Survey may be used to determine the variation in annual and seasonal streamflow, flow duration and peak flow discharge for major physiographic regions in Pennsylvania and to develop predictive equations for water yield values based on climatic, edophic, topographic and land-use parameters.

Research data from the Leading Ridge experimental watersheds operating by the School of Forestry will be used to develop water yield models which will then be tested on other selected watersheds to devise regional coefficients and to relate coefficients to watershed physiographic features.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Pennsylvania State University

2.0930, INFLUENCE OF FOREST COVER AND TIMBER HARVESTING METHODS ON STREAMFLOW

W.E. SOPPER, Penn. State University, Agricultural Experiment Sta., *University Park, Pennsylvania* 16802

1. Determine the influence of forest cover on the disposition of precipitation. 2. Determine the influence of forest cover on stream regimen. 3. Determine effect of timber harvesting methods on streamflow regimen.

Six experimental watersheds ranging in size from 50 to 300 acres will be calibrated and subjected to different methods of timber harvesting.

SUPPORTED BY U.S. Dept. of Agriculture

2.0931, TRACE ELEMENTS IN RESIDUAL SOILS

A. KABATAPENDIAS, Inst. of Soil Sci. & Pl. Cult., *Pulawy, Poland*

Object: To formulate principles to aid in the prediction of micronutrient distribution in soils and to assess the importance of factors which affect the solubility of certain micronutrients in soils.

Plan of work: Work plan will proceed along the following lines: collection of 20 residual soils--half developed from igneous, half developed from sedimentary rocks; separation, where possible, of clay fraction from each sample; mineralogical identification and total chemical analysis of each fraction; determination of total and soluble micronutrients in each soil sample; saturation of clays with individual micronutrients with measurement of elements before and after treatment; use of different extractants with analysis of extracted solutions for major trace elements; and extension of saturation studies to whole soils and mineral samples as the need is indicated by results up to this point.

SUPPORTED BY U.S. Dept. of Agriculture

2.0932, RAINFALL CHARACTERISTICS, DROUGHT INCIDENCE AND THE DEVELOPMENT OF A RAINFALL DEFICIENCY INDEX FOR THE AGRICULTURAL REGIONS OF PUERTO RICO

M. CAPIEL, Univ. of Puerto Rico, Agricultural Experiment Sta., *Gurabo, Puerto Rico*

To characterize rainfall occurrence and recognize drought incidence in the agricultural regions of Puerto Rico by developing a suitable rainfall deficiency index.

DESCRIPTION OF WORK: The agricultural regions of Puerto Rico, defined on the basis of similar rainfall occurrence and temperature range, will be evaluated by their rainfall characteristics and agricultural drought incidence.

Daily precipitation from representative stations within a climatic region, comprising the largest available number of years, will constitute the main source of meteorologic information. An attempt will be made to develop from it a rainfall deficiency index, useful to evaluate priorities concerning water resources for supplemental irrigation in the so-called humid and subhumid agricultural areas of Puerto Rico.

SUPPORTED BY U.S. Dept. of Agriculture
Puerto Rico Government

2.0933, WATER REQUIREMENT BY SUGARCANE UNDER IRRIGATION

R. VAZQUEZ, Univ. of Puerto Rico, Agricultural Experiment Sta., *Lajas, Puerto Rico*

To determine the amount of irrigation water required for evapotranspiration and deep percolation for sugarcane. The effect of different soil moisture treatments on crop yields and sucrose content and the correlation between soil moisture and plant moisture content will be studied. The interaction between fertilizer and water application and the moisture distribution in the soil profile will also be studied.

Description of Work: Four experiments will be conducted. In one of these experiments half of the plots will be planted with sugarcane and half will be left bare covered with plastics. In another experiment the irrigation treatments will be discontinued at 6, 5, 4, 3, 2, and 1 month prior to harvest. Different levels of plant tissue moisture content will be maintained. Present installation of lysimeter tanks will be planted with sugarcane under two irrigation and nitrogen fertility levels.

SUPPORTED BY Puerto Rico Government

2.0934, LOSS COEFFICIENT IN A CHANNEL BEND WITH NATURALLY DEFORMED BED

C. HADJITHEODOROU, Univ. of Puerto Rico, Water Resources Research Inst., *Mayaguez, Puerto Rico*

In spite of many investigations concerning the loss coefficient in a channel bend with uniform cross-section, engineers are still not able to determine accurately the loss of head across a channel bend because uniform cross-sections are rarely found in rivers or canal system.

The first part of the study will include experimental investigations and numerical solution for a laminar flow over a two-dimensional hump to understand the mechanism of energy transformation; bed-shear stresses, velocity distributions, and water-surface will be measured and computed.

A model of meandering channel will be built in accordance with the best information available. Also, bed-shear stresses, velocity distributions, and waters-surface drop will be measured. The loss of head will be computed from the work-energy relationship and compared with the direct measurement of water-surface drop.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Puerto Rico

2.0935, THEORETICAL AND EXPERIMENTAL STUDY OF SUPERCRITICAL FLOW IN CIRCULAR DRAINS AND OF THE FORMATION OF HYDRAULIC JUMP IN THE SAME

L.A. NUNEZ, Univ. of Puerto Rico, Water Resources Research Inst., *Mayaguez, Puerto Rico*

The object of this project is to make an exhaustive study of both the theoretical and experimental aspect at the supercritical flow in circular drains. It will begin with a complete library search on existing bibliography on the subject, followed by experimental work directed towards a verification of known facts and the investigation of new ones on circular drains. The study will seek to determine:

1. If Manning's formula is applicable whenever the conduction slope is more than 0.10. 2. The variation of coefficient n with respect to depth within the drain. 3. The effect of air mixed in the flowing flow under supercritical condition. 4. The study of the hydraulic jump of easy formation in circular drain in supercritical flow.

This work intends to clear up the doubts through experimentation and particularly those related to the design of circular drains.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Puerto Rico

2.0936, DRAINAGE OF SUGARCANE LANDS IN THE HUMID SECTIONS OF PUERTO RICO

R. PEREZESCOLAR, Univ. of Puerto Rico, Agricultural Experiment Sta., *Mayaguez, Puerto Rico*

1. To evaluate various sugarcane planting systems adaptable to complete mechanization in relation to their drainage characteristics. 2. To determine the effect of depth to water table on the yield of sugarcane and its sucrose content.

Description of Work: This project is aimed at evaluating sugarcane planting systems in the poorly drained areas of the northern, eastern and western sections of the Island such as the local conventional system and the original Louisiana system, the turtle backing system and precision grading.

Observations and measurements will be made at each experimental site including daily rainfall, water table fluctuations, degree of ponding, uniformity of cane growth, chlorotic streak incidence, rotten cane, and cane and sugar yields.

In the water table studies several depths to the water saturated zone will be studied to determine the optimum water table for highest cane and sugar yields. The study will be conducted under controlled conditions in lysimeter tanks and under actual field conditions.

SUPPORTED BY Puerto Rico Government

2.0937, DETERMINATION OF SAFE LEVELS OF POLLUTION IN PUERTO RICO

A.S. VAZQUEZ, Univ. of Puerto Rico, Water Resources Research Inst., *Mayaguez, Puerto Rico*

Some Puerto Rico Bays are receiving raw sewage and other organic pollution in high concentrations. Damage has been done to the fish population and to the recreational use of surrounding beaches, the best example being the Bay of Mayaguez just near the Campus of the College of Agriculture and Mechanic Arts where the Institute will have its headquarters.

It is proposed to investigate the degree of contamination of the bay to evaluate the proportional effect of the different factors which contribute directly to its actual and future sanitary conditions and its effects on the fish, ecology and the recreational aspect of the bay and surroundings.

This study will be carried on through the systematic measurement of parameters such as BOD, dissolved oxygen, solids, coliform group, biota, etc. Similarly, physical, chemical, and meteorological factors affecting the locality of the Mayaguez Bay will also be determined inside the bay. The goal will be to establish the relationships among the most important of the factors that enter into the problem, with the purpose of establishing criteria for prediction for similar situation in tropical bays.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Puerto Rico

2.0938, THE LOSS OF FERTILIZERS BY LEACHING FROM THE SUGARCANE SOILS OF PUERTO RICO

G. SAMUELS, Univ. of Puerto Rico, Agricultural Experiment Sta., *San Juan - Rio Piedras, Puerto Rico* 00931

1) To measure and collect leachings from various soils while used to produce surgarcane. 2) To determine the chemical composition of the leachings so as to measure the plant nutrients lost by leaching. 3) To determine how the method and time of application and form of fertilizer influences the loss of fertilizer nutrients by leaching.

DESCRIPTION OF WORK: By means of special lysimeters constructed in the field the loss of fertilizers in the soils by leaching will be studied throughout the life of the crop in order to determine how the method and time and form of fertilizer application influence these losses.

SUPPORTED BY Puerto Rico Government

2.0939, EVAPOTRANSPIRATION LOSSES AS RELATED TO SITE AND VEGETATION DIFFERENCES

J.H. BROWN, Univ. of Rhode Island, Agricultural Experiment Sta., *Kingston, Rhode Island* 02881

Objectives: 1. Determine differences in evapotranspiration from several cover types occurring on similar and unlike soils and in various aspects. 2. Evaluate stand and soil properties which influence evapotranspiration including canopy interception for each cover type, and hydrologic properties of the major soil series.

Procedures: Evapotranspiration will be determined from plot studies for stand in major upland vegetation types which vary in soil type and aspect on a small forested watershed in Rhode Island. Methods based upon soil moisture changes from field capacity will be used to determine evapotranspiration employing neutron scatter methods. Where vegetation types are on poorly drained soils changes in water levels of soil wells will be used as an index of evapotranspiration. Evapotranspiration will be correlated with soil type, vegetation type and aspect taking into consideration hydrologic properties of the various soils and differences in interception by the various vegetation types.

SUPPORTED BY U.S. Dept. of Agriculture

2.0940, SOIL MOISTURE DISTRIBUTION PATTERNS UNDER MIXED OAK FOREST

J.H. BROWN, Univ. of Rhode Island, Agricultural Experiment Sta., *Kingston, Rhode Island* 02881

The study objective will be to relate soil moisture distribution patterns under mixed oak forests to precipitation reaching the ground by flowing down tree stems (stemflow), and precipitation falling through tree crowns (throughfall).

Studies of interception in oak forests now being conducted in Rhode Island show large differences in stemflow between white oak (Quercus alba) and species in the red oak group. This striking difference between species must influence considerably soil moisture distribution patterns under oak forests. Information on such patterns could have important ecological and hydrological applications.

The study will be conducted in an even-aged mixed oak stand on uniform soil. Soil moisture content will be determined using the neutron-scatter method. Access tubes will be placed at varying distances from overstory oak trees so that the influence of stemflow and throughfall can be related to soil moisture content. Patterns of soil moisture distribution will be determined and related to stemflow and throughtfall and differences in species.

SUPPORTED BY University of Rhode Island

2.0941, THE WATER ECONOMY OF TURFGRASS

I.H. STUCKEY, Univ. of Rhode Island, Agricultural Experiment Sta., *Kingston, Rhode Island* 02881

Objective: To evaluate the water economy of several commonly used species and varieties of turfgrasses in relation to soil type, maintenance practices and environmental conditions.

Description of Work: Measurements will be made regularly of soil moisture, soil atmosphere, soil and air temperature, and turf scores on a 1-5 basis (1 - poorest, 5 - best). The influence of fog and dew, on plant growth will be studied intensively since it is felt that these contribute materially to plant growth in areas where fog and dew are frequent but they are not reported as moisture in most weather records.

SUPPORTED BY Rhode Island State Government

2.0942, WEATHER RECORDS

R.C. WAKEFIELD, Univ. of Rhode Island, Agricultural Experiment Sta., *Kingston, Rhode Island* 02881

Records of air temperature, precipitation, soil temperature, wind movement, relative humidity, soil moisture and evaporation are taken to characterize the climate in the experimental plot area and aid in interpretation of data.

SUPPORTED BY Rhode Island State Government

2.0943, HYDROLOGICAL STUDY

C.E. KNOX, U.S. Dept. of Interior, Geological Survey, *Providence, Rhode Island*

Hydrologic data is obtained and analyzed on small water sheds in Rhode Island which can be used for hydraulic design of highway structures. Fifteen peak-stage and five recording gaging stations were located at various sites. Water discharge measurements are being recorded at all stations each month.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Rhode Island State Government

2.0944, A COMPARATIVE STUDY OF TRACE ELEMENT CYCLES IN SIX LAKES IN SOUTH CAROLI

J.S. MARSHALL, U.S. Atomic Energy Commission, Savannah River Plant & Labs., *Aiken, South Carolina* (AT(07-2)-1)

The objective is to determine (1) the distribution and abundance of certain trace elements in lakewater solutions, seston, net plankton, and sediments and (2) the influence of key environmental factors in six dissimilar lakes in South Carolina. The most intensive work is being conducted on Par Pond, a 2700-acre reservoir on the site of the AEC Savannah River Plant. For comparative purposes, monthly samples are being collected from five other lakes: (1) Clark Hill Reservoir, a 78,000-acre impoundment of the Savannah River above SRP; (2) Pond B, a 250-acre, abandoned SRP reactor cooling pond; (3) Big Snooks Lake, a relatively large and deep oxbow lake in the swamp bordering the Savannah River below SRP; (4) Clear Lake, a typical 'Carolina Bay,' and (5) Dicks' Pond, an abandoned farm pond on the SRP site. Iron, manganese, chromium, and zinc will be determined by atomic absorption spectroscopy. Cobalt will be determined by neutron-activation analysis. Key environmental factors will be determined by standard limnological methods.

SUPPORTED BY U.S. Atomic Energy Commission

2.0945, TRACE ELEMENT CYCLES IN A SOUTHEASTERN RESERVOIR LAKE

J.S. MARSHALL, U.S. Atomic Energy Commission, Savannah River Plant & Labs., *Aiken, South Carolina* (AT(07-2)-1)

The objectives are to determine (1) the seasonal and vertical distribution of the dissolved and particulate forms of certain trace elements, (2) rates of deposition of these elements, (3) distribution and abundance of these elements in sediments, benthos, and plankton, (4) seasonal variations in sorption of introduced radionuclides by the seston at different depths, and (5) the influence of key environmental factors. In order to provide a basis for predicting or explaining the fates of radionuclides in lakes, the proposed work deals with trace elements that have radioisotopes of potential ecological significance and whose lacustrine geochemistry is incompletely known. Trace elements are determined by atomic absorption spectroscopy. Radionuclides are determined by gamma ray spectrometry. Other environmental factors are determined by standard limnological methods. The study is being conducted on Par Pond, a 2700-acre reservoir on the site of the AEC Savannah River Plant.

The cycles of iron, manganese, cobalt, and zinc in Par Pond have been studied since January 1966. The concentrations of these and several other elements in lakewater solutions, seston, net plankton, sediments, and trapped deposits (formalin-preserved as well as unpreserved) at several depths have been determined monthly. In addition, the sorption (%) of 59Fe, 54Mn, 57Co, and 65Zn by seston at several depths have been determined twice monthly.

SUPPORTED BY U.S. Atomic Energy Commission

2.0946, INFLUENCE OF VEGETATION IN SOIL MOISTURE FLOW

C.M. PATTERSON, U.S. Atomic Energy Commission, Savannah River Plant & Labs., *Aiken, South Carolina*

The amount of rain that infiltrates a soil surface is significantly influenced by vegetation. A study is planned to measure the influence of vegetation on soil moisture flow using the deuterium oxide tracer method.

SUPPORTED BY U.S. Atomic Energy Commission

2.0947, GROUNDWATER FLOW

C.M. PATTERSON, U.S. Atomic Energy Commission, Savannah River Plant & Labs., *Aiken, South Carolina*

Groundwater studies are aimed at determining the flow path and velocity of groundwater in areas used to store high level waste, bury solid waste, or dispose of very low level liquid waste to the ground.

Tritium tracing has shown that groundwater flow rates vary from a few hundredths of a foot per day to about 1 foot per day and that the rates are quite variable, even within a small area, due to variable permeability of the soil.

Tritium in seepage basin water has been useful in determining the flow path of waste from such basins toward surface streams. A study is being conducted using the tritium in this waste to study the vertical component of groundwater flow and to evaluate the significance of this flow in the transport of radionuclides from storage or disposal areas.

2. WATER CYCLE

SUPPORTED BY U.S. Atomic Energy Commission

2.0948, UNDERSTANDING OF THE INFILTRATION OF RAIN INTO BURIED WASTE

C.M. PATTERSON, U.S. Atomic Energy Commission, Savannah River Plant & Labs., *Aiken, South Carolina*

Solid radioactive waste is buried in the zone of aeration. With a better understanding of water flow in this zone, we can better protect waste from leaching.

Since water in the zone of aeration is under a pressure less than atmospheric, it will not flow into a cavity or large pores such as in a layer of gravel unless the soil becomes saturated. Use of this phenomenon to divert soil moisture flow around buried waste is being studied. With gravel at a depth of 87 cm, sandy loam or sandy clay can temporarily store 5 to 7 cm of infiltrating rain above the gravel before leakage into the gravel occurs. A gravel barrier was found unsatisfactory for protecting burial trenches as water could not be diverted beyond 2 meters.

Determine, using tensiometers and the soil moisture neutron meter, water movement and water content in burial trench soil following controlled additions of water and following normal rainfall.

SUPPORTED BY U.S. Atomic Energy Commission

2.0949, STUDIES ON VEGETABLE CULTURE

W.C. BARNES, Clemson University, Agricultural Experiment Sta., *Clemson, South Carolina* 29631

Objectives: To study various phases of Vegetable Culture such as nutrition, weed control, cultural methods, drainage, plant production, etc.

SUPPORTED BY South Carolina State Government

2.0950, FEASIBILITY STUDY OF ELECTRICAL GEOPHYSICAL METHODS IN THE DETERMINATION OF SUBSURFACE HYDROGEOLOGIC ENVIRONMENTS IN SOUTH CAROLINA

T.L. DRAKE, Clemson University, School of Engineering, *Clemson, South Carolina* 29631

The study will determine the effectiveness of electrical resistivity and induced electrical polarization techniques as an aid in the determination of the subsurface hydrogeologic environments in the Piedmont area of South Carolina.

The research task of this proposal involves simultaneous resistivity and induced polarization soundings and traverses over the somewhat known geologic and hydrologic environments of the Fant's Grove area to determine how well this combination of methods may predict the nature of the subsurface. The Fant's Grove area is chosen because it is representative of the Piedmont area of South Carolina.

It is hoped the position of water table, thickness and type of unconsolidated material overlying the bedrock, and delineation of potential zones of high permeability in the bedrock can be identified and mapped by these methods.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Clemson University
South Carolina State Government

2.0951, PHYSICAL, METEOROLOGICAL, AND HYDROLOGIC ASPECTS OF EVAPOTRANSPIRATION

J.R. LAMBERT, Clemson University, School of Engineering, *Clemson, South Carolina* 29631

The objectives of the project are: 1. To investigate the physics of water movement through plants, 2. To determine the effects of meteorological variables and soil moisture on evatranspiration, and 3. To investigate the effect of reduced evapotranspiration rates on the water yield of watersheds.

Emphasis will be placed on the effect of evapotranspiration on the water balance of watersheds, particularly in the Piedmont regions of the Southeast. Actual evapotranspiration rates from lysimeters and watersheds will be compared with existing prediction equations using meteorological data for the 600-acre watershed on which the research will be carried out. A small subwatershed will be treated with a transpiration suppressant such as a chemical which tends to close the stomates or a coating on the leaf surfaces which increases the resistance to water vapor movement. The resulting effect in sub-surface and surface contributions to yield will be determined. The research on the physics of water flow through plants will be basic, using 1 or 2 representative plants and will be both theoretical and experimental work in controlled-humidity growth chambers.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Clemson University

2.0952, CRITERIA FOR FUNCTIONAL ANALYSIS OF SOIL-PLANT-WATER SYSTEMS

J.R. LAMBERT, Clemson University, Agricultural Experiment Sta., *Clemson, South Carolina* 29631

Objectives: 1. To determine methods of quantifying the moisture regime of plants. 2. To determine the quantitative effect of moisture regime on quality and quantity of output of one or two crops which have water management potential in South Carolina. 3. To interpret the effects of moisture regime on the selected crops in terms of production functions. 4. To determine water management needed and crop output on a frequency basis from production functions, climatological data, and soils characteristics.

Description: Plants will be grown under various moisture regimes in growth chambers and under partially controlled field conditions. Moisture regimes will be considered to be composed of soil moisture, temperature, atmospheric humidity and solar radiation, all as a function of time. Prediction equations for crop output will be developed in the growth chamber, and checked and extended in the fields. The results from both types of experiments will be analyzed in attempts to determine parameters necessary to quantify moisture regime.

SUPPORTED BY U.S. Dept. of Agriculture
South Carolina State Government

2.0953, PHYSICAL, METEOROLOGICAL, AND HYDROLOGIC ASPECTS OF EVAPOTRANSPIRATION

J.R. LAMBERT, Clemson University, Agricultural Experiment Sta., *Clemson, South Carolina* 29631

1. To investigate the physics of water movement through plants. 2. To determine the effects of meteorological variables and soil moisture on evapotranspiration. 3. To investigate the effect of reduced evapotranspiration rates on the water yield of watersheds.

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SUPPORTED BY South Carolina State Government

2.0954, DEVELOPMENT AND EVALUATION OF HYDROLOGIC SIMULATION MODELS

J.T. LIGON, Clemson University, Water Resources Research Inst., *Clemson, South Carolina* 29631

The Stanford Watershed Model or a version of it will be adapted for use on computing equipment available to the researchers. The sub- procedures of this model will be checked against extensive field data available from a 561-acre experimental watershed in the Upper Piedmont region of South Carolina. Where possible improved procedures will be developed to simulate more faithfully the conditions existing in this physiographic region. The data from this experimental watershed and other watersheds within the region will be utilized for evaluation of specific model parameters.

Simultaneously, attempts will be made to develop new models. Particular attention will be given to the simulation of soil moisture and groundwater conditions as well as streamflow. Again, available soil moisture and groundwater data from the experimental watershed will be utilized in developing procedures and checking results.

It is anticipated that the work done under this project will serve as a basis for more extensive future studies possibly involving the effects of restraints placed on the hydrologic system and economic considerations.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Clemson University
South Carolina State Government

2.0955, DEEP SEEPAGE ON PIEDMONT WATERSHEDS

J.T. LIGON, Clemson University, Water Resources Research Inst., *Clemson, South Carolina* 29631

Objectives: (1) To determine principal soil and geologic factors influencing the percolation of water through the soil profile to the water table. (2) To develop relationships to quantitatively express percolation rates and amounts in terms of measurable physical quantities.

Unsaturated and saturated flow theory will be combined with soil parameters in an attempt to express the rate of downward flow of water under various surface input conditions. Required soil parameters will be measured in the field and in the laboratory.

Existing precipitation, soil moisture, and groundwater data from a typical Piedmont watershed will be analyzed to develop time-quantity relationships between specific rainfall events and water table fluctuations. Attempts will be made to follow movement of water through the soil profile by intensive use of gamma-ray attenuation equipment, neutron soil moisture detectors, and radioactive tracers.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Clemson University
South Carolina State Government

2.0956, EFFECT OF MOISTURE STRESS ON RATES OF PHOTOSYNTHESIS

W.H. MCGREGOR, Clemson University, Agricultural Experiment Sta., *Clemson, South Carolina* 29631

1. To determine the effect of various internal moisture stresses on the rates of photosynthesis and respiration of the two species. 2. To try and relate any differences in the above to differences in the rates of growth of the two species under the same moisture conditions.

Seedlings will be brought to various degrees of stress by varying watering schedules, and rates of exchange of CO2 in photosynthesis and respiration will be measured under fixed light and temperature conditions using an Infra-red Gas Analyzer. Growth in height and dry weight will be measured.

SUPPORTED BY U.S. Dept. of Agriculture

2.0957, EVAPORATION AND EVAPOTRANSPIRATION IN RELATION TO SOIL PROPERTIES AND MOISTURE STRESS

T.C. PEELE, Clemson University, School of Agriculture, *Clemson, South Carolina* 29631

The proposed research involves field and laboratory investigations of evaporation and transpiration as related to soil properties and moisture stress.

The field investigations will employ weighing lysimeters and supplemental field plots for measuring moisture loss under different soil conditions.

The laboratory investigations will consist of evaluation of the physical properties of the soils used in the field tests and determinations of moisture tension curves for relating water content of the field soils to moisture stress.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Clemson University
South Carolina State Government

2.0958, HYDROLOGY OF PIEDMONT AGRICULTURAL WATERSHEDS

R.H. RAMSEY, Clemson University, Agricultural Experiment Sta., *Clemson, South Carolina* 29631

Objectives: 1. To determine water yield and peak rates of surface flow as affected by climate, vegetation, water control facilities, and management of agricultural watersheds on typical Piedmont soils and terrain. 2. To determine the influence on ground water and ground water movement by vegetation, water control facilities, and management. 3. To determine the effects of evaporation and transpiration on the total available water from an agricultural watershed.

Description of Work Proposed: The hydrology of a 600 acre Piedmont agricultural watershed will be studied. Topographic maps, a complete soils survey, and field layout maps will be made and kept up-to-date. Rainfall, evaporation, radiant energy, temperature, relative humidity, and wind speed will be measured. Gaging stations will be set up to measure runoff from the 600 acres as well as sub-watersheds with different soils-topography-vegetation complexes. On the basis of records obtained, attempts will be made to correlate watershed yield and other hydrologic characteristics with rainfall-characteristics combined with watershed characteristics. Attempts will be made to account for the disposition of all water falling on the watershed.

SUPPORTED BY U.S. Dept. of Agriculture
South Carolina State Government

2.0959, INSECTICIDE LEACHING TESTS

J.K. REED, Clemson University, Agricultural Experiment Sta., *Clemson, South Carolina* 29631

Objectives: To determine the rate of release of various insecticides from granules when leached with water; to determine the physical properties of the granules that affect the rate of release of any given insecticide; and to determine the behavior of insecticides carried by water when the water passes into soil.

Description of Work Proposed: Granular formulations are widely used in the control of soil-infesting insects but little is known regarding the rate of release of the toxicant from the granule. Samples of the insecticide formulations will be placed in glass tubes and water passed over them for a period of time. Samples of the water will be collected and analyzed by bio-assay and chemical methods to determine the rate of release of the toxicant. At the end of the leaching period the residue in the glass tubes will be analyzed to determine how much of the toxicant remains. Different formulations will be tested to determine the effect of such factors as solvents, type of clays, etc. on the rate of release of the toxicant.

SUPPORTED BY South Carolina State Government

2.0960, IRRIGATION OF COTTON AND CORN.

UNKNOWN, Clemson University, Agricultural Experiment Sta., *Clemson, South Carolina* 29631

Objectives: 1. To determine the amount of fertilizer required for maximum cotton yields with and without irrigation. 2. To determine the effects of soil fumigation for nematode control on yields of irrigated and unirrigated cotton. 3. To determine the response of irrigated and unirrigated corn to rates and times of application of nitrogen.

Description of Work Proposed: Field experiments will be conducted to determine the effects on corn and cotton of different amounts of fertilizer applied to irrigated and unirrigated blocks of these crops. The effects of subsoiling and soil fumigation by the row method will be determined in conjunction with the irrigation and fertilization tests.

2. WATER CYCLE

SUPPORTED BY South Carolina State Government

2.0961, THE INTERFLOW PROCESS ON SLOPING WATERSHED AREAS

T.V. WILSON, Clemson University, School of Engineering, *Clemson, South Carolina* 29631

The proposed research plan involves laboratory and field studies to determine the primary factors influencing interflow on Piedmont watersheds. It is proposed to place sufficient instrumentation in lab models and in selected watershed sites to enable detection of directions of water movement during and after rainfall events. Tracers will also be employed to follow the movement of water through the soil. Physical soil parameters influencing water movement will be measured. Relationships between rates and quantities of interflow and the soil parameters will be evaluated on the basis of data obtained in the lab and field studies. The development of prediction equations, using measurable physical parameters, will be investigated.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Clemson University
South Carolina State Government

2.0962, STREAM IMPROVEMENT STUDY

D.L. ARCHER, State Wildlife Resources Dept. , *Columbia, South Carolina*

Objectives: To conduct a post-stream improvement study to further evaluate the use of stream improvement structures as a tool useful to South Carolina's trout management program.

To establish an additional 1/4-mile stream section in which to incorporate the gabion type stream improvement structure under heavily silted conditions.

Procedure: Post-stream improvement surveys will be conducted on two 1/2-mile sections of stream in which stream improvement structures have been built. This survey will consider such parameters as the fish population composition and density, abundance of aquatic food organisms, and other physical characteristics of the streams such as average depth and width, ratio of flow and pool riffle ratios.

These data will be compared with that gathered in the pre-improvement study to evaluate the success of such a stream improvement program.

An additional section of stream bed will be surveyed and gabion type structures placed so as to create pools and otherwise improve a heavily silted type stream bed. The same pre-improvement studies previously described will be initiated followed by post-improvement studies to be conducted in the future.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
South Carolina State Government

2.0963, EFFECT OF LAKES MARION AND MOULTRIE AS SEDIMENT TRAPS

T.R. CUNNINGS, U.S. Dept. of Interior, Water Resources Division, *Columbia, South Carolina*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of South Carolina.

Purpose: To determine the effectiveness of Lakes Marion and Moultrie as sediment traps.

Methods: Suspended sediment stations will be operated in the tailrace of the hydro plant, at the spillway on Lake Marion and at the railroad bridge at Rimini. The first two stations will provide a measure of the total sediment discharged from Lake Marion and Lake Moultrie. The latter station will provide a measure of the flow of sediment into the lake system.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
South Carolina State Government

2.0964, THERMAL GRADIENTS IN SOUTH CAROLINA

G.E. SIPLE, U.S. Dept. of Interior, Geological Survey, *Columbia, South Carolina*

This research is part of the program of water resources investigations conducted by the U.S. Geol. Survey in cooperation with the State of South Carolina The objective of this study is to obtain precise water temperature data in wells located in the unconsolidated Mesozic and Cenozoic sediments of the S.C. Coastal Plain and in the Paleozoic to pre-paleozoic crystalline rocks of the Piedmont. Temperatures are measured with a single thermometer sensor enclosed in a brass sonde filled with silicon oil and connected to a rubber jacketed cable, using the technique described by Diment and Robertson (1963). These data will be used to determine changes in the earth's thermal gradient over these areas and the relation of thermal changes to structural or stratigraphic parameters.

In addition, an attempt will be made to assess these values as criteria for differentation of hydraulic parameters (such as permeability and yield) and, where core material is available, to determine thermal conductivities to be used in the computation of heat flow. Other objectives include the correlation of temperature gradient with such factors as ground-water movement, lithology, porosity, drilling disturbance, direction of rock foliation and schistosity, and differences due to the variant instruments used.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
South Carolina State Government

2.0965, REDUCTION OF SCOUR AROUND BRIDGE PIERS

F. CHANG, South Dakota State University, School of Engineering, *Brookings, South Dakota* 57007

The effect of circular piles placed in front of piers on the reduction of scour depth around bridge piers is being determined and a measure for the protection of existing piers is sought.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
South Dakota State Government

2.0966, SCOUR AND FILL IN THE MISSOURI RIVER AS RELATED TO THE WATER RESOURCES PLANNING

F.M. CHANG, South Dakota State University, School of Engineering, *Brookings, South Dakota* 57007

For the development of the Missouri River Basin, Oahe Dam and Big Bend Dam were constructed in the Missouri River near Pierre and Fort Thompson, South Dakota. The aggradations upstream and the degradations downstream of these dams are evident due to the unbalance of the sediment discharge in this reach.

Hydraulic engineers must continuously observe the change in the river configuration and be aware of the possibility of floods and other damages from sediment deposition. And, a study of the future bed elevation is also mostly important for the planning of the irrigation systems in order to obtain the optimum functioning of the entire systems.

The specific objectives of this study are: 1. To derive an empirical relationship between sediment discharge and flow characteristics from the observed data collected by the Army Corps of Engineers in the reach between Oahe Dam and Big Bend Dam. 2. To develop, by using continuity equation, an implicit computer method to predict the change in river bed elevation at transient phases. 3. To estimate bed elevation in the future for the irrigation planning and for the prevention of the possible disasters and damages caused by floods.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
South Dakota State University

2.0967, THE INVESTIGATION OF SOIL PROBLEMS IN RELATION TO IRRIGATION DEVELOPMENT IN SUBHUMID AREAS

L.O. FINE, South Dakota State University, School of Agriculture, *Brookings, South Dakota* 57007

Work in connection with this project entails field and laboratory studies of management aspects of water, soils and plants as related to the performance of crops, and behavior and properties of soils, and the use and needs of water by crops. Water management studies include frequency, timing and quantity of irrigation. Utilization of water as influenced by soil management and crop management has been investigated with several crops and variation of several soil factors affecting fertility.

Crop management variables such as plant spacing, population and sequence, and effect on performance have had major emphasis.

SUPPORTED BY South Dakota State Government

2.0968, UNDERSTANDING AND IMPROVING THE SOIL-PLANT ENVIRONMENT FOR MORE EFFICIENT UTILIZATION OF WATER

M.L. HORTON, South Dakota State University, School of Agriculture, *Brookings, South Dakota* 57007

Objectives: 1. Field measurement of soil, plant, and meteorological parameters necessary to describe the plant environment and to determine evapotranspiration rates. 2. To develop relationships for predicting irrigation water requirements. 3. To devise methods that improve the efficiency with which water and solar energy is utilized in crop production.

Description of Work: The meteorological parameters will be measured continuously, where possible, using the best available instrumentation. Soil and plant paramenters will be measured frequently on a regular schedule. Evapotranspiration rates will be determined directly with weighing lysimeters and computed using energy budget methods.

Penman type equations and empirical equations for predicting irrigation water requirements will be evaluated for sub-humid Plains conditions.

Methods of application of irrigation water, modification of the microclimate, or improved management practices that show potential for more efficient utilization of water or solar energy will be studied.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
South Dakota State University

2.0969, SOIL MOISTURE EVAPORATION AND ITS CONTROL

M.L. HORTON, South Dakota State University, Agricultural Experiment Sta., *Brookings, South Dakota* 57007

Investigate the basic mechanism of water evaporation from the soil surface. Develop a laboratory method of measuring the rate of evaporation from the soil surface. Determine the effectiveness of crop residues and artificial mulches on the rate of evaporation from the soil surface under field conditions.

Description of Work: Laboratory experiments will be conducted on mechanisms of reducing evaporation from the soil surface. Mechanisms that will be investigated include, liquid film forming materials, solid films, long chain alcohols, and silicone. The most promising methods will be examined under field conditions. Various tillage methods will also be investigated and compared with chemical materials under field conditions.

SUPPORTED BY U.S. Dept. of Agriculture
South Dakota State Government

2.0970, SALINITY ABOVE A WATER TABLE AS AFFECTED BY RAINFALL AND IRRIGATION

W.D. LEMBKE, South Dakota State University, School of Engineering, *Brookings, South Dakota* 57007

The proposed research involves laboratory and field investigation to determine the effect of salt accumulation on water movement in a soil under irrigated conditions, as compared to conditions of natural rainfall. It also involves a study of methods of leaching accumulated salts.

Laboratory investigations will be used to measure the transmission characteristics of the soil as affected by moisture.

A field investigation with lysimeters will be employed to measure the effect of salt accumulation on water transmission and evaporation with a controlled water table.

After salt accumulation has occurred, two methods of reclaiming the soil will be compared and evaluated.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
South Dakota State University
South Dakota State Government

2.0971, EFFECT OF GRAZING MANAGEMENT ON RANGE LIVESTOCK NUTRITION AND ON THE RANGE RESOURCE

J.K. LEWIS, South Dakota State University, Agricultural Experiment Sta. , *Brookings, South Dakota* 57007

Since 1942 replicated range pastures at the Cottonwood Range Field Station, 75 miles east of Rapid City, have been grazed heavily, moderately, or lightly from early or mid-May to early or late November by cattle and are now in high poor, high fair and high good range condition, respectively. The Agricultural Research Service under line project SWC2-d1 and SWC2-d2 have established four two-acre watersheds on relatively uniform soils in one replication of each grazing treatment.

Stocking rates will be controlled to keep the pastures as nearly as possible in the present range condition. Forage production and residue will be measured at two week intervals on permanent plots using a capacitance meter. These data will be related to precipitation, runoff, and soil moisture records taken by ARS. Livestock production from the pasture will be measured with yearling steers next year. Heifer calves will be permanently allotted to the study in the fall of 1968 and livestock diets studied in subsequent years.

SUPPORTED BY South Dakota State Government
South Dakota State University

2.0972, HYDROLOGY OF SMALL DRAINAGE BASINS FOR DEVELOPING HYDRAULIC DESIGN

W.F. LYTLE, South Dakota State University, Water Resources Institute, *Brookings, South Dakota* 57007

The first phase of the study consists of an investigation of existing records of rainfall and runoff through the State. A determination will be made of physical parameters above a particular gaging station with past flow records to see if they can be adequately measured. In areas of particular interest necessary instrumentation and parameter determination will be made to supplement existing records.

After determination of physical parameters at the gaging station or in the watershed above the gaging station has been made, an analysis will be made on stations with long periods of daily records to determine duration of flow curves. By comparing physical parameters of the gaging station with partial records to those with complete records, a determination can be made of which partial record stations can be used by knowing where good correlation exists. Newly instrumented stations will be used similar to partial record stations.

An analysis will be made of stations with maximum and minimum flow by extreme value probability methods and by comparison of physical parameters with stations of known extreme flow values. A process of synthesis will be used to determine duration of flow curves and extreme flow values in those ungaged watershed areas where physical parameters can be determined.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
South Dakota State University

2.0973, EFFECT OF THE CLIMATE AND MICROCLIMATE ON AGRICULTURE IN SOUTH DAKOTA

W.F. LYTLE, South Dakota State University, Agricultural Experiment Sta. , *Brookings, South Dakota* 57007

Objectives: To determine the benefits and effects of climate and microclimate on the agricultural production and range management in South Dakota. A. By use of weather information on punch cards and statistical methods to describe the variations and singularities in rainfall, temperature, humidity, wind, evaporation, and transpiration in South Dakota--keeping current and back-logging as fast as time will permit. B. By proper instrumentation on an agricultural weather station being established on the Agricultural Engineering Research Farm to measure gradients of temperature, humidity, wind, eddy diffusion in the micro-climatic layer between the ground and four feet above the ground. C. To develop a mobil micro-climatic laboratory that could be used anywhere in the state for securing research data.

Work planned: A. At Agricultural Engineering Research Farm: 1. Full operation of temperature, humidity, and net radiation equipment, all purchased. 2. Establishment of soil moisture, dew, evaporation measurements, recording rain gauge. B. Remote recording of temperature and humidity. C. Continuation of work on cards.

SUPPORTED BY South Dakota State Government

2.0974, DRAINAGE INVESTIGATIONS OF PROPOSED IRRIGATED SOILS IN

J.L. WIERMA, South Dakota State University, School of Agriculture, *Brookings, South Dakota* 57007

Permeability Measurements - Field and laboratory measurements will be made of the permeability of Beotia silt loam soils. The purpose of these measurements will be; (1) to evaluate the permeability of soils near the location of a proposed field drainage plot and (2) to evaluate several methods of measuring permeability.

A Field Drainage Plot - A low permeability has been observed in some Bootin silt loam soils. A field drainage plot will be established on such soil at the Redfield Farm.

The purposes of the plot will be (1) to evaluate soil permeability using actual drainage outflow that will occur in a field situation and (2) to evaluate some new methods of improving the drainability of this soil.

The plot will be designed so that water in the plot area will flow into one tile drain. The edges of the plot will consist of a plastic barrier that will extend to as deep a depth as will be practical. The plot will be surrounded by a border area which will be saturated to the same extent as the soil on the plot.

Measurements will be made of tile outflow, piezometric pressure on the plot, deep seepage, evaporation loss and flow onto the plot. An overall permeability of the plot will be obtained using theoretical equations.

The permeabilities determined by field and laboratory measurements at different depths in the plot will be analyzed and compared with the actual permeability measured by the outflow of piezometer data.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

2.0975, HYDROGEOLOGY OF GLACIAL OUTWASH NEAR SIOUX FALLS, SOUTH DAKOTA

E.A. ACKROYD, U.S. Dept. of Interior, Water Resources Division, *Huron, South Dakota*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with State and local agencies in South Dakota.

Purpose: To determine the water resources available for anticipated municipal and industrial growth in the area between Sioux Falls and Dell Rapids.

Methods: The existing hydrologic data will be collected and analyzed to determine the additional data needed to construct an analog model of the area. An inventory of wells, test drilling, pump tests, and measurements of observation will be completed as required for the construction of the analog model. The analog model will be probed to determine the adequacy of available water resources for anticipated needs.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
South Dakota State Government

2.0976, BASIC HYDROLOGIC RESEARCH IN SELECTED AREAS IN SOUTH DAKOTA

E.F. LEROUX, U.S. Dept. of Interior, Water Resources Division, *Huron, South Dakota*

This reseach is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of South Dakota.

Purpose: To determine the contribution which a relatively small amount of physical and geophysical data for specific aquifers could make to areal reconnaissance studies of water resources in South Dakota.

Methods: Specific information for each aquifer at a site in Beadle County will be obtained by test drilling and various logging methods. Five wells will be constructed at this site. Each well will be drilled to the bottom of an aquifer, cased to the top of the aquifer and have screened or perforated casing opposite the aquifer. Water samples will be collected and aquifer tests will be made.

After these data have been evaluated, another site in South Dakota where similar data is to be collected will be selected.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
South Dakota State Government

2.0977, IRRIGATED GRASS INVESTIGATIONS ON THE BELLE FOURCHE PROJECT

C. ERICKSON, South Dakota State University, Agricultural Experiment Sta. , *Newell, South Dakota*

Objectives: To evaluate production characteristics and potentials of introduced grasses. To develop an improved irrigated pasture program for western South Dakota. To investigate methods of increasing the yield from irrigated pastures.

Different species and eventually varieties of introduced grasses will be tested on the irrigated soils. Information on date of grazing readiness, proper harvest date, regrowth characteristics, response with alfalfa, response to nitrogen fertilizer and total forage yield will be taken. These factors will assist in evaluating each species for its purpose in a grazing program.

SUPPORTED BY South Dakota State Government

2.0978, STUDY OF TURBIDITY - PRODUCTION FACTORS IN LAKE KAMPESKA CODINGTON COUNTY, SOUTH DAKOTA

J.C. SCHMULBACH, State Dept. of Game Fish & Pks, *Pierre, South Dakota*

Objectives: To identify agent(s) causing turbidity and to determine seasonal turbidity levels of Lake Kampeska. Also, to determine the effects of turbidity upon light penetration, primary production, and plankton and benthos production.

Procedures: Horizontal and vertical sampling of the water mass to assess turbidity levels will be continued throughout the summer and fall. Special attention will be directed toward appraising the influence of the Sioux River diversion ditch upon turbidity. 1) Turbidity levels (ppm) will be determined with a colorimeter (Hach Chemical Co.) Transparency will also be evaluated with a Secchi disc. 2) Light penetrance, extinction coefficients, compensation levels will be determined with the aid of matched Weston photoelectric cells. 3) Water quality will be monitored using standard techniques and equipment. The following features will be routinely assessed: water temperature, pH, dissolved oxygen, total alkalinity and specific conductance. 4) Primary production will be estimated using the dark-light bottle technique or the carbon 14 method. 5) Net plankton samples will be collected with a Miller plankton sampler fitted with a Teske flow meter. 6) Water samples will also be assessed for their organic and inorganic fractions using a combination of techniques and equipment. The potassium dichromate method will be used to determine total organic content. Other samples will be centrifuged and ignited in a muffle furnace to determine and particulate dissolved organic matter content, and the inorganic fraction of the sample. 7) Benthic organisms will be sampled with a Petersen dredge and taken to the Laboratory for identification, counting, weighing and volumetric determinations. This part of the project will be given low priority.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
South Dakota State Government

2.0979, INVESTIGATION OF WATER LOSSES TO SINKHOLES IN THE PAHASAPA LIMESTONE, AND THEIR

RELATION TO RESURGENT SPRINGS BLACK HILLS, SOUTH DAKOTA

J.P. GRIES, South Dakota School of Mines, School of Engineering, *Rapid City, South Dakota* 57701

It is proposed to determine stream losses accurately by systematic gauging above and below areas of loss, and to compare the volume of losses with flows from the large artesian springs surrounding the Black Hills. At the same time, an attempt will be made to verify the connection between the sinkholes and springs by chemical analyses and by use of dyes, or chemical or radioactive tracers introduced into the areas of water loss.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
South Dakota School of Mines & Technology

2.0980, COAL STRIP MINE WATERSHED STUDY

J.C. ALLEN, U.S. Tennessee Valley Auth. , *Knoxville, Tennessee*

A watershed project to determine how coal strip mining and subsequent reclamation affects water quality and stream ecology. The 136-acre watershed under study is in Jackson County, Alabama. Over half the watershed will be stripped for coal in 1970. Hydrologic data collection began in May 1968 upon completion of the weir and project instrumentation, and will continue for two years prior to mining, during the mining operation, and for ten years after reclamation. Biologists began sampling the stream and streamside flora and fauna in February 1968, and will continue periodic measurements through life of the study to identify ecological change.

SUPPORTED BY U.S. Tennessee Valley Auth.

2.0981, FLOOD HYDROGRAPH SYNTHESIS - UNGAGED WATERSHEDS

B.J. BUEHLER, U.S. Tennessee Valley Auth. , *Knoxville, Tennessee*

A study to develop more adequate methods of synthesizing flood hydrographs for ungaged areas in the Tennessee Valley with particular emphasis on small watersheds. This is a continuing study which is being expanded to include in the evaluation some of the more recently developed approaches to hydrograph synthesis.

SUPPORTED BY U.S. Tennessee Valley Auth.

2.0982, FLOOD FREQUENCY STUDIES

B.J. BUEHLER, U.S. Tennessee Valley Auth. , *Knoxville, Tennessee*

A continuing study to develop relationships and procedures for synthesizing flood frequency relationships for ungaged areas:

SUPPORTED BY U.S. Tennessee Valley Auth.

2.0983, SIMULATED OPEN CHANNEL HYDRAULICS

B.J. BUEHLER, U.S. Tennessee Valley Auth. , *Knoxville, Tennessee*

A mathematical model (Simulated Open Channel Hydraulics - SOCH) based upon the basic differential equations of continuity and momentum which describe unsteady, nonuniform open channel flow has been developed. Digital computer solution of the model is accomplished using the numerical methods developed by Stoker. Field measurements of stage and velocity in Wheeler Reservoir, stage in the Cumberland River below Barkley Dam, stage in Barkley Reservoir, and discharge in the canal connecting Barkley and Kentucky Reservoirs all have been successfully reproduced, thus providing verification for the basic model and computational scheme. From this base a variety of complex transient flow problems have been investigated. Research is being directed toward broadening the applicability of the model to include a broader spectrum of transient flow problems and toward other computational schemes. In these research and application efforts TVA is being assisted by MIT consultants Drs. Ronald McLaughlin and Frank Perkins.

A portion of this work is described in the publication 'Transient Flow Investigations for TVA's Browns Ferry Generating Station,' Buehler, B. J., Price, J. T., and Garrison, J. M., Proceedings, 7th Annual Sanitary and Water Resources Engineering Conference, Vanderbilt University, Nashville, Tennessee, May 1968.

SUPPORTED BY U.S. Tennessee Valley Auth.

2.0984, WATER DISPATCHING OPERATIONS BY ELECTRONIC COMPUTER

A.J. COOPER, U.S. Tennessee Valley Auth. , *Knoxville, Tennessee*

A study to convert the daily streamflow forecasting and water control operation work of the River Control Branch to an IBM electronic computer. This work involves the continuous dispatching and control of all water which reaches the 33 hydro projects in the Tennessee River Basin presently owned or operated by TVA. Two programs are required to perform this work: (1) one program, completed in 1963 for an IBM 704 electronic computer and converted to an IBM System/360 in August 1967, will compute reservoir inflows for each of the hydro projects using rainfall-runoff relations based on antecedent precipitation index (API) and unit hydrographs; (2) work is continuing on the other program for use on the System/360 which will be used for scheduling discharges at the hydro projects mainly for power generation and flood control.

SUPPORTED BY U.S. Tennessee Valley Auth.

2.0985, COMPUTER-ORIENTED MATHEMATICAL MODEL FOR CONTINUOUS STREAMFLOW PREDICTION

A.J. COOPER, U.S. Tennessee Valley Auth. , *Knoxville, Tennessee*

A study, currently in the analytical phase, to develop a model which should mathematically closely simulate the response of a watershed to rainfall and should be capable of predicting streamflow at a given point at any time. It is hoped that this model will yield results of the high degree of accuracy required for the optimum operation of the large TVA system of multipurpose reservoirs.

SUPPORTED BY U.S. Tennessee Valley Auth.

2.0986, FOREST INFLUENCES STUDIES

B.W. ELLERTSEN, U.S. Tennessee Valley Auth. , *Knoxville, Tennessee*

Investigations are conducted to determine basic relationship between the effect of forest cover and forestry practices on runoff, infiltration, water quality, and other factors involved in the water cycle, and to determine hydrologic effects of reforestation, other erosion control practices, logging road construction and use, timber cutting, wildlife management, and other multiple land-use activities. This information will be used to identify practices of greatest benefit to the economy from the standpoint of optimum forest and water resource utilization. Since 1934 six watershed studies have been initiated in completely or partially forested areas. Results to date indicate that reforestation and other erosion control practices can produce pronounced changes in watershed hydrology. Twenty years after conversion to forest cover peak discharge of summer storms was reduced about 60 percent, duration of summer storm runoff was prolonged, surface runoff was retarded and sediment loss was reduced more than 95 percent on the White Hollow and Pine Tree Branch watersheds. In Parker Branch where open land predominated, farmers making optimum use of all farm resources found the objective of maximizing income was largely compatible with conservation objectives of reducing soil erosion, surface runoff, peak discharge rates, etc.

SUPPORTED BY U.S. Tennessee Valley Auth.

2.0987, UPPER BEAR CREEK EXPERIMENTAL PROJECT

P.C. SPATH, U.S. Tennessee Valley Auth. , *Knoxville, Tennessee*

The Upper Bear Creek Experimental project established in 1962 is being carried on cooperatively by the U. S. Forest Service and TVA. The project is located in the upper reaches of Bear Creek, near Haleyville, Alabama, lying partially in the Bankhead National Forest and includes approximately 143 square miles.

Purpose: This project is designed specifically for the formulation and numeric evaluation of hydrologic methods needed for area resource development. The main objectives are: (1) The development of methods to predict streamflow information for small headwater areas from physical watershed measures and hydrologic data and project this information downstream to larger drainage areas, and then develop techniques for using these projection and predicting methods to simulate hydrologic information on other areas where data are scarce or missing. (2) To obtain basic soils-water-cover relationships in the Highland Rim area of the Tennessee River Basin. (3) To obtain data on the relationships of soils, land-use, and water quality.

Project activities have included the development of a general computer program to solve nonlinear equations, the developing of mathematical models for generating parametric measures of streamflow, the detail study of these mathematical models to assure that consistent results are obtained, a factor analysis study of the physical measures of watershed characteristics, and development of a model to relate streamflow parameters to the physical watershed measures. Papers published concerning project activities included: 1. 'Design of a Hydrologic Condition Survey Using Factor Analysis,' Hydraulic Data Branch Research Paper No. 5, November 1965. 2. 'Upper Bear Creek Experimental Watershed--Research in Hydrologic Analysis Synthesis' by Roger P. Betson, Pub. 66 I.A.S.H., Symposium of Budapest, pp 178-184, October 1965. 3. 'DIFCOR A Program to Solve Nonlinear Equations,' Hydraulic Data Branch Research Paper No. 6, June 1967. 4. 'Analytically Derived Unit Graph and Runoff' presented at the American Society of Civil Engineers national meeting, New York, on Water Resources Engineering, October 16-20, 1967.

SUPPORTED BY U.S. Tennessee Valley Auth.

2.0988, DEVELOPMENT OF HYDROLOGIC ANALYSIS TECHNIQUES

P.C. SPATH, U.S. Tennessee Valley Auth., *Knoxville, Tennessee*

This research, started in 1964, is for the development of new analysis techniques that are now possible with the utilization of electronic computers. Research covers the development of specific mathematical models and special studies aimed at improving hydrologic knowledge using data obtained from various TVA Watershed projects. It includes the derivation, development, and verification of equations designed to simulate various aspects of hydrology and hydrologic response as these are related to land cover, topography, and other watershed characteristics so that watershed hydrology can be incorporated in land-use improvement plans. Progress to date includes: Completion of a study of the convergence properties of a technique used to solve non-linear equations. Some of the results of this study are included in Hydraulic Data Branch Research Paper No. describes the computer program. Completion of a computer program to compute annual flow duration information from mean daily discharge data. The establishment of a series of hydrologic response index watersheds to be used in future evaluation of water resource development activities.

Research underway in 1968 includes: Development of a program package to process daily rain gage data on the computer and for the computer automatically to print daily and monthly amounts of precipitation for more than 600 stations in tables for direct use in the monthly and annual bulletins 'Precipitation in the Tennessee River Basin.'

Development of a program to reduce the U. S. Weather Bureau's graphical API-Runoff Index model for predicting surface runoff, being used in TVA river control operations, to an analytic mathematical model using only five coefficients. Predictions using both models are comparable, but the analytic model is much easier to derive and uses far less core storage.

Completion of a series of programs to be used with a chart digitizer that is used to abstract data automatically from a variety of different recorder charts.

SUPPORTED BY U.S. Tennessee Valley Auth.

2.0989, FERTILIZER AND IRRIGATION EFFECTS ON TREE DEVELOPMENT

E.R. BUCKNER, Univ. of Tennessee, Agricultural Experiment Sta., *Knoxville, Tennessee* 37916

To test: (a) fertilizer (15-15-15) broadcast at 1,000 lbs per acre, and (b) irrigation watering through soaker hose to bring soil back to field capacity. The four treatment of (a) alone; (b) alone; (a) and (b) in combination; and, control with neither (a) nor (b) were applied to plots in 25-year old yellow-poplar (each plot with over five 3-inch stems) on both upper and lower slopes with four replications. Effects measured by annual height and DBH growth, and 2-year seed production and properties of wood increment. Plantings of loblolly pine, sweetgum and northern red oak will be subjected to similar tests.

SUPPORTED BY U.S. Dept. of Agriculture
Tennessee State Government

2.0990, THE ECOLOGY OF CLOSTRIDIUM BOTULINUM IN THE TVA LAKES AREA

D.F. HOLTMAN, Univ. of Tennessee, Graduate School, *Knoxville, Tennessee* 37916

For the past four years we have had in progress an investigation covering the distribution of Clostridium botulinum in the TVA lakes area. Altogether, several thousand mud samples and fish have been examined. To date findings have revealed C. botulinum, types B and E. Of great interest to us is the location in the area of two sizeable canneries that discharge their wash water and other wastes into one of the lakes. These, however, do not appear to contribute to the presence of Cl. botulinum.

The study of the distribution of C. botulinum in TVA lakes has involved Cherokee, Douglas, Norris, Loudon and Watts Bar. *Also, we made and intensive study* of a sizeable number of sporebearing anaerobes that elaborated in vitro a toxin capable of killing mice protected by all the available C. botulinum antitoxins. These turned out to be primarily Cl. perfringens of several different types. In view of the role of this organism in food poisoning, it seems possible that it could be regarded as a health hazard in an area where there is much commercial fishing.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

2.0991, MOISTURE USE CHARACTERISTICS OF CERTAIN CROP PLANTS

W.L. PARKS, Univ. of Tennessee, Agricultural Experiment Sta., *Knoxville, Tennessee* 37916

Objective: To determine effect of soil moisture levels, fertility, weather, and crop variety on the moisture use characteristics and yields of certain farm crops.

Description of work proposed: Neutron moisture measurements will be used to determine the rate and extent of soil moisture depletion by crop plants. Additional moisture will be applied to some treatments to determine the influence of low soil moisture tensions on the moisture use characteristics of the crop plants. Selected varieties of a few crops will be evaluated under several moisture levels to determine how varieties differ in yield potential. Variable fertility levels will be used to determine the extent of moisture-fertility interaction. Records on moisture use during all stages of plant growth and developm e use rates for different periods of growth, total moisture use for the entire growing season, and moisture use efficiency. The extent that climate affects yield, growth and moisture use will be evaluated through regression techniques. Initial studies will be restricted to corn but cotton and other crops will be studied as the investigation progresses.

SUPPORTED BY U.S. Dept. of Agriculture
Tennessee State Government

2.0992, TURBULENT MIXING IN SUBMERGED TWO-DIMENSIONAL WALL JETS

C.J. REMENYIK, Univ. of Tennessee, School of Engineering, *Knoxville, Tennessee* 37916

This project is concerned with turbulent mixing mechanisms which result as a stream of water bearing soluble or thermal pollutants is discharged into a second stream. The research objective is to provide fundamental information useful for engineering predictions of the pollutant concentration in the vicinity of the stream junction.

Applicability of the concept of eddy diffusivity (or diffusion coefficient) to mixing flows will be investigated. The experiments will involve the measurement of Reynolds stress distributions in a two-dimensional wall jet of air.

Need for such an investigation is indicated by previous research which produced evidence that the application of the concept of eddy diffusivity to mixing streams may not be valid.

The project's aims are, on one hand, to verify these findings with a higher degree of accuracy than was possible previously, and to do that by an independent method. The former aspect of this objective will be achieved with a hot wire anemometer equipped with a new linearizer circuit, the latter by a single, rotated hot wire method.

On the other hand, experimental information will be gathered to establish quantitatively details of the relationship between the turbulent shear stress and velocity distributions. The results will be used to construct a model modifying or replacing the concept of eddy diffusivity.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Tennessee

2.0993, EXPERIMENTAL INVESTIGATION OF HYDRAULIC TRANSIENTS IN RIVER-RESERVOIR SYSTEMS

B.A. TSCHANTZ, Univ. of Tennessee, School of Engineering, *Knoxville, Tennessee* 37916

The proposed research project involves a laboratory investigation to develop a qualitative and quantitative description of the hydraulic transient phenomena associated with the response of a stationary (reservoir) or moving (stream) body of water to upstream and downstream positive and negative discharge changes.

Complementary computations of water depth, discharge, and velocity will be made using an unsteady flow digital computer computational model to provide guidance and comparisons with the measured results from the physical setup.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Tennessee

2.0994, FLOODING OF SMALL STREAMS IN NASHVILLE-DAVIDSON CO. AREA, TENN.

L.C. CONN, U.S. Dept. of Interior, Water Resources Division, *Nashville, Tennessee*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with State and local agencies in Tennessee.

Purpose: To determine the effect of urbanization on the volume, magnitude, frequency, and time of concentration of flood flows.

Methods: Hydrologic data presently available inside and outside of the county and additional data to be collected will be analyzed. Within a particular stream basin the following will be obtained:

1. Continuous streamflow and synchronized precipitation records at one site in the basin.
2. Continuous recordings of floodflow and concurrent storm precipitation at sites in selected sub-basins and at key points along the principal stream channels.
3. Supplementary surveys of high-water profiles between gaged sites following major flood events.
4. Channel cross-section and bed profile surveys necessary for flood- profile computations.
5. Compilation of necessary basin and urbanization parameters.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Tennessee State Government

2.0995, HYDROGEOLOGIC MAPPING OF PALEOCENE SEDIMENTS, WESTERN TENNESSEE

W.S. PARKS, U.S. Dept. of Interior, Water Resources Division, *Nashville, Tennessee*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Tennessee.

Purpose: To delineate the outcrop areas of the '1,400 foot' sand and Memphis aquifers in western Tennessee.

Methods; The outcrop area of the Paleocene sediments (a major aquiclude) must be mapped and studied first before it will be possible to interpret correctly surface observations in the unmapped aquifer outcrop areas. Hence, it is proposed to map the surficial geology of the 7.5 minute quadrangles that comprise the belt of outcrop of the Paleocene sediments. This will require field mapping of the 1,500 square miles in 28 quadrangles.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Tennessee State Government

2.0996, HYDROLOGY OF UPPER BUFFALO RIVER BASIN

W.J. PERRY, U.S. Dept. of Interior, Geological Survey, *Nashville, Tennessee*

Purpose: To define the interrelation of ground and surface water in sufficient detail to evaluate feasibility of short cut methods for evaluating total water occurrence and availability in future river basin studies.

Methods: Complete streamflow records since 1920 are available for a gaging station on Buffalo River near Flat Woods, Tenn. Systematic measurement of ground-water levels at selected sites, and of stream and spring discharge will be made. Comprehensive coverage of surface water flows, spring flows, and ground-water levels will be made during periods of at least 2 different conditions of base flow. Streamflow, spring flow, and ground-water level patterns and geologic character of the basin will be used to define surface-ground water relations and ground-water movement in the basin.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Tennessee State Government

2.0997, LOW FLOW CHARACTERISTICS OF TENNESSEE STREAMS

W.J. PERRY, U.S. Dept. of Interior, Water Resources Division, *Nashville, Tennessee*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Tennessee.

Purpose: To interpret available streamflow records and provide low-flow frequency curves for use by water-supply planners and system designers.

Method: Low-flow frequency curves and tables will be prepared for all long term gaging stations. Low-flow indices will be determined for short term gaging stations, for low-flow partial record stations and possibly for some miscellaneous sites. Duration curves will be presented for selected sites and relations between duration, low-flow frequency and mean annual flow will be investigated.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Tennessee State Government

2.0998, GEOHYDROLOGY OF SHALLOW AQUIFERS IN HENRY AND WEAKLEY COUNTIES, TENNESSEE

J. WILSON, U.S. Dept. of Interior, Water Resources Division, *Nashville, Tennessee*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Tennessee.

Purpose - To determine the cause or source of contamination of ground water and to appraise the shallow water-bearing formations.

Methods - An inventory of representative wells will be made. Water from wells will be sampled and analyzed to determine the bacteriological and chemical quality of ground waters. Test holes will be augered, observation wells will be constructed and pumping tests will be performed to define the areal extent and water bearing characteristics of shallow aquifers.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Tennessee State Government

2.0999, GEOCHEMISTRY AND HYDROLOGY OF A SMALL BASIN IN THE UPPER BUFFALO RIVER WATERSHED, TENNESSEE

R.G. STEARNS, Vanderbilt University, Graduate School, *Nashville, Tennessee* 37203

The purpose is to gain more knowledge and understanding of the manner and rate of chemical weathering on the Western Highland Rim, Tennessee. The study plan is to determine the properties of water in various portions of the basin system to be able to interpret the changes in water through the hydrologic cycle in this small basin. The basin was chosen because of its topographic form, characteristic bedrock and residuum, numerous wells, and easy accessibility. These factors make frequent chemical and piezometric monitoring feasible.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Vanderbilt University

2.1000, RADIONUCLIDE CYCLING IN AQUATIC ECOSYSTEMS AND THE USE OF ISOTOPES TO DELINEATE AND QUANTIFY BASIC ECOLOGICAL PROCESSES

D.J. NELSON, U.S. Atomic Energy Commission, Oak Ridge National Lab. , *Oak Ridge, Tennessee* (W-7405-ENG-26)

Biogeochemical studies--Previous studies employing whole-body counting techniques showed the rapid uptake of radiostrontium from water by white cruppies (Pomoxis annularis). Current experiments using serial sacrifices were conducted with blue-gills (Lopomis macrochirus) to determine the relative importance of flesh and blood in the uptake of radiostrontium. The greatest rate of uptake occurred within 48 hours in both components. These studies showed that the blood accounted for a significant proportion of radiostrontium activity in the soft tissues of bluegills during the period of initial Sr uptake. Parallel research on the effect of different environmental Sr concentrations on Sr uptake in flesh showed the concentrations in the tissue were directly proportional to those in the water within the range of 0.003 to 30 ppm. This research shows that isotopic dilution would not be an effective means of reducing radiostrontium uptake.

Research with Cs 137 in white crappies continued with determination of biological half-lives. After the passage of a contaminated bolus through the gut a half-life for Cs 137 of approximately 170 days (at 120 degrees C) is indicated. These results show that crappies are long-term integrators of Cs 137 in the aquatic environment. The passage of the contaminated bolus may have interfered with detection of shorter components in the excretory curve. With snails (Goniobasis, Physa, Lymnea) a short component of about 4 days and a longer component of 12-16 days was observed for radiocesium excretion. Data on the biological half-life of Cs in snails will be used in connection with studies of their feeding rates in White Oak Lake.

Aquatic food chain studies--The transfer of Ru 106, Cs 137, and Co 60 from detritus and algae collected in White Oak Lake to snails (Physa), worms (Limnodrilus), and midges (Stictochironomus, Procladius) larvae was studies in laboratory microcosms.

Peak concentrations of all radionuclides occurred in the detritus feeders by day 3 while peak activity appeared in Procladius on day 14. The study also showed that food particle size affected levels of acitvity in the detritus feeders. With whole detritus the worms accumulated the most redioactivity while with pulverized detritus Stictochironomus was higher. Thus, physical size of contaminated food particles affects environmental pathways of radionuclides.

SUPPORTED BY U.S. Atomic Energy Commission

2.1001, PRIMARY PRODUCTION

B.C. PATTEN, U.S. Atomic Energy Commission, Oak Ridge National Lab. , *Oak Ridge, Tennessee* (W-7405-ENG-26)

Strontium-85 assimilation by plankton communities of Melton Hill Lake (Clinch River embayment) is greater in light than in dark. Dark uptake can be correlated with respiration as measured by changes in dissolved oxygen. Light assimilation is quantitatively related to photosynthetic activity, except at high light intensities where the oxygen method indicates inhibition of photosynthesis while 85 Sr continues to accumulate in cells in proportion to illumination. These results suggest that 85Sr may be useful in the estimation of aquatic production, with possibilities of being superior to the oxygen method at high light intensities, and to the 14C method due to ease of counting.

SUPPORTED BY U.S. Atomic Energy Commission

2.1002, MICROCLIMATE ANALYSIS

J.T. CARR, State Water Development Board, *Austin, Texas* 78711

Objective: To study the effect of the microclimate on evaporation, transpiration, the use of electricity to operate irrigation pumps, and the use of water to protect irrigated orchards and row crops from frost damage, as well as to investigate the turbulent exchanges of heat, moisture, and momentum in the planetary boundary layer.

Approach: An analysis of detailed records of temperature, humidity and wind observations taken at several levels on a 50 foot tower located on the grounds of the Medina Electric Cooperative's generator station near Pearsall, Texas, and comparison of these records with electric power consumption rates.

SUPPORTED BY Texas State Government
Medina Electric Cooperative, Inc.

2.1003, QUALITY OF WATER OF THE TEXAS BAYS AND ESTUARIES

D.C. HAHL, U.S. Dept. of Interior, Water Resources Division, *Austin, Texas*

Purpose: To define 1) the occurrence, source, and distribution of nutrients; 2) current patterns, directions, and rates of movement; 3) the physical, organic, and inorganic water quality and its areal distribution and time variation; and 4) the occurrence, quantity, and dispersion of fresh water, and return flows through the estuaries.

Methods: Reconnaissance quality-of-water surveys will be used to select ranges for repeat surveys to define the quality of water, areal and vertical distribution of organic and inorganic constituents, and patterns of movement. Each survey along a range will be made over a time span long enough to define changes during a tidal cycle. Also, repeat surveys will be made to define the quality changes over different seasons and under different hydrologic conditions. The surveys will be made using a boat equipped with a sampling system, and with instrumentation so that specific conductance, temperature, pH, and dissolved oxygen content can be determined in the field at different points in the vertical at each sampling site.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Texas State Government

2.1004, PERMIAN BASIN - ORIGIN OF SALINE WATER DISCHARGE

P.R. STEVENS, U.S. Dept. of Interior, Water Resources Division, *Austin, Texas*

Natural brine discharging through seeps, springs and salt flats contaminates the water in many streams in the Permian Basin. Previous investigations have ascribed this salt condition to the circulation of ground-waters through salt-bearing rocks and ultimately the discharging of the salt water in topographic low areas. Another hypothesis postulates that brine underlies the entire Permian Basin at a relatively shallow depth; the brine is overlain by relatively fresh water; the interface describes a surface of hydrodynamic equilibrium which also functions as a impermeable boundary separating the brine and fresh water into essentially discrete hydraulic units. The objective is to study all aspects of the occurrence of brine in this area and suggest measures that might alleviate the condition.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.1005, HYDROLOGIC STUDIES OF SMALL RURAL TEXAS WATERSHEDS

T. TWICHELL, U.S. Dept. of Interior, Water Resources Division, *Austin, Texas*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of TExas and the Soil Conservation Service.

Purpose: To determine the effects of temporary storage in small flood-detention structures and of land-treatment measures on the water yield to major water-conservation reservoirs and to provide data which can be utilized in the design of future structures and in checking the performance of existing structures.

Methods: Rainfall and runoff records are being collected and computed on a continuing basis in eleven watersheds. Rainfall-runoff analyses are being made for outstanding storms each year in every watershed, and these data will be used to study possible changes in rainfall-runoff relations between watersheds and the effects of flood- detention structures within each basin. Runoff records collected at points in some adjacent basins will be used as currently being collected in the small watersheds. In basins where no flood-detention structures have been built, detailed hydrologic data are available for several years, and by continuing the data-collection program, the analysis before and after conditions of development will be facilitated.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Texas State Government
U.S. Dept. of Agriculture

2.1006, EXTERNAL GEOMETRY OF SUPERPOSED ELONGATE SANDSTONES, NORTH-CENTRAL TEXAS

L.F. BROWN, Univ. of Texas, Bureau of Economic Geology, *Austin, Texas* 78712

The project is a study of surface and shallow subsurface Upper Pennsylvanian and Lower Permian channel-fill sandstones of fluvial and deltaic origin within 2,000 square miles of North-central Texas (Stephens, Eastland, Callahan and Shackelford counties). Areal distribution, stratigraphic position, and primary control of multistory and multilateral sandstone patterns are of primary interest. Approximately 350 measured sections and 250 wells were used to delineate these linear sandstone bodies at the outcrop and to project them into the West Texas Basin. Channel-fill sandstones are primary aquifers (excepting Quaternary deposits) although exploration for them is complicated by narrow, meandering patterns. Sandstones occur at thirty stratigraphic positions; ten major systems were studied in detail, Second-derivative structural and isopach mapping provides an approach for predicting sandstone distribution.

SUPPORTED BY University of Texas

2.1007, THE WILCOX GROUP IN TEXAS

W.L. FISHER, Univ. of Texas, Bureau of Economic Geology, *Austin, Texas* 78712

The project is an investigation of the Carrizo-Wilcox sequence of sedimentary strata throughout the Texas Gulf Coastal Plain in outcrop and subsurface downdip through the Wilcox trend. The study involves stratigraphic delineation, interpretation of depositional history, and geometry of principal rock units based on measured outcrop sections, descriptions of well cuttings and cores, and study of electric logs from about 3,000 wells. Aspects of the project directly related to water resources concern the nature of ground water aquifers as related to specific fluvial facies and constituent sand units.

SUPPORTED BY University of Texas

2.1008, MINERAL RESOURCE STUDY--RESERVOIR SITES

W.L. FISHER, Univ. of Texas, Bureau of Economic Geology, *Austin, Texas* 78712

This project involves study of mineral resources in ten reservoir sites in east and south Texas to determine location, nature, and value of mineral deposits which might be inunated when dams are constructed. Work under contract with Texas Water Development Board.

SUPPORTED BY University of Texas

2.1009, SELECTIVE WITHDRAWAL AT LAKE LIVINGSTON

E.G. FRUH, Univ. of Texas, School of Engineering, *Austin, Texas* 78712

The overall goal of this project is to evaluate the significance of selective withdrawal as a tool in the water quality management program for impoundments.

Impoundments at Livingston of the relatively rich organic and inorganic nutrient laden Trinity River will bring about a marked variation in water quality with depth. Lake Livingston fortunately is one of the few impoundments in Texas having an outlet works that provides a means for selecting release water from various depths. By releasing different strata of water through the dam's variable depth outlets, the quality of water desired both for Houston's supply and for the freshwater input to Galveston Bay can perhaps be met.

To fulfill this goal, field and office investigations will determine the limnologically significant water quality parameters of the Trinity River at and above Livingston before and while the impoundment fills. At the same time, laboratory investigations on two types of 'pilot impoundment units' will be conducted to predict water quality changes for simulated reservoir conditions. Following impoundment filling, field studies will determine the water quality of the impoundment and its releases. These data will be useful in evlauating the water quality changes predicted through use of the 'pilot impoundment units.' Furthermore, from such field data an experimental operating program can be organized for the following year to evaluate this use of selective withdrawal as a water quality management tool.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Texas

2.1010, MODEL RIVER SYSTEM STUDIES

E.F. GLOYNA, Univ. of Texas, School of Engineering, *Austin, Texas* 78712

A 200 ft. long flume-pond ecosystem is being used to simulate a stream receiving radioactive wastes. The variables in the system are modified to stimulate ranges of stream flow regimes, and the partitioning of fate, of the radioactive species is recorded. The ultimate goal of this project is the development of a mathematical model, which when given several parameters easily measured in the stream system in question will enable a prediction of the behavior of the radionuclides released and an evaluation of the safeness of the operation.

The flume system enables many of the variables to be kept constant or, at least, to be controlled so that the effect of others can be determined, thereby making it practical to develop such a math model.

A mathematical model simulating the transport of cesium, strontium, ruthenium, zinc, cobalt and chromium in a dynamic stream system has been initiated. The effect of suspended material and changing chemical nature of the ecosystem on the uptake and release of the various radionuclides will be determined.

2. WATER CYCLE

SUPPORTED BY U.S. Atomic Energy Commission

2.1011, GEOLOGY AND HYDROLOGY OF THE PRESIDIO BOLSON, TEXAS AND ADJACENT MEXICO

C.G. GROAT, Univ. of Texas, Bureau of Economic Geology, *Austin, Texas* 78712

This project involves a detailed stratigraphic study of bolson deposits and the geohydrology of the basin. Bolsons are common throughout the southwestern United States, but only in a few localities, such as the Presidio Bolson, have bolson deposits been dissected by streams to the degree that affords extensive exposures. Utilizing these exposures, the distribution of sediment types has been mapped and the sediments described in detail. This information has been used to interpret the geological history of the basin and to obtain a better understanding of the relationships between bolson stratigraphy and the quantity and quality of ground water present.

Because bolson deposits are important sources of ground water, it is important to have an understanding of the relation of stratigraphy to ground-water yield and quality in order to attain the most beneficial use of bolson ground water. It is hoped that the relationships exhibited in the Presidio Bolson, when combined with other data, can be applied to the construction of a model to aid in ground-water development in other bolsons.

SUPPORTED BY University of Texas

2.1012, RELATION OF PASS OPENINGS ON PHYSICAL EXCHANGE AND SALINITY IN ESTUARIES

F.D. MASCH, Univ. of Texas, School of Engineering, *Austin, Texas* 78712

It is generally accepted that there is not enough fresh water to meet the State of Texas' inland water requirements, and at the same time provide the fresh water necessary to maintain fisheries, pollution control, and recreation in the coastal bays and estuaries. Consequently, alternatives for meeting the desired salinity distribution and pollution control requirements in estuarine waters must be considered.

Most of the estuaries along the Texas Gulf Coast are separated from the Gulf of Mexico by a long thin chain of offshore or barrier islands. The exchange between gulf and bay waters takes place through a few natural and artificial passes through the barrier islands. It is the principle objective of this proposed project to determine whether the physical exchange of waters between the bays and gulf can be increased by either dredging new passes, or by enlarging existing passes through the barrier islands. In particular, the effects of modifications or additions of passes on the volume of physical exchange, the degree of mixing, and on salinity gradients is to be determined.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Texas

2.1013, HORIZONTAL DISPERSION IN SHALLOW ESTUARIES OF IRREGULAR SHAPE

F.D. MASCH, Univ. of Texas, School of Engineering, *Austin, Texas* 78712

This proposed research involves the development and verification of a numerical model to evaluate transport characteristics in shallow vertically-mixed estuaries of irregular shape. The model is designed to assist in developing water quality requirements and evaluating the assimilative capabilities of the shallow irregular estuaries found along the Gulf Coast of the United States.

The study includes the following three phases: 1. Adaptation of an explicit numerical model of the two-dimensional convective dispersion equation to the irregularly-shaped estuary. 2. Evaluation of the dispersion coefficients from graphical and analytical considerations of the circulation and scale of turbulence in the estuary. 3. Verification of Phases 1 and 2 in a hydraulic model and then in the field.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

2.1014, GEOLOGY OF THE LAJITAS AND REDFORD QUADRANGLES, BREWSTER AND PRESIDIO COUNTIES, TEXAS

J.F. MCKNIGHT, Univ. of Texas, Bureau of Economic Geology, *Austin, Texas* 78712

This project, the geologic field mapping of an area in western Texas, is the latest in a continuing series of geologic quadrangle maps prepared by various geologists and issued with an accompanying text. The maps of this series are published at scales of 1:63,360; 1:48,000; 1:31,680; and 1:24,000. They provide geological information that is fundamental to ground-water studies. Field work has been terminated and the manuscript is in preparation.

SUPPORTED BY University of Texas

2.1015, MATHEMATICAL SIMULATION OF RAINFALL RUNOFF PROCESSES

W.L. MOORE, Univ. of Texas, School of Engineering, *Austin, Texas* 78712

Methods of relating runoff and rainfall will be developed whereby electronic computers, together with a fairly short period of records, will be used to develop parameters that represent the runoff characteristic of the watershed. The methods will utilize the available information on spatial and temporal variations in the rainfall.

The study will be concerned with two types of problems; the first dealing primarily with the amount of runoff and the second with the time distribution of the runoff at the outlet of the watershed. In both cases, the runoff will be treated on a storm by storm basis. For studies of water yield, the solution to the first type of problem will be sufficient, but for studies of flood discharge it will be necessary to have solutions for the second type of problem also.

The determination of the amount of runoff will be based on correlating runoff to rainfall using a computer and selected storms to determine a group of parameters which will be chosen to best represent the watershed conditions by use of an optimization process. The runoff sequence at the watershed outlet will be determined using a modified unit hydrograph concept which will be determined using a modified unit hydrograph concept which will lead to another group of parameters, describing the temporal chracteristics of runoff from the watershed. The values of these parameters will again be determined by an optimization process using electronic computers.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Texas

2.1016, DETERMINATION OF FACTORS AFFECTING THE COMPETITIVE ABILITY OF WEEDS IN SEMI-ARID AREAS

A.F. WIESE, Texas A & M University System, Agricultural Experiment Sta. , *Bushland, Texas*

OBJECTIVE: To determine the role of root growth pattern, root and top growth rate, moisture extraction patterns and other factors on the competitive ability of various weeds under semi-arid conditions.

WORK PROPOSED: Studies will be conducted in the greenhouse, growth chamber and field to determine what characteristics (rate of top growth, rate of root growth, moisture extraction pattern, development of assimilation surface, water requirement and nutrient uptake) make weeds good competitors under semi-arid conditions. The greenhouse will be used to determine root growth characteristics, water requirement and nutrient uptake. The growth chamber will be used to study the effect of light, humidity, temperature and soil moisture on seed germination, vegetative growth and floral initiation. Field studies will be used to determine moisture extraction patterns.

SUPPORTED BY U.S. Dept. of Agriculture
Texas State Government

2.1017, RESEARCH ON THE METEROGENEITY OF CLOUD STRUCTURE

B. ACKERMAN, Texas A & M University System, Graduate School, *College Station, Texas* 77843

It has been established that clouds, and particularly convective clouds, are turbulent and that the turbulence is accompanied by equally characteristic irregularities in the space distributions of most meteorological variables. The first phase of the work is concerned with establishing the wavelengths, at which energy or variance is put into the system. The second phase of the research is concerned with establishing the functional relationship between power density and frequency, which provides information as to the distribution of the energy of a system among the frequency components of that system.

SUPPORTED BY Texas A. & M. University System

2.1018, SEDIMENT PRODUCTION YIELD AND DELIVERY RATE IN RELATIONS TO CLIMATIC AND WATERSHED CHARACTERISTICS

R.W. BAIRD, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

Small watershed areas have contributed large amounts of sediment to streams and reservoirs in the Blacklands. Measuring the effectiveness of improved land use practices on the amount of sediment and its movement downstream is the objective of this study.

Sediment yields are measured from 5 watersheds. One is a check area of 176 acres with no special improved practices. The second, an area of 132 acres with improved land uses including grasses on selected areas and terraces as recommended on cultivated land. The third, an area of 16 acres of small grain crop. And the other two watersheds of 1,110 acres and 4,400 acres with the practices common in the Blacklands.

Data now available indicate that the improved land uses, including grasslands, reduce the sediment yield about 80 percent as compared to the check areas, and cropland with terraces and a small grain crop reduces sediment yield 50 percent or more. Apparently there is enough sediment deposited in the lower parts of the small watersheds so that sediment yields, in tons of soil per acre, decrease with size of area.

For the watersheds of 1,100 to 4,400 acres, there is less decrease in sediment yield. The fine clay particles in suspension apparently will move downstream without a large amount of deposition in the stream channels.

SUPPORTED BY Texas State Government

2.1019, MEASUREMENT OF RUNOFF AND SOIL LOSS DIFFERENCES BETWEEN ESTABLISHED PLOTS

R.W. BAIRD, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

A group of 12 plots each 1 and 1/2 acres in size had been in operation several years with measurements of runoff and soil loss. Variations with treatments were greater than anticipated and a uniform treatment has been established to determine the variability when treatments are alike.

In addition to the rainfall, runoff, and soil loss information, fifteen shallow (18 to 20 feet) ground water wells have been established and instrumented in the area adjacent to the plot areas. During drilling operations some of the borings penetrated permeable strata with water under artesian pressure, causing a rise in water level to within 2 feet of the ground surface. The effect of this variable ground water on surface runoff has not yet been evaluated.

Several years of record will be required before the differences other than the differences due to treatment can be evaluated.

SUPPORTED BY Texas State Government

2.1020, SEDIMENT YIELD IN RELATION TO CLIMATIC AND WATERSHED CHARACTERISTICS IN THE EDWARDS PLATEAU

R.W. BAIRD, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

Measurement of sediment deposition in flood water detention reservoirs has been possible in connection with runoff studies at five flood dentention reservoirs in Lowrey Draw. These range lands in the Edwards Plateau are not considered areas with large sediment yields even though much of the area is seriously overgrazed.

Detail topographic maps of the five reservoir pool areas have been made, and range lines established in two. As these flood detention reservoirs are frequently dry, resurveys will be made and the range lines rerun when sufficient sediment has been deposited to be determined by such surveys.

Deposition from runoff during a heavy storm period September 19- 24, 1964 was not sufficient to justify resurveys.

SUPPORTED BY Texas State Government

2.1021, RUNOFF AND WATER YIELD AS AFFECTED BY CLIMATIC AND WATERSHED CONDITIONS IN THE BLACKLANDS OF TEXAS

R.W. BAIRD, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

The objectives are (1) to determine from records of runoff from agricultural watersheds the effects of watershed characteristics, treatment, and climatic factors on rates and amounts of storm runoff and water yield- and (2) to develop methods to predict from available data the effects of probable land uses and treatments on the magnitude and frequency of flood flows, the amount of storm runoff and water yield. Rainfall and runoff data have been collected from 16 watersheds over a period of years. One watershed has been continued in the same use throughout the entire period of record, but changes have occurred on all others since the original five-year period, when all had nearly the same treatment.

Several reports on rates and volumes of runoff, and effects of treatments have been published. Additional studies now in progress include the effects of different land uses as affected by stage of growth.

The effects as measured on watersheds with maximum size of about 300 acres will be projected to areas of as much as 4,400 acres where runoff and rainfall records are als available.

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SUPPORTED [illegible]. Texas State Government

2.1022, VARIATION OF SATURATED HYDRAULIC CONDUCTIVITY OF HOUSTON BLACK CLAY WITH SOIL DEPTH AND WITH DIAMETER OF SOIL COVES

E. BURNETT, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

The objective of this study was to determine the saturated flow- rate of water through undisturbed cores of Houston black clay and to develop procedures for utilizing large diameter soil cores for measuring hydraulic conductivity. Large diameter (16 and 30 inches) columns of undisturbed Houston black clay were obtained by a new procedure developed at this location. Small diameter (3 to 4 inches) soil cores were obtained by standard methods. Saturated hydraulic conductivity was determined on both the large soil columns and small cores under carefully controlled environmental conditions. In addition, bulk density at field moisture content and at saturation were made on the small cores.

In general, bulk density showed a linear increase with an increase in soil depth. There was a general linear decrease in permeability with increases in soil and was associated with the increasing density, especially in the higher density ranges from 1.25 to 1.45 g/cc. Below 1.25 g/cc, permeability was not related to bulk density and apparently depended upon other factors.

Permeability values from the large diameter soil cores were generally higher than corresponding values from the small cores.

Over prolonged periods, permeability of the large cores declined with time probably due to clogging of soil pores by some mechanism not evaluated.

The study has been completed, and the results are being interpreted and analyzed prior to manuscript development.

SUPPORTED BY Texas State Government

2.1023, RESEARCH ON CHARACTERISTICS OF CONVECTIVE CLOUDS IN TEXAS

H.R. BYERS, Texas A & M University System, Graduate School, *College Station, Texas* 77843

The purpose of this project is to analyze data collected during June 1967 by a specially equipped, cloudphysics, research aircraft on 20 sorties into cloud-free as well as cloudy air in Southeast Texas. The aircraft was provided without charge by the National Center for Atmospheric Research, Boulder, Colorado, and the data represent the print-out from NCAR's CDC 6600 Computer--also provided without charge. The goal of the research is to determine the appropriate models of fair-weather cumulus, swelling cumulus humilis, and comulus congestus clouds that occurred during the period of observation.

SUPPORTED BY Texas A. & M. University System

2.1024, A HYDROMETEOROLOGICAL STUDY RELATED TO THE DISTRIBUTION OF PRECIPITATION AND RUNOFF OVER SMALL DRAINAGE BASINS - URBAN VERSUS RURAL AREAS

R.A. CLARK, Texas A & M University System, Graduate School, *College Station, Texas* 77843

This study will utilize rainfall and runoff data from several rural and urban basins in Texas to determine variability in runoff due to: 1. Type of urbanization (including stage of development). 2. Changes in vegetation and vegetative cover. 3. Possible effects on the rainfall regime due to urbanization.

The ultimate goal of such studies is to develop objective techniques for determination of values to be used in hydraulic design based on easily obtained parameters. Such techniques would incorporate parameters which reflect changes caused by urbanization.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Texas A. & M. University System

2.1025, THE EFFECTS OF SWEETCLOVER, NITROGEN, SUPPLEMENTAL IRRIGATION, AND PLANT POPULATION ON GRAIN SORGHUM YIELDS OF BLACKLAND SOILS

J.W. COLLIER, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

Data will be obtained on water stable aggregates, organic matter, bulk density, water intake, runoff, and soil loss in order to determine the effects of previous cropping systems on soil physical properties. These data will also be examined for use in evaluating the duration of improved soil physical conditions caused by previous cropping systems.

SUPPORTED BY Texas State Government

2.1026, GROWTH AND YIELD OF COTTON AND TOMATOES UNDER DIFFERENT MOISTURE LEVELS AND PLANT SPACING IN THE LOWER RIO GRANDE VALLEY

C.J. GERARD, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

1. To evaluate the influence of moisture levels and plant spacings on yield and quality of cotton and tomatoes. 2. To determine the water requirement for optimum production of cotton and tomatoes in the Lower Rio Grande Valley of Texas. 3. To determine the influence of moisture levels and plant spacing treatment and their interaction on plant growth characteristics.

The influence of moisture level and spacing treatments on the growth, yield and quality of cotton and tomatoes will be evaluated in the field. The influence of moisture level treatments on water requirement of cotton and tomatoes will be determined in the field with a neutron probe.

SUPPORTED BY Texas State Government

2.1027, STATISTICAL ANALYSES OF THE VARIATIONS OF PRECIPITATION-TEMPERATURE AND EVAPORATION IN TEXAS

J.F. GRIFFITHS, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

Objectives--(1) To analyse statistically those aspects of the three climatic parameters (rainfall, temperature and evaporation) considered to be of prime importance by agricultural and meteorological specialists. (2) To present the results of these analyses in a simple manner, generally graphically or in map form, so that users may extract rapidly the pertinent details.

Description--(1) A collection of the pertinent available data will be made and stored on the A&M campus. (2) After discussions with personnel of Texas Agricultural Experiment Station concerning priorities various aspects of the parameters will be tackled in order. (3) For each chosen aspect statistical analysis will follow, roughly, the pattern; Rainfall (1) annual and monthly totals, (2) monthly persistence (auto-correlation) and dependence (serial correlation), (3) wet and dry spells, (4) trends and cycles; Temperature (1) monthly auto- and serial correlation, (2) daily variations, (3) degree days spectra analysis; Evaporation--empirical relationship with other climatic parameters.

SUPPORTED BY U.S. Dept. of Agriculture
Texas State Government

2.1028, RUNOFF PRODUCTION FROM UNIT SOURCE WATERSHEDS IN THE EDWARDS PLATEAU

W.G. KNISEL, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

Seven small watersheds ranging in size from 4.5 to 12.2 acres have been established in the Edwards Plateau near Sonora to determine the effects of soils and geology, and cover condition on runoff rates and amounts. Six of the watersheds are located on the Texas Agricultural Experiment Station Substation No. 14 where different levels of grazing are maintained for range management experiments. The seventh watershed is on privately owned land. A recording rain gage is located near each watershed. Data from these watersheds will be used to develop rainfall runoff relationships for Edwards Plateau rangelands.

Although little data are available at the present time, some preliminary analyses indicate that 7-day antecedent precipitation, 15-minute rainfall intensity, and total storm rainfall are dominant factors in runoff volume prediction within soil and geology groups. Cover conditions which are important factors, will be evaluated when sufficient data are available.

Currently available runoff prediction techniques tend to overestimate runoff compared with measured volumes. The overestimate is apparently partially due to geologic mantle underlying the watersheds.

The watersheds have been in operation for too short a period to arrive at any conclusions. Measurements and observations are being continued.

SUPPORTED BY Texas State Government

2.1029, RUNOFF PRODUCTION BY UNIT SOURCE AREA

W.G. KNISEL, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

The major objectives are (1) to determine rates and amounts of runoff as affected by land use and treatment, and changes in soil moisture, (2) to determine rainfall-runoff relationships, and (3) to develop techniques to predict runoff on ungaged, mixed land use watersheds from readily available data.

Rainfall-runoff relationships with antecedent soil moisture as a parameter have been developed for the major crops in the blacklands. Soil moisture accretion-depletion techniques have been developed with pan evaporation and mean daily temperature as indicators, by crop and season. The runoff prediction technique has been tested on gaged watershed where rainfall, evaporation, temperature, and land use data are available. The results are encouraging in that measured and computed runoff volumes from the mixed land use watershed agreed within 15 percent. Refinements of the procedure are in progress but are not complete for all land uses. Storms occurring when antecedent moisture is low are causing the largest error rather than the flood producing storms with high soil moisture.

SUPPORTED BY Texas State Government

2.1030, RELATION OF CLIMATIC AND WATERSHED CHARACTERISTICS TO STORM RUNOFF IN THE EDWARDS PLATEAU

W.G. KNISEL, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

Very little information has been obtained on rates and volumes of storm runoff from small range watersheds in the Edwards Plateau. The objectives of this work are primarily to determine the rates and volumes of storm runoff as affected by size of area, soils and geology.

Five soil conservation service flood detection reservoirs have been instrumented to measure inflow and outflow. The drainage areas range from 686 acres to 10,787 acres. Runoff is measured at a mainstream station with a drainage area of 48 square miles of which approximately 70 percent is controlled by the five reservoirs.

Precipitation records are obtained from a network of 14 rain gages for the 48-square mile area and the five subwatersheds.

During a 7-day storm period, rainfall ranged from 7 to 19 inches, but runoff was less than expected from the hydrologic group D soils. The fractured limestone underlying the soil was an important factor in maintaining high percolation rates throughout the storm period.

Isolated convective type thunderstorms typify the summer climate. Considerable volumes of runoff have been measured from this type storm, but due to the relatively small area of coverage, mainstream flow is small, and widespread flooding is rare during the summer months of June, July, and August.

SUPPORTED BY Texas State Government

2.1031, WATER YIELD AND GROUNDWATER MOVEMENT IN THE EDWARDS PLATEAU AS AFFECTED BY GEOLOGY, CHANNEL AND VALLEY MATERIALS, AND FLOOD STRUCTURES

W.G. KNISEL, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

Rainfall, runoff and groundwater data are obtained in the 48 square mile Lowrey Draw watershed and subwatersheds to evaluate water yield and groundwater movement in this karst area. Three groundwater observation wells near a floodwater retarding structure have been instrumented for continuous water level records. Manual measurements are made at six other wells in the Lowrey Draw area. Changes in water level as affected by natural recharge from rainfall, and by flood detention reservoirs can be evaluated.

Losses from floodwater detention reservoirs during storm periods indicate that large volumes of water are transmitted through the limestone solution channels in the reservoir floors. Groundwater levels have been observed to rise as much as 85 feet in wells near a reservoir during a major storm period. A rise of 60 feet was observed during the storm period at a well approximately 3/4 mile from the reservoir. Other wells outside the direct influence of the reservoirs indicated a maximum of 3-foot rise which has primarily natural recharge from rainfall. Water level fluctuations indicated a relatively high transmission rate throughout the storm.

Abstractions from mainstream flow appear to be large during storms of partial area contribution to surface runoff. Abstractions during storms of large areal coverage are more difficult to evaluate, but the percent of abstraction is less.

Two papers have been published in the ARS 41-series on geology and groundwater studies.

SUPPORTED BY Texas State Government

2.1032, PRECIPITATION CHARACTERISTICS INFLUENCING RUNOFF FROM AGRICULTURAL WATERSHEDS IN THE BLACKLANDS AND EDWARDS PLATEAU OF TEXAS

W.G. KNISEL, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

The primary objective is to furnish basic precipitation data for experimental watersheds in the development of rainfall-runoff relationships. In addition to the supporting role, regional characteristics of precipitation are evaluated.

Rain gage networks of varying density have been maintained for 30 years in the Blacklands at Riesel and 6 years in the Edwards Plateau at Sonora. Daily rainfall is measured and rainfall intensity and kinetic energy are computed. Antecedent moisture and rainfall amount is the major factor in the rainfall -runoff relationship for the Blacklands. Preliminary analyses indicate that 15-minute intensity may be important for small areas in the Edwards Plateau. Seven-day antecedent rainfall was also found to be an indicator of runoff. Various weighting coefficients are currently being tested. Other weighting coefficients are currently being tested. Other characteristics will be studied as considered necessary.

Studies of agricultural drouths (plant production) in the Blacklands indicate approximately two months will occur on the average of once in two years when there will be not more than 0.25 inch of rain in any one 24-hour period. Criteria other than the '0.25 inch in any one 24-hour period' are being tried, but the study has not been completed.

SUPPORTED BY Texas State Government

2.1033, EFFECTS OF CULTURAL PRACTICES, SOIL MOISTURE LEVELS, AND FERTILITY LEVELS ON CITRUS TREE REACTION, AND ON SOIL PROPERTIES

R.F. LEYDEN, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

Objectives: 1. Evaluate the effects of cultural practices, soil moisture levels, fertility levels, and their interactions on: (a) the growth of citrus trees (b) the quantity and quality of fruit produced (c) the cold tolerance of citrus trees (4) the prevalence of disease in citrus orchards. (2) Determine the influence of cultural practices, soil moisture levels, and fertility levels on: (a) the physical and chemical properties of the soil (b) the consumptive water use requirements of citrus orchards.

SUPPORTED BY Texas State Government

2.1034, CITRUS FERTILIZER TEST ON SEVERAL PRINCIPAL CITRUS SOIL TYPES IN THE LOWER RIO GRANDE VALLEY OF TEXAS

N.P. MAXWELL, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

Objectives: 1. Determination of effect of varying amounts and ratios of fertilizer nutrients on yield and quality of citrus grown on different important citrus producing soil types. The differential response in yield and quality among varieties and species of citrus with varied fertility levels, soil types, and management practices such as (a) time method and rate of application of fertilizers, (b) time, method and rate of application of irrigation water, (c) kind and management of cover crops.

SUPPORTED BY Texas State Government

2.1035, ESTABLISHMENT AND MAINTENANCE OF VEGETATION ON HIGHWAY RIGHTS-OF-WAY

W.G. MCCULLY, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

Project Objective: (1) To compare and improve specified methods of erosion control by determining requirements, planting materials and procedures for establishing a vegetative cover on finished slopes and other areas subject to soil erosion. (2) To adapt recommended agricultural methods of plant control to highway requirements.

Description of Work Proposed: This project is a continuation of project S1291. Work under this research outline will be primarily in the field of vegetation establishment. This research will agument the testing and will provide an outlet for materials being evaluated under H988, 'Evaluation of Potentially Drouth Resistant Grasses for the Southwest'. Outturn from this project should provide recommendations for planting or serve as a basis for future work on grass establishment for reclamation of eroded or similiar sites on range lands.

The work under the second objective will enlist the cooperation of other existing projects within the Texas Agricultural Experiment Station, but work under this project will be only on an opportunity basis or to solve specific problems.

SUPPORTED BY Texas State Government

2.1036, EVALUATION OF SUBIRRIGATION FOR CROP PRODUCTION

J.S. NEWMAN, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

Objectives: 1. To develop engineering design data on the size of pipe, friction pressure loss, length of rows, size and type of outlet for different soils under field conditions. 2. To evaluate the effect of subsurface irrigation on plant growth and application efficiency. 3. To study the capillary movement of water iron perforated plastic pipe buired at different depths and horizontal spacings in soil of different texture.

SUPPORTED BY Texas State Government

2.1037, SOIL MOISTURE STORAGE AND UTILIZATION.

P.A. RICH, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

Objectives: 1. To determine relations between stored moisture and plant functions. 2. To develop methods of moisture storage and utilization. 3. To determine the effects of increased nutrients in stored moisture.

Description: Comparison of continuously cropped plots with alternate crop and fallow plots plus these two systems with different drill widths will be utilized to evaluate preseasonal and seasonal moisture storage methods. An addition of 60-30-0 to half the plots will be used to determine added nutrient effects plus stored moisture effects on plant characteristics.

SUPPORTED BY Texas State Government

2.1038, ROLE OF LIGHT QUALITY, ETC, ON TRANSPIRATION OF WATER LOSSES BY PLANTS

J.A. RUNKLES, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

Determine role of light quality (spectrum wave lengths) effecting transpirational water losses by cotton, bean, and tomato plants under controlled conditions of environment. Special emphasis will be placed on the red and far-red parts of the light spectrum. Study interactions of light quality, temperature (soil and air), and relative humidity on water-use rates by cotton, bean, and tomato plants under controlled environmental conditions. Evaluate further a thermal method for measuring water flow rates in agricultural plants as affected by changes in light quality, temperature, and relative humidity. Evaluate and report data periodically.

DESCRIPTION OF WORK: All fundamental phases concerning light quality, soil and air temperatures; and relative humidity will be conducted under controlled and climatic conditions in the laboratory. Light quality will be accomplished by using different colored fluorescent tubes (blue, green, yellow, red). Infrared source will be incandescent lamps. Radiation will be measured by a Beckman hemispherical radio-meter initially. Air and soil temperatures will range in combinations between 55 degrees and 115 degrees F. Relative humidity will range between 20% and 85%. Plant response to environment changes will be indicated by use of the thermoelectric method for measuring water flow rates in stem of selected plants.

SUPPORTED BY U.S. Dept. of Agriculture
Texas State Government

2.1039, A STUDY OF THE MECHANISMS AND SUPPRESSION OF EVAPORATION OF WATER FROM SOILS

J.R. RUNKLES, Texas A & M University System, School of Agriculture, *College Station, Texas* 77843

The proposed research involves controlled environment and field experiments directed towards the suppression of evaporation from soils. The main objective of this investigation is to study the basic mechanism of evaporation from different soils and to develop the best method of suppression of these soils.

The controlled environment phase will study the important parameters alone or in combination as to their influences on the evaporation process. Both soil and atmospheric parameters will be studied. Mechanisms of suppression will be studied under controlled conditions.

The field phase will be concerned with extrapolating the best suppression mechanisms to field conditions. The important soil and atmospheric parameters will be measured under field conditions.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Texas A. & M. University System

2.1040, CONTROL OF EVAPORATION AND TRANSPIRATION THROUGH SOIL, PLANT AND AIR - WATER INTERFACE MODIFICATIONS

J.R. RUNKLES, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

1. To study the basic influence of evaporation suppression by surface-active chemicals applied to soils and water. 2. To determine the influence of selected surface-active chemicals and soluble salts on evaporation from soils and water. 3. To determine the influence of selected chemical compounds and soluble salts on transporation by plants. 4. To determine the influence of genetic leaf modifications (color, size and shape) on transpiration of cotton. 5. To analyze and report data periodically.

The research will utilize controlled environment chambers, greenhouse and field plots facilities to accomplish the objectives described above.

SUPPORTED BY Texas State Government

2.1041, INVESTIGATION OF A LINEAR MODEL TO DESCRIBE THE HYDROLOGIC PHENOMENON OF DRAINAGE BASINS

F.A. SCHMER, Texas A & M University System, Water Resources Institute, *College Station, Texas* 77843

This research is directed toward hydrologic research in small drainage basins. Small drainage basins will be utilized to evaluate a linear model. If this model is adequate for small watersheds, then its application to basins of any size would be similar to the empirical unit hydrograph approach that is presently being used by many hydrologists, but greater accuracy and flexibility should result. Three specific objectives of this research are: 1. To determine the applicability of available linear mathematical models to the rainfall- runoff hydrologic phenomenon in natural drainage basins. 2. To evaluate the ability of a specific lumped linear time-invariant system, the convolution relation, to adequately represent the rainfall-runoff hydrologic phenomenon of natural drainage basins. 3. To investigate possible relationships between the unit impulse response of the convolution relation and drainage basin characteristics provided the validity of the use of the convolution relation is substantiated.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Texas A. & M. University System

2.1042, WATER POLLUTION FROM ERODED SEDIMENTS

E.T. SMERDON, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

To investigate the nature of sediment transport in shallow flow with superimposed rainfall.

Description of Work Proposed: The study is directed to the problem of initial transport of eroded sediments from the point of detachment to streams in which the flow is sufficiently deep so that the effect of rainfall energy on the surface of the flow is negligible. The study will include the investigation of factors such as velocity distribution in clear and sediment-laden flows, shear distribution within the flow, suspended transport capacity, all as affected by rainfall of various intensity levels.

SUPPORTED BY Texas State Government

2.1043, PREDICTING SOLUTE MOVEMENT AND DISTRIBUTION IN SOILS

G.W. THOMAS, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

Salts will be added to soil columns made up of important, representative soil types and then eluted with solvents. Measurements of spreading and the lag of solutes behind the water front will be taken. From these data, solute concentration vs. depth of soil curves for specified leaching situations will be obtained. Field data on movements of solutes also will be taken for comparison with idealized laboratory results.

To predict the shape and position of salt concentration curves in soils, the band spreading equations will be combined with chromatographic equations and corrected for the rate of hydrolysis. It is anticipated that realistic, workable and useable prediction equations will be the most important result of these studies.

SUPPORTED BY Texas State Government

2.1044, INVESTIGATION OF BLOSSOM-END ROT OF PEAR TOMATOES

UNKNOWN, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

Objectives: (1) To determine the cause of blossom-end rot of pear tomatoes. (2) To determine the influence of different factors on blossom-end rot of pear tomatoes. (3) To determine the water transfer from fruit to other plant parts using a thermoelectric method. (4) To determine the influence of transpiration suppressants, growth regulators or plant modification on transpiration blossom-end rot, yield and other growth characteristics.

A hypothesis is proposed which states that blossom-end rot occurs due to loss of water from tomato fruits. The transfer of water to other plant parts is probably the most significant mechanism which causes blossom-end rot of pear tomatoes. It is the purpose of this research to clarify the proposed hypothesis and to evaluate the influence of different factors on loss or transfer of water from fruit to atmosphere or at plant parts. It is also the purpose of this investigation to try to find suitable transpiration suppressants. The influence of these possible suppressants or plant modifications on transpiration, blossom-end rot, yield and other plant growth characteristics will also be evaluated.

SUPPORTED BY Texas State Government

2.1045, FERTILIZER REQUIREMENTS OF CROPS GROWN IN DIFFERENT CROPPING SYSTEMS

H. WALKER, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

Objectives: 1. Fertilizer requirements of cotton growth under natural rainfall and natural rainfall plus supplemental irrigation under continuous cotton and in a 6-year rotation of 3 years of alfalfa fertilized uniformly followed by 3 years of cotton. 2. Fertilizer requirements of corn grown under natural rainfall and natural rainfall plus supplemental irrigation under continuous corn in a 6-year rotation of 3 years alfalfa fertilized uniformly followed by 3 years of corn. 3. Fertilizer requirements of alfalfa grown under natural rainfall plus supplemental irrigation when fertilizer is applied every third year. 4. Relative merits of alfalfa-corn versus alfalfa-cotton systems under natural rainfall and natural rainfall plus supplemental irrigation.

SUPPORTED BY Texas State Government

2.1046, WATER TRANSFER FROM SOIL TO THE ATMOSPHERE AS RELATED TO CLIMATE AND SOIL PROPERTIES

C.W. WENDT, Texas A & M University System, School of Agriculture, *College Station, Texas* 77843

The transfer of water from the soil to the atmosphere will be investigated in relation to soil properties and atmospheric conditions. Evaporation will be measured with field lysimeters in conjunction with a complete micrometeorological measuring system. Evaporation of soil moisture will be related to soil water content, soil texture, porosity and surface roughness. The atmospheric parameters which will be related to evaporation are: solar radiation, wind speed, relative humidity, and air temperature.

The study will be conducted at the South Plains research and Extension Center at Lubbock, Texas.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Texas A. & M. University System

2.1047, EVALUATION OF ESTUARINE DATA

C.R. CHAPMAN, U.S. Dept. of Interior, Biological Laboratory, *Fort Crockett - Galveston, Texas*

Increasing demands upon Gulf coast water resources are rapidly producing significant alterations and, in many cases, destruction of the estuarine and coastal marsh environment. Engineering construction projects, both small single-purpose units as well as large basin-wide developments, are being initiated with increasing frequency. the complexity of basin-wide developments and the large numbers of smaller projects makes it extremely difficult to treat each project in sufficient detail. Thus, it becomes increasingly evident that every expediency must be employed to assist with preconstruction studies and evaluations. This aim can be greatly facilitated by properly organizing and distributing existing data and information.

Project objectives are to inventory and organize existing published and unpublished data and information describing and relating to Gulf coast estuaries; make this data and information available in readily accessible or retrievable form; apply and include new data and information as it becomes available; and assist in establishing requirements for future estuarine research.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

2.1048, ECOLOGY OF WESTERN GULF ESTUARIES

W.L. TRENT, U.S. Dept. of Interior, Biological Laboratory, *Fort Crockett - Galveston, Texas*

Demands upon water resources along the coast of the Gulf of Mexico are rapidly altering the estuarine environment. These combined alterations disturb the integrity of large estuaries to the extent that entire biological systems may be significantly affected. Basic to an evaluation of the effects of estuarine alteration is knowledge of the interrelations of factors, such as nutrients, bottom types, marine organisms, and vegetation.

Project objectives are to (1) compare the productivity of natural estuarine habitats with areas altered by dredging, spoiling, bulkheading and filling; (2) determine practical methods for rehabilitating altered habitats so that productivity can be reestablished; and (3) determine management procedures for maintaining or increasing the productivity of estuarine areas.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

2.1049, CULTURAL PRACTICES OF VEGETABLE CROPS

J.H. KYLE, Texas A & M University System, Agricultural Experiment Sta., *Lubbock, Texas*

Cultural Practices to Aid Production of Vegetable Crops on the High Plains - 1. To determine the proper rate and placement of fertilizer for maximum yield and highest quality. 2. To study and develop better cultural practices which lead to higher production and better quality of vegetable grops. 3. To study the irrigation practices which lead to higher production and the conservation of water.

Research shall be undertaken to study onions and carrots. Plant populations, i.e. variable number of rows on a 40 inch bed, irrigation levels and fertility levels shall be the treatment variables in the experiment. The onions shall be grown as an early crop (planted about March 20) and the carrots shall be grown as a late crop (planted about July 20). Two replications shall be used in both tests with thirty- two foot experimental plots.

SUPPORTED BY Texas State Government

2.1050, IRRIGATION STUDIES FOR THE HIGH PLAINS

J.S. NEWMAN, Texas A & M University System, Agricultural Experiment Sta. , *Lubbock, Texas*

Objectives: (1) To evaluate different methods of applying irrigation water to crops on the high plains for maximum irrigation water efficiency. (2) Investigate timing and rates of irrigation applications on major crops produced in the area. (3) Determine the consumptive use, water requirements, irrigation requirements, and moisture-fertility interactions for major crops produced in the area. (4) Determine the influence of moisture levels on yield and quality of produce for major crops in the area. Methods physical sites have been located on research center and on selected farms in the area. Standard equipment has been used to measure appropriate parameters for determinations listed in the objectives on cotton, grain sorghum, soybeans and castors. Yields and produce quality were taken and used as an indicator of the most acceptable combinations of cultural practices. Progress: (1) The water and irrigation requirements have been determined for present varieties and cultural practices on cotton, grain, sorghum, soybeans and castors. (2) New cultural and irrigation practices are being evaluated for use as adjustments to a diminishing supply of irrigation water anticipated in the not too distant future. (3) Standard irrigation research procedures used on commonly grown crops in the area are being used to research water and irrigation requirements for new crops adapted but not grown in the area and for new crops being grown on a limited basis in the area.

SUPPORTED BY Texas State Government

2.1051, SOIL MOISTURE SURVEY FOR SOUTH PLAINS OF NORTHWEST TEXAS

O.H. NEWTON, Texas Technological College, School of Agriculture, *Lubbock, Texas* 79409

Project Objective: To determine through use of the most modern soil moisture measuring devices, the content of subsurface soil moisture to a depth of four feet in all or a major part of the area described as the South Plains of West Texas. The size of the area to be sampled will be determined by the availability of funds.

Procedures: (1) Not less than eight nor more than fifteen observation sites will be established in each of at least ten counties and permanent access tubes installed from which soil moisture observations will be taken. (2) Observations will be selected after consultation with county agents and careful consideration given to soil types, drainage and other factors that might influence a representative evaluation. (3) Selection of the observation site and the installation of the access tube will be made only after requirements have been met and a pledge of full cooperation has been obtained from the property owner. (4) After selection of observation sites has been completed and access tubes installed, soil measurements will be taken annually during late October and early November and again in late February and early March. (5) Evaluation and analysis of the data will be completed as quickly as possible following each observation period and this data distributed to all agricultural interests throughout the South Plains.

SUPPORTED BY Texas State Government

2.1052, PHREATOPHYTE EVAPORATION RESEARCH

T.E. VANHYLCKAMA, U.S. Dept. of Interior, Water Resources Division, *Lubbock, Texas* 79410

The objective is to measure the use of ground water by saltcedar (Tamarix pentandra) in evapotranspirometers and to evaluate these data against those obtained by energy budget and mass transfer methods.

Six plastic-lined tanks 9 x 9 meters of surface and 4.5 meters deep were constructed and planted in saltcedar to the same density as the surroundings. The use of water from these tanks is being measured daily and at times more frequently. Ground water in the tanks can be maintained at different levels and the effects of depth to water on the transpiration and evaporation can be evaluated.

Five smaller tanks (6 x 6 meters and 2 meters deep) provide information on water losses from bare soil as well as on the effect of difference in salinity of the ground water on water use in vegetated tanks.

Equipment for measuring the energy budget as well as mass transfer components has been installed and data are recorded on potentiometers and other devices.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.1053, IRRIGATION PRACTICES WITH RANGER PEACHES

U.A. RANDOLPH, Texas A & M University System, Agricultural Experiment Sta. , *Montague, Texas*

To obtain information on the effect of irrigation at different periods of fruit development on fruit size and yield of the Ranger peach.

Description of work proposed: Four irrigation treatments designed to insure adequate available soil moisture at various intervals prior to harvest will be compared. Fruit size and total yield will be measured.

SUPPORTED BY Texas State Government

2.1054, PRECIPITATION CHARACTERISTICS INFLUENCING RUNOFF FROM WATERSHEDS IN THE SOUTHERN PLAINS

W.G. KNISEL, U.S. Dept. of Agriculture, *Temple, Texas*

Object: To develop basic information on amounts, duration, areal and seasonal distribution, storm paths and other characteristics of rainfall as affected by geographic location, topographic location, and other factors, to the extent that the characteristics influence runoff from watersheds.

Plan of Work: The study is carried on by means of networks of recording raingages in the vicinity of Chickasha, Oklahoma; Riesel, Texas; and Sonora, Texas. Data from the Chickasha location are made available to the Weather Bureau in connection with development and evaluation of radar for precipitation measurements.

SUPPORTED BY U.S. Dept. of Agriculture

2.1055, THE ROLE OF SOIL STRUCTURE IN CROP PRODUCTION AND METHODS FOR IMPROVING SOIL PHYSICAL CONDITIONS

C.J. GERARD, Texas A & M University System, Agricultural Experiment Sta. , *Weslaco, Texas*

Objectives: 1. To inventory and assess changes which have occurred in soil structure as a result of continued cropping in major agricultural areas in Texas. 2. To study of soil structure on growth of plants and the effects roots and crop residues on formation and stabilization of soil structures. 3. To develop or improve methods for measuring and characterizing soil structure. 4. To determine influence of soil structure on water movement and storage. 5. To develop principles which may increase our understanding of soil structure and from which new management practices may be developed.

The research this year has been concerned with (1) the effect of selected cationic, anionic and nonionic surfactants on clays and (2) the hydraulic conductivity of soils in the unsaturated state. It has been found that anionics had no effect on the d-spacing of montmorillonite and did not interfere with hydration of clay surfaces. Their effects on soil physical properties were directly related to the lowering of surface tension of the liquid phase. Cationics were strongly adsorbed by the clay surfaces through ionic bonding in amounts equal to or even greater than the cation exchange capacities of the clays. Their presence on clays significantly reduced hydration and water-content to the extent of making clay surfaces completely hydrophobic at the high treatment rates. Their effects on soil physical properties were directly related to the degree of hydrophobicity imparted. Nonionics were adsorbed by hydrogen-bonding of polar-active groups to oxygen rich clay surfaces. Their sorption energy was somewhat greater than that of water, and they displaced water when adsorbed.

The hydraulic conductivity (unsaturated) of Norwood silt loam has been investigated using the steady state method and the modified transient flow system. At a moisture content of 25% as determined in the lab of about .2 to .3 cm/min.

SUPPORTED BY Texas State Government

2.1056, THE EFFECT OF TILLAGE AND ORGANIC MULCHES UPON SOIL MOISTURE MOVEMENT AND SOIL TEMPERATURES IN THE LOWER RIO GRANDE

C.J. GERARD, Texas A & M University System, Agricultural Experiment Sta., *Weslaco, Texas*

The use of petroleum resin and other covers to modify the environment of summer planted seeds and subsequent young seedlings shows promise with some crops.

The relationship between soil temperature and 1/2 inch and stand was established for peppers. Soil temperatures between 110 to 115 degrees F at 1/2' depth caused a seed dormancy reaction in the case of peppers. Carrots were more sensitive to high soil temperature. Damping off young seedings was significantly related with surface moisture level (0-2 inch depth). Plans are to continue evaporation and temperature studies under different covers through 1966.

SUPPORTED BY Texas State Government

2.1057, UNDERSTANDING AND IMPROVING SOIL-PLANT-ATMOSPHERIC RELATIONSHIPS FOR MORE EFFICIENT UTILIZATION OF WATER

C.L. WIEGAND, U.S. Dept. of Agriculture, *Weslaco, Texas*

Object: To develop basic knowledge regarding the role of soil and atmospheric factors on the use of water in plant growth processes; to devise procedures based on soil-plant-atmospheric relationships for more efficient timing and use of irrigation water in plant growth; and to study the effects of modified soil microclimate on plant growth and water utilization.

Plan of Work: Experiments will be conducted in (1) controlled growth chambers to determine the effects of soil moisture suction on root aeration, water movement, evaporation, and uptake by plant roots; and the effects of light intensity, temperature, and humidity on water use and plant growth; and (2) greenhouse, laboratory, lysimeter, and specifically controlled field experiments to study the interacting effects of soil moisture properties, water tables, microclimatic variations and plant characteristics on water use in plant growth processes. Basic studies will be made of the mechanism of water transfer from the soil into the plant. Methods for irrigation timing will be developed to obtain efficient plant growth and water conservation and use. Studies of ways to modify the soil microclimate, including moisture and temperature, for more efficient utilization of water will be conducted.

Cooperation: Texas Agricultural Experiment Station; SCS; Agricultural Extension Service; soil conservation districts.

SUPPORTED BY U.S. Dept. of Agriculture

2.1058, CALCULATION OF TEMPERATURE AND PRECIPITATION VALUES

G.L. ASHCROFT, Utah State University, Agricultural Experiment Sta., *Logan, Utah* 84321

Objectives: 1. To determine the probabilities for selected precipitation values to occur in weekly periods. 2. To calculate the probabilities for critical temperature values to occur during certain periods. 3. To calculate the probabilities of degree-day-totals coming in certain ranges.

Description of work proposed: 1. To fit an incomplete-distribution to the rainfall data. 2. To fit a normal distribution to the critical temperature data. 3. To find a good distribution to fit the degree- total-date.

SUPPORTED BY U.S. Dept. of Agriculture
Utah State Government

2.1059, ELECTRONIC ANALOG MODEL STUDIES OF RIVER BASINS

J.M. BAGLEY, Utah State University, School of Engineering, *Logan, Utah* 84321

The basic hydrologic processing of precipitation, snowmelt, surface and subsurface runoff, groundwater storage and movement, evapotranspiration, streamflow, etc., are being modeled electronically as a complete hydrologic system. Model will be used to predict performance of various parts of the hydrologic system resulting from proposed water management and water development changes.

The project was started in 1964. The model is completed. Verification and utility in various problem situations is being explored. Plans are now underway to add considerably more capacity in order to handle a wider variety of problems more expeditiously and to permit greater sophistication and detail in hydrologic definition.

SUPPORTED BY Utah State Government
U.S. Dept. of Agriculture

2.1060, CHARACTERISTICS OF UTAH STREAMS

J.M. BAGLEY, Utah State University, Utah Water Research Laboratory, *Logan, Utah* 84321

A comprehensive analysis of characteristics of Utah streams is being made. Streamflow data from only those gaging stations measuring 'natural' flow (free from any man-made regulation or division upstream), and having a relatively long and continuous record were selected for analysis.

Analyses include magnitude of error in determination of mean annual and seasonal flow, as affected by number of years of record; serial correlation analysis to investigate nature of carryover and lag; analysis of high and low flow sequences and their probabilities of occurrence; an the monthly flow exceedence probabilities. Regional and geographic patterns in flow characteristics are being sought.

SUPPORTED BY Utah State Government
Utah State University

2.1061, INCIPIENT MOTION OF ROUGHNESS ELEMENTS IN TURBULENT OPEN CHANNEL FLOW

C.G. CLYDE, Utah State University, School of Engineering, *Logan, Utah* 84321

The objectives of the proposed research are: 1. To develop suitable criteria for the incipient motion of large roughness elements in turbulent open channel flow under prototype conditions. The parameters to be utilized are time-dependent lift and drag forces, intensity of turbulence, edge velocity, velocity profiles and gradients, flow depths, discharge, and energy gradient. 2. To measure the flow resistance of large roughness elements in order to extend present flow resistance data to large elements and, also, to verify whether or not particular criteria developed from research on various smaller roughness elements by other investigators are applicable to the larger roughnesses. 3. To study the interrelationships between time-dependent lift and drag forces, intensity of turbulence, probability of incipient motion, flow resistance, and the other hydraulic parameters listed under Item 1.

SUPPORTED BY U.S. National Science Foundation

2.1062, INCIPIENT MOTION OF LARGE ROUGHNESS ELEMENTS IN TURBULENT OPEN CHANNEL FLOW

C.G. CLYDE, Utah State University, Utah Water Research Laboratory, *Logan, Utah* 84321

Suitable criteria will be developed for the incipient motion of large roughness elements (hemispheres and spheres varying in diameter between 3 and 12 inches) in turbulent open channel flow under prototype conditions. The parameters to be utilized are time-dependent lift and drag forces, intensity of turbulence, edge velocity, velocity profiles, and gradients, flow depths, discharge, and energy gradient.

The flow resistance of large roughness elements will be measured in order to extend present flow resistance data to large elements and, also to verify whether or not particilar criteria developed from research on various smaller roughness elements by other investigators are applicable to the larger roughnesses.

The interrelationships between time-dependent lift and drag forces, intensity of turbulence, probability of incipient motion, flow resistance, and other hydraulic parameters listed under Item 1 will be studied.

SUPPORTED BY Utah State Government
U.S. National Science Foundation
Utah State University

2.1063, EFFECTS OF RANGE PLANT FOLLIAGE REMOVAL ON SOIL MOISTURE REGIME

G.B. COLTHARP, Utah State University, Agricultural Experiment Sta., *Logan, Utah* 84321

1. To determine the effects of light (25%), medium (50%), and heavy (75%) levels of foliage removal from native range plants on soil moisture regime. 2. To determine the effects of season of foliage removal from native range plants on soil moisture regime.

Proposed work: Small circular plots (approx. 50 sq. ft.) will be located in typical summer range, i.e., native grass and browse. Plots will be subjected to light, medium, and heavy foliage removal treatment by means of clipping. Clipping dates will be: June 1 for one set of plots; June 1, July 1, August 1, and September 1 for the other set of plots. There will be three replications of each treatment combination. Soil moisture will be sampled, by means of a neutron scattering device, immediately prior to clipping and at bi-weekly intervals thereafter. Data will be analysed by means of analysis of variance technique for a randomized block plot design.

SUPPORTED BY U.S. Dept. of Agriculture

2.1064, EVAPORATION AND CLIMATIC STUDIES

J.E. FLETCHER, Utah State University, Utah Water Research Laboratory, *Logan, Utah* 84321

Evaporation, evapotranspiration, and sublimation from snowpacks are all functions of the climatic environment and constitute the principal water losses to the United States. An investigation of the climatic factors which affect the quantity, quality, and timing of these losses is being conducted in order for a more precise formulation of the location and character of water supply utilization to be developed.

SUPPORTED BY Utah State Government
Utah State University

2.1065, SNOW COVER COMPACTION AND SOIL MOISTURE

J.E. FLETCHER, Utah State University, Utah Water Research Laboratory, *Logan, Utah* 84321

Plants growing under areas where snow has been compacted frequently show better growth than adjacent plants following melting of undisturbed snow. Moisture levels in the soil are followed and observations of the plants between compacted and uncompacted areas are being made.

SUPPORTED BY Utah State Government
Thiokol Chemical Corporation

2.1066, A THEORETICAL STUDY OF INFILTRATION INTO RANGE AND FOREST SOILS

J.E. FLETCHER, Utah State University, Utah Water Research Laboratory, *Logan, Utah* 84321

The research is aimed at developing theoretically sound relationships between watershed retention and the physical parameters involved in infiltration interception, depression storage, rainfall intensity, surface detention and others in order to develop a good relationship between physically observable parameters and surface runoff.

The second line of investigation is aimed at estimating infiltration and runoff from ungaged watersheds by utilizing precipitation, soil and watershed parameters.

SUPPORTED BY U.S. Dept. of Agriculture

2.1067, EFFECTS OF PINYON-JUNIPER CONVERSION ON WATERSHED VALUES IN UTAH

G.F. GIFFORD, Utah State University, Agricultural Experiment Sta., *Logan, Utah* 84321

Objectives: To determine the water budget of natural stands of pinyon-juniper versus areas which have been cleared and seeded; to determine the effects of conversion on soil physical properties and stability, runoff, sediment movement and production; to ecologically evaluate sites before and after as to phenology, composition, and vegetative production; to evaluate the economics of conversion practices in terms of watershed values and multiple use relations; and to obtain data necessary for the determination of hydrologic soil-cover complex numbers from pinyon-juniper sites before and after treatment.

Procedures: Three small watersheds will be selected at two widely separated sites in Utah, within the pinyon-juniper vegetative type, representative of similar areas on which conversion by chaining is a standard procedure. Each will be instrumented for climatic data, runoff and sediment yields, soil moisture and temperatures, etc. Detailed soil and vegetative samplings and measurements will be made. When satisfactory calibration has been obtained, two watersheds at each site will be treated (1) double chains, leave debris in place, broadcast seeding, (2) one-way chain, windrow and burn debris, drill seeding.

SUPPORTED BY U.S. Dept. of Interior - Bu. Land Mgmt.

2.1068, DATA REDUCTION METHODS FOR STREAMFLOW FROM SMALL, WILDLAND WATERSHEDS

G.E. HART, Utah State University, Agricultural Experiment Sta., *Logan, Utah* 84321

Objectives: 1. To develop electronic computer integration techniques for the reduction of streamflow data. 2. To evaluate long- term streamflow record for undisturbed watersheds in the Wasatch Mountains.

Abstract of Procedures: Manual methods of compiling and computing discharge from streamflow recorders will be modified to permit semi- automated reduction by electronic computer. A general program will be developed to cover a variety of conditions, both for the input and output. Time and water level values will be transcribed to cards in sufficient detail for reconstruction of the hydrography by machine methods.

SUPPORTED BY U.S. Dept. of Agriculture

2.1069, REMOTE ELECTRO-MAGNETIC SENSORS FOR DETECTING TRANSPIRATIONAL WATER USE BY PLANTS SUBJECTED TO VARIOUS FOLIAR CHEMICAL TREATMENTS

F.W. HAWS, Utah State University, Utah Ctr. For Water Resour., *Logan, Utah* 84321

This project has a dual purpose: (1) to evaluate the usefulness of remote electro-magnetic sensors to detect amounts of transpirational use of water by vegetation, and (2) to evaluate various foliar chemical treatments for reducing transpirational water losses. Spectral reflectance, absorption and thermal emission characteristics of typical forest vegetation and forest soils will be determined. If spectral changes occur with moisture stress a remote sensing technique will be devised to measure and evaluate these changes. Anti-transpirants will be applied to a forest test plot which has been instrumented to measure moisture use. Various anti-transpirants will be evaluated by measuring moisture regime with remote sensors, sap velocity meters, and soil moisture probes.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Utah State University

2.1070, EFFECT OF VARIOUS IRRIGATION TECHNIQUES ON SOIL AERATION, SOIL STRUCTURE, AND CROP RESPONSE

J. KELLER, Utah State University, Agricultural Experiment Sta., *Logan, Utah* 84321

1. A laboratory study to determine the influence of various irrigation techniques on soil structure. 2. To correlate the laboratory study to field response by a field study. 3. To establish a procedure for predicting field responses to the irrigation techniques studies.

The laboratory study will be conducted on soils from possible field sites. The major variables will be water application rate, soil moisture and soil type. Crop response studies will be made at the sites where the laboratory soil samples were taken.

SUPPORTED BY Utah State Government

2.1071, STORAGE AND CONVEYANCE OF IRRIGATION WATER

C.W. LAURITZEN, Utah State University, Agricultural Experiment Sta., *Logan, Utah* 84321

Objectives: To develop (1) methods and materials for the control of seepage and channel stabilization; (2) equipment and construction practices designed to reduce the cost of lining; (3) new methods of conveying water on the farm.

Description of Work Proposed: Properties of materials expected to influence the effectiveness of a lining material will be measured. Measurements will include: (1) permeability and stability of materials, (2) susceptibility to biological deterioration, (3) resistance to weathering, (4) resistance to damage from impact, puncture, hydrostatic pressure, and other types of mechanical damage, and (5) resistance to plant peneration.

Materials investigated will include: (1) earth, (2) asphalt, (3) concrete, (4) metal, (5) chemical stabilizers, and (6) structures fabricated from asphalt, plastics, and elastomers.

The use of new materials frequently necessitates the development of new techniques in construction involving the design and testing of equipment for handling, compacting, joining, and protecting the lining material and other conveyance structures, Some of these factors can only be evaluated in operating canals and reservoirs. Evaluation takes many forms, depending upon the lining employed: (1) seepage measurements, (2) permeability and apparent specific volume determinations, (3) measurement to determine physical and chemical properties, and (4) observation of usual deterioration, such as breaks, cracks, and checking.

SUPPORTED BY Utah State Government

2.1072, DEVELOPMENT OF IMPROVED SNOW SURVEYING AND STREAM-FLOW FORECASTING TECHNIQUES

C.H. MILLIGAN, Utah State University, Agricultural Experiment Sta., *Logan, Utah* 84321

In this project data on antecedent streamflow, as measured by the U.S. Geological Survey, rainfall, temperature, soil moisture, and accumulative winter snowfall will be collected for the Logan River watershed. These antecedent data will be correlated with streamflow for the irrigation season. Functional relationships thus developed will be utilized for advance information will guide water management. This advance information is especially valuable in years of drought. The objectives of this project are to develop improved techniques and equipment for measurement of the variables which affect streamflow and to improve forecasting relationships, all so that more accurate forecasts of expected streamflow can be made.

SUPPORTED BY U.S. Dept. of Agriculture
Utah State Government

2.1073, OPEN CHANNEL ROUGHNESS CHARACTERIZATION

D. OVERTON, Utah State University, Utah Water Research Laboratory, *Logan, Utah* 84321

This is a laboratory study of flow in an open channel flume with 3 7/8' diameter hemispherical bed elements attached to the bottom. The study will include eleven patterns at various slopes and discharges. The effect of various regular longitudinal and transverse spacings as well as random spacings will be investigateed.

SUPPORTED BY Utah State Government
Utah State University
U.S. Dept. of Agriculture

2.1074, UTAH ATMOSPHERIC WATER RESOURCES (THE WASATCH WEATHER MODIFICATION PROJECT)

G.W. REYNOLDS, Utah State University, Utah Water Research Laboratory, *Logan, Utah* 84321

The purpose of this study is to quantify the effects of cloud seeding on the winter snowpack in the Wasatch Mountains in Utah. Initially, at least, the seeding is to be with silver iodide from two mountain top and two valley generators, along the Wasatch Front, near Ogden. The evaluation is to be based primarily upon data from 150-200 telemetering precipitation gages. Approximately 40 of these stations are to be in operation during the 1967-68 winter. These measurements are to be supported with radar and special rawinsonde observations.

Support studies in several areas are required: silver iodide background and plume nuclei studies; inadvertent cloud seeding by air pollution; precipitation analysis for silver and iodine; time and space synoptic climatology-cloud-precipitation studies; and hydrologic studies. These support studies have only been started. The bulk of the effort thus far has been on the development, adaptation, manufacture, and installation of the telemetering system (remote stations and terminal readout system).

The evaluation system will involve the comparison of natural and seeded precipitation patterns. Variations in both time and space will be considered. Both target versus control and seeded versus unseeded comparisons are to be made. Non-parametic statistical significance tests will be applied.

SUPPORTED BY U.S. Dept of Interior - Bu. Reclamation

2.1075, THE SIMULATION OF HYDROLOGIC EVENTS IN ARID REGIONS

J.P. RILEY, Utah State University, Utah Water Research Laboratory, *Logan, Utah* 84321

The hydrologic characteristics of watersheds in semiarid regions are dependent upon many variable and often interrelated factors. A quantitative knowledge of these factors and of their relative influence upon the system as a whole is needed in order to improve the efficiency of watershed management in these areas. In an attempt to develop a comprehensive simulation model of a semiarid watershed, research workers in the Agricultural Research Service considered the electronic analog computer, and a cooperative research agreement was subsequently signed with Utah State University.

Analog modeling concepts are based upon the development of basic relationships which describe the various processes which occur within the surface hydrologic system of a semiarid watershed. Once established, the model is applicable to any particular geographic unit by determining the appropriate constants of the hydrologic equations. The analog computer is ideally suited to the many time-dependent differential equations which are encountered in hydrologic systems.

To test individual equations and to verify the model, a subbasin of Walnut Gulch Watershed in southern Arizona was simulated. In preliminary tests, close agreement was achieved between the observed and computed runoff hydrographs for a single storm. Some progress has also been made in the development of an analog technique to plot isohyetal lines corresponding to selected time intervals during the course of a storm.

The project was initiated in February 1965 and has no specific termination date. It is however, subject to renewal on July 1 of each year.

SUPPORTED BY U.S. Dept. of Agriculture

2.1076, PREDICTION OF WATER MOVEMENT IN UNSATURATED SOILS

S.A. TAYLOR, Utah State University, Agricultural Experiment Sta., *Logan, Utah* 84321

Objectives: 1. To delineate the influence of structural and electrostatic differences as well as solute concentration and energy gradients upon the movement of solutes, energy, and water in soils. 2. To devise quantitative expressions describing the simultaneous movement of water, solutes, and energy in soil.

Description of Work: 1. Simultaneous measurements of the flow of different kinds of matter and energy through soil materials that have been subjected to simultaneous driving forces will need further developing as their extension to other materials comes about. The results of such measurements will be used to calculate transfer coefficients. These coefficients will then be tested by experimentally verifying the flow equations. 2. The systems of interest will be subjected to further theoretical analyses, in order to find general flow equations. The appropriate equations will be tested using the data collected in connection with objective 1, and by other cooperators in Western Regional Research Project W-68.

SUPPORTED BY U.S. Dept. of Agriculture
Utah State Government

2.1077, WATER-SOIL-PLANT RELATIONS

S.A. TAYLOR, Utah State University, Agricultural Experiment Sta., *Logan, Utah* 84321

Objectives: 1. Investigate relationships between water stress in root media and internal water status of plants as affected by environment and plant development. 2. Evaluate effect of plant structures, physiological processes and transpiration retardants on water movement and loss from plants. 3. Seek unification of divergent hypotheses concerning soil water and its effect on plants as a basis for developing concepts leading to more efficient use of water.

Description of Work: 1. Measurement of the different components of the water potential (total, osmotic, and solute) in plants will be made using vapor pressure psychrometers. 2. The influence of respiration inhibitors, oxygen concentration, and pressure on the water potential, respiration potential, and permeability of root systems will be made. 3. Various explanations of water transport in the soil- plant atmosphere system will be studied theoretically and quantitatively using simultaneous flow of water, heat, salts and other materials and forms of energy through the system.

SUPPORTED BY U.S. Dept. of Agriculture
Utah State Government

2.1078, COMBINED INFLUENCE OF ATMOSPHERIC DESICCATION AND SOIL WATER POTENTIAL ON THE IRRIGATION NEED AND WATER POTENTIAL OF PLANTS

S.A. TAYLOR, Utah State University, Agricultural Experiment Sta., *Logan, Utah* 84321

Objective: To integrate the parameters of atmospheric desiccation, soil water potential, and the thermodynamic condition of internal plant water as a precise method to determine irrigation need and practice.

Procedure: Three different irrigation regimes will be used to maintain the soil water potential in the root zone of mature peach trees within predetermined limits. Leaf water content will be measured continuously. Relative turgidity measurements and direct measurements of plant water potential will be made on plant tissue samples. Atmospheric desiccating conditions will be characterized by potential evapotranspiration as calculated from a Penman equation. If possible the equation will be modified to account for advective energy. The necessary parameters in the equation will be measured continuously using self-recording equipment recently developed and tested at Utah State University.

SUPPORTED BY U.S. Dept. of Agriculture

2.1079, HYDRODYNAMIC FORCES ON NON-COHESIVE BED PARTICLES INCLUDING SEEPAGE

G.Z. WATTERS, Utah State University, School of Engineering, *Logan, Utah* 84321

This research will consist of an investigation of the hydrodynamic forces on spheres placed in the bottom of a flowing open channel and subjected to a seepage flow both into and out of the channel. These spheres represent idealized noncohesive bed particles normally found in mobile-boundary water conveyance channels.

The experimental apparatus is a dynamically similar model of the prototype bed with 3-inch diameter spheres being used to represent the bed particles. A mineral oil with a viscosity about 100 times that of water will be used to insure dynamic similarity between the model and a prototype bed with particles about 0.5 to 1.0 mm in diameter.

The forces will be measured with a strain-gage dynamometer under various conditions of seepage and channel flow. The contributions to the total hydrodynamic force of the seepage flow and the external channel flow will be determined separately. The use of spheres to model the channel bed will eliminate the statistical scatter inherent when natural bed materials are used and provide definitive results which will reveal the conditions under which seepage is important in influencing the forces on bed particles.

SUPPORTED BY U.S. National Science Foundation

2.1080, SOIL AND CLIMATE EFFECTS ON IRRIGATION WATER REQUIREMENTS

L.S. WILLARDSON, Utah State University, Agricultural Experiment Sta., *Logan, Utah* 84321

1. To determine whether the same consumptive use coefficients can be used under different climatic conditions. 2. To compare field measurements of consumptive use with current methods of calculating consumptive use from weather data. 3. To test a technique for separating measured consumptive use into components of evapotranspiration and deep percolation.

Studies will be conducted at 3 locations having different growing seasons. Laketown (Latitude 41.8, Seasonal F 23.85), Richmond (Latitude 41.9, Seasonal F 30.39), and Logan (Latitude 41.7, Seasonal F 38.78), Utah having been selected. Irrigated fields planted either to spring or fall grain and fields of established alfalfa will be used. Study sites will be selected with the help of county agents and the local Soil Conservation Service personnel. Soil classification information will be obtained. Neutron meter tubes for soil moisture measurements will be installed in the normal cropped area before growth starts in the spring. Other tubes will be installed in a representative location nearby in the same field.

SUPPORTED BY Utah State Government

2.1081, SPRINGS OF UTAH

J.C. MUNDORFF, U.S. Dept. of Interior, Geological Survey, *Salt Lake City, Utah*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Utah.

Objective: To appraise the chemical, physical, and thermal characteristics, quantity variation, geologic source, and mineral resource potential of the major springs of Utah.

Methods: Assembly of all available data supplemented by field reconnaissance. Laboratory analysis will include complete standard analyses, spectographic analyses for minor element concentration, and possibly radiochemical and gas analyses for selected springs. Data will be entered on punch-cards for statistical treatment and analysis.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Utah State Government

2.1082, HYDROLOGY OF THE SUB-LAKE SEDIMENTS BENEATH GREAT SALT LAKE

W.P. HEWITT, Univ. of Utah, State Geolog. & Min. Surv. , *Salt Lake City, Utah* 84112

In those holes being drilled to determine the engineering characteristics of the bottom sediments of Great Salt Lake, and to test for deep brines, records are to be made of water pressures within the sediments at various depths beneath the brine-mud contact. It is planned to install casing in a few selected holes to study the transmissibility of water within these sub-Lake sediments. From data thus obtained, it is hoped that knowledge will be obtained that pertains to sub-Lake recharge.

This program will be commenced during the fiscal year that starts July 1, 1965. Status: work deferred until funds are available for casing and measuring devices. Will most likely be coordinated as a cooperative project with other State agencies and the U.S. Geological Survey.

SUPPORTED BY Utah State Government

2.1083, CARBON, OXYGEN AND SULFUR ISOTOPES AND THE ORIGIN AND SOURCES OF URANIUM MINERALIZATION

M.L. JENSEN, Univ. of Utah, Graduate School, *Salt Lake City, Utah* 84112

During past years, this contract has provided diagnostic evidence of the mechanism by which sandstone-type uranium deposits form. This evidence consists of the analytical isotopic analyses of sulfur and carbon stable isotopes indicating that CO2 and H2S, derived from sulfur reducing anaerobes, has provided the effective reductant, H2S, that has concentrated insoluble tetravalent uranium from solutions carrying soluble hexavalent uranium that transit zones containing the reductant H2S.

Although the mechanism for the concentration of uranium is now known, it is most important to have information on the sources of the metal. At the present time, therefore, this research contract is studying oxygen isotopes derived from uranium oxides, quartz, silicates, and oxide minerals that occur intimately associated with the uranium deposits. Using the diagnostic isotopic ratios of 016/018 of uranium, etc., it should be possible to determine 1) the influence of bacterial activity on the genesis of these deposits and 2) the isotopic composition and genesis of the transporting aqueous medium in light of 016/018 studies from which the uranium assemblages were deposited.

Finally, in order to have a better understanding of the isotopic - temperature relationships of the oxygen bearing solutions, laboratory experiments are being done to determine the isotopic exchange equilibrium reactions between water - uranium oxide and water - uranium oxide - carbon dioxide systems. This information will enable us to evaluate post depositional isotopic exchange of primary uranium oxides with local ground waters and with atmospheric oxygen. If the data can be extrapolated to higher temperatures, the data may be applied to uranium bearing minerals in pegmatites.

SUPPORTED BY U.S. Atomic Energy Commission

2.1084, AUTECOLOGICAL STUDIES ON SOME DOMINANT PHYTOPLANKTON SPECIES OF LAKE CHAMPLAIN

P.W. COOK, Univ. of Vermont, Graduate School, *Burlington, Vermont* 05401

At the present time, the phytoplankton of Lake Champlain seems to be characteristic of mesotrophic conditions with a trend toward eutrophication in some of the more isolated embayments. Very little data is available on the ecology of some of the dominant organisms and Tabellaria fenestrata, Coelosphaerium naegelianum, and Aphanizomenon flos-aquae have been chosen for detailed consideration. Attempts will be made to correlate quantitative estimates of these species with physico-chemical data collected as part of the general limnological program of the Lake Champlain Studies Center. Chlorophyll content will be used as an indirect measurement of total phyto-plankton; differential counts will be used to obtain semi-quantitative data on the more common species. If feasible, studies of the nutrition of the selected species will be initiated.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Vermont

2.1085, PARAMETERIZATION OF THE OBSERVED HYDROGRAPH AS A MEANS OF UNDERSTANDING RUNOFF PHENOMENA FROM SMALL WATERSHEDS

R.N. DOWNER, Univ. of Vermont, School of Engineering, *Burlington, Vermont* 05401

The primary objective of this investigation will be to develop an analytical method of fitting a mathematical model to the observed hydrograph and to express this model by parameters which can be related to measurable watershed characteristics. By establishing meaningful relationships between the model parameters and the characteristics of the watershed it should be possible to predict hydrographs for certain known contributory conditions.

The study will involve the fitting by means of the computor of a form of the incomplete gamma function to the observed hydrographs from a small watershed. Incidental to this work will be the establishment of criteria for goodness of fit. Once fits have been made for many storms statistical procedures will be used to establish relationships between the parameters of the hydrograph and the causative factors. Testing of the methodology will be carried out with the cooperation of the Sleepers River Research Watershed operated by the USDA-ARS at Danville, Vermont. Having developed adequate relationships between the parameters of the hydrograph and their causative factors for a gaged watershed, an attempt will be made to extend their methodology to ungaged watersheds typical of the northeast.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Vermont

2.1086, CHEMICAL CHARACTERISTICS OF PRECIPITATION FALLING IN CHAMPLAIN VALLEY

E.B. HENSON, Univ. of Vermont, Graduate School, *Burlington, Vermont* 05401

Rain and snow will be collected from several stations as it falls to the ground. This water will be analysed for major cations (Ca, Mg, Na, K) present and the anions HCO3, Cl, SO4, and PO4. The total alkalinity or acidity, pH. Conductivity will also be determined, when possible. Special rain buckets of inert plastic will be placed in strategic locations in the Champlain basin. Some will be placed on the New York Shore, some in the middle of the lake, and a number of collectors will be located in Vermont. The precipitation from a complete storm sequence will be collected in most instances; records will be maintained by the U.S. Weather Bureau in Burlington as to the type of precipitation.

From the analyses of the water in these collections, it is anticipated that some general conclusions can be made as to the chemical nature of the water that falls in the Champlain watershed, and that we therefore will have some knowledge of the amount of nutritive or contaminating load that is added to the local hydrological scene.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Vermont

2.1087, BOTTOM SEDIMENTS OF LAKE CHAMPLAIN

A.S. HUNT, Univ. of Vermont, State Resources Res. Center, *Burlington, Vermont* 05401

A reconnaissance study has been undertaken to collect data on the physical, chemical, and mineralogical properties of the sediments at the sediment surface and at depth in Lake Champlain. The grain size is being measured in order to study current, erosion, and sediment transport. Grain size is also related to organic content, clay mineralogy, benthonic organisms and other dependent variables. In order to better understand the relationship between the sediments discharged into the lake and the lake's waters, chemical and mineralogical analyses of selected sediment samples is being undertaken

A grid system has been used to select the sample sites which are located by transit. Surface samples are collected with a grab sampler; cores are collected using a gravity and Mackereth corer. The grain size is being determined using a settling tube and hydrometer methods and the data is processed by means of a computer program. The mineral content of the sediments is being studied using X-ray diffraction methods, magnetic separation, and other standard procedures. Chemical analyses are performed using atomic absorption and other conventional methods.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Vermont

2.1088, LIMNOLOGY OF LAKE CHAMPLAIN

M. POTASH, Univ. of Vermont, State Resources Res. Center, *Burlington, Vermont* 05401

The Objectives of the project are twofold; (1) to carry out field studies on Lake Champlain to determine, as far as possible, its physical, chemical, and biological characteristics; and (2) to continue long-term studies to determine whether these characteristics are being altered in any harmful way, or in any region of the lake, by the addition of pollutants.

Immediate research will concentrate on obtaining further descriptive information on such characteristics as temperature, light transparency, oxygen, pH, carbon dioxide, nutrients, currents and water flow, and bottom sediments. After the basic character of the lake had been described, continued research will be carried out to determine the biological character of the lake. As far as possible, research will emphasize the distribution and quantity of phytoplankton, zooplankton, benthic organisms, correlating their patterns with environmental data previously obtained.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Vermont

2.1089, GLACIAL GEOLOGY OF THE CHAMPLAIN VALLEY

W.P. WAGNER, Univ. of Vermont, Graduate School, *Burlington, Vermont* 05401

The prime objective is to determine the Pleistocene (Ice Ages) glacial history of the Champlain Valley. Glacial deposits around Lake Champlain will be studied and mapped using aerial photographs and topographic maps and the other usual field and laboratory techniques. In addition, the clay mineralogy of tills will be studied by Differential Thermal Analysis. Sediment analyses will be treated statistically with the aid of a computer.

A secondary objective is to determine whether or not an interaction of glacial ice and ancient Lake Champlain water resulted in similar topographic and sediment characteristics as the principal investigator found in Michigan and Alberta, Canada. The techniques involved are the same as outlined above.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Vermont

2.1090, SOIL WETTABILITY AND TREATMENT IN RELATION TO WATER MOVEMENT IN SOILS

E.G. DUNFORD, U.S. Dept. of Agriculture, Forest Service, *Arlington, Virginia* 22209

Object: To provide understanding of soil wettability, its effect on infiltration, retention, and release water, and the feasibility of modifying wettability through application of wetting agents.

Plan of Work: The investigator will conduct most of this research in the laboratory. Soils with variable properties of wettability, organic matter, mineralogy, and surface area will be packed in columns and wetting agents will be flowed through the columns to determine sorption, etc. He will attempt to extract and identify the active material of nonwettability. The physical effect of wetting agents will be studied and waterflow through porous media with various surface properties will be measured.

SUPPORTED BY U.S. Dept. of Agriculture

2.1091, UNSTEADY FLOW AND SALINE INTRUSION IN ESTUARIES

R.A. BALTZER, U.S. Dept. of Interior, Water Resources Division, *Arlington, Virginia*

It is of fundamental importance to recognize that flow in natural channels is basically unsteady flow. To be sure, the degree of its unsteadiness is often of such minor significance that, with sound reason, such flow can be assumed to be steady flow, thereby taking advantage of greatly simplified analytic representation. Nevertheless, proper and thorough understanding of the mechanics of unsteady flow is important per se in determining the discharge of regulated streams, in flood routing, in determining flows in tidal reaches of homogeneous density, and, in fact, in any situation where open-channel flow cannot be assumed to be steady flow. Moreover, an understanding of the mechanics of unsteady flow is fundamental to improving the understanding of saline intrusion and diffusion in estuaries.

The ultimate objective of this investigation is the development of mathematical models representing unsteady open-channel flow, particularly as associated with estuarine channels. These models, hopefully, could then be used to predict-- or using certain field obtained parameters -- to determine such quantities as outflow, saline intrusion, and effects of channel changes upon flow.

A thorough appraisal of present knowledge of unsteady, open-channel flow is being conducted, including categorization of flow types and their required mathematical representation. Mathematical models will be derived and evaluated utilizing various solution techniques employing both analog and high-speed digital computers. Selected field data will be employed in the evaluation process.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.1092, REGIONAL HYDROLOGIC SYSTEM ANALYSES (HYDRODYNAMICS)

R.R. BENNETT, U.S. Dept. of Interior, Water Resources Division, *Arlington, Virginia*

The general objective is to determine the degree of significance of the factors that control or affect regional groundwater flow patterns in large hydrologic systems and to determine the principles of the functional nature of permeability distribution in granular sediments so that physical characteristics of hydrologic systems can be predicted. Two hydrologic systems are being used as prototypes. The field data and samples collected from the prototypes are being analyzed in the laboratory for directional permeability, fabric orientation and grain-size distribution. This project is being conducted in conjunction with the project, 'Permeability distribution and sedimentational features,' J. D. Bredehoeft, Project Leader.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.1093, MECHANICS OF GROUND-WATER FLOW

H.H. COOPER, U.S. Dept. of Interior, Water Resources Division, *Arlington, Virginia*

Mathematical analyses and analog studies of the movements of water in underground reservoirs provide a theoretical background for methods and techniques and the criteria for sound judgment in water management. Current studies are concerned with movements in anisotropic aquifers and in multi-aquifer systems, induced recharge from surface streams, and the response of water levels in wells to earthquakes.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.1094, MINERALOGIC CONTROLS ON CHEMISTRY OF GROUND WATER

B.B. HANSHAW, U.S. Dept. of Interior, Water Resources Division, *Arlington, Virginia*

Results of Laboratory investigations of the behavior of compacted clays as semi-permeable or osmotic membranes indicate that they are capable of affecting the chemistry of subsurface water and the fluid pressure. Salt filtering occurs when a saline solution is forced through compacted clay. Where a pressure differential exists across a body of shale, this process may be effective in increasing the salinity on the high pressure side of the membrane. The ability of shale to act as an osmotic membrane could also be a factor in the occurrence of anomalously low fluid pressures in parts of some sedimentary basins.

Compacted clay membrane electrodes have been used to study the action distribution coefficient between the clay and an internal solution. Preliminary results suggest that the distribution coefficient (exchange constant) varies as a function of compaction pressure.

Research into the use of C dating of ground waters is being studied along with a study of other isotopic equilibria in ground water in an attempt to understand better the rate, direction of movement, and recharge of ground-water aquifers.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.1095, MINERAL-WATER INTERACTION IN SALINE ENVIRONMENTS

B.F. JONES, U.S. Dept. of Interior, Water Resources Division, *Arlington, Virginia*

The chief processes being considered are evaporative dissolved- solid concentration, solid-solute reaction, mineral precipitation and re-solution, and compositional variation resulting from hydrographic fluctuation. Pilot study of the Deep Springs Valley, California has emphasized the compositional influence of salt storage mechanisms in sediments over simple or cyclic hydrographic variation of saline waters, and has elucidated the effects of precipitate geochemistry on brine composition. Delineation of trends in inflow chemistry has indicated the interrelation but basic dominance, or lithologic over climatic controls. Details of these findings are being examined further in other basins. Problems of methodology in solution analysis over an extremely wide range of conditions, and in better definition of associated solids, have received much attention, and work to further refine techniques in this progress.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.1096, NUMERICAL SIMULATION OF HYDRODYNAMIC PHENOMENA BY DIGITAL COMPUTER

C. LAI, U.S. Dept. of Interior, Water Resources Division, *Arlington, Virginia*

Purpose: To develop numerical methods for solving selected surface and ground water fluid dynamics problems; to develop new computer simulation techniques with which to model natural field phenomena.

Methods: Movements of wave-crest in open channels will be simulated, pictorial representations of surface profiles of wave-crest movements will be developed and results will be compared with field observations.

Free-surface, unsteady, gravity flow through porous media induced by transient open-channel flows will be simulated by digital models.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.1097, THE POST-PLEISTOCENE EPICYCLE SEQUENCE OF ALLUVIATION AND EROSION IN THE LOWER SAN JUAN DRAINAGE

D. OBRYAN, U.S. Dept. of Interior, Water Resources Division, *Arlington, Virginia*

Non-nuclear techniques such as sedimentation, geomorphology, palynology, dendrochronology, archaeology, and history are being applied in a study of late Recent sequencies of alluviation, arroyo cutting, and terracing along parts of Chinle Wash in northeastern Arizona. These sequences will be related to the effects of environmental and hydrogeologic controls in an effort to reconstruct the local paleoenvironment, and to aid in the reconstruction of paleoenvironments in other semi-arid parts of the world.

The alluvium consists mainly of two deposits; the older was deposited between 2,000 B. C. (?) and A. D. 1100-1200, and the younger accumulated between A. D. 1300 and 1850, when the present arroyos began to form. Remains of prehistoric Pueblo Indian culture occur in the upper part of the older alluvium. Sites representative of Basketmaker III and Pueblo I (8th to 10th centuries) occur as much as 25 feet below the top of the older alluvium. Pueblo II and III (11th to 13th centuries) remains either are buried in the upper few feet of the older alluvium or occur on the terraced surface cut from that unit.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.1098, PERIODIC PLANT GROWTH PHENOMENA AND HYDROLOGY

R.L. PHIPPS, U.S. Dept. of Interior, Geological Survey, *Arlington, Virginia*

Most plant growth phenomena (sprouting, height and diameter growth, leafing, flowering, fruiting, etc.) may be regarded as integrated responses to present and past environments within hereditary limits. Though relationships between these growth activity phenomena and hydrologic components of environment are incompletely understood, data relative to such an understanding may be easily collected for a wide number of plant species over a large area by 1) noting dates of occurrence of various plant-growth phenomena and relating them to precipitation and streamflow and, where practicable, to soil moisture and ground-water fluctuations; 2) mapping of vegetation and making observations concerning related microclimatic variation to facilitate interpretation of periodicity of plant activity; and 3) making measurements of rates of current three-dimensional growth of trees for inclusion with, and analysis of, tree-ring data and growth form. These data are potentially of value as a means of further definition of cycles of hydrologic activity in vegetated areas, of estimating trends and variability in hydrologic phenomena, and of extending hydrologic records in space and time.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.1099, THERMAL CHARACTERISTICS OF AQUIFER SYSTEMS

R. SCHNEIDER, U.S. Dept. of Interior, Water Resources Division, *Arlington, Virginia*

Background: One of the most difficult problems in defining the flow pattern in aquifer systems is the determination of vertical permeability of aquifers and their confining strata. Under natural conditions or when induced by pumping, there can be a significant quantity of cross-formational flow. In general our ability to predict the effects of the large-scale development of aquifers is directly related to the precision with which we can estimate the spatial distribution of permeability. The study of the relation between thermal and hydrologic characteristics of various types of aquifers would improve our capability for defining permeability in a vertical direction.

Objectives: To study the temperature distribution in representative coastal-plain aquifers and carbonate-rock aquifers, in which hydrologic conditions are well known and relatively simple and relate this parameter to vertical permeability and other flow characteristics of the aquifer system.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.1100, BASIC RESEARCH IN VEGETATION AND HYDROLOGY

R.S. SIGAFOOS, U.S. Dept. of Interior, Water Resources Division, *Arlington, Virginia*

The objective is to determine qualitative and quantitative differences in vegetation which are related to flooding and low flow of streams, to differences in quality of surface and ground water, and to recent activity of mountain glaciers.

Plants are identified and mapped and trees are measured in the field; the distribution of them is related to type of surficial material and bedrock, to height above low water, to height of floods of different frequency, to topographic features, to estimated depth to water table, and to land use. Where appropriate, cores and sections of trees are taken, and ages of trunks are determined. In the office, significance of association or independence of the variables is tested statistically, and mathematical methods of expressing vegetation differences are determined.

2. WATER CYCLE

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.1101, GRAIN SIZE DISTRIBUTION AND BEDLOAD TRANSPORT

G.P. WILLIAMS, U.S. Dept. of Interior, Water Resources Division, *Arlington, Virginia*

Flume experiments will be carried out relating bedload transport rate to channel factors, and especially variations resulting from changes in size distribution keeping median grain size constant. Bed forms, including values of linear grain concentration, will be measured.

The basin hydraulic parameters of the upper limit of flow of G. X. Gilbert experiments will be duplicated and runs will extend these data to larger values of discharge and grain size.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.1102, TRANSPORT PROPERTIES OF NATURAL CLAYS

R.G. WOLFF, U.S. Dept. of Interior, Water Resources Division, *Arlington, Virginia*

The work includes (a) Assessing the applicability of existing sampling and measuring techniques for determining the hydraulic properties of undisturbed clay samples. Modifying the techniques as necessary. (b) Developing in stages, the equipment and techniques for measuring all the transport properties that govern the movements of water and dissolved solids through undisturbed clay samples. (c) Introducing the use of these measurements to field problems and, using the data obtained, attempting to correlate the transport properties of natural clays with their mineralogical, chemical, and geological characteristics.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.1103, EFFECTS OF ZOOPLANKTON ON PHOTOSYNTHESIS BY ALGAE IN LAKES

J.W. BISHOP, Virginia Polytechnic Institute, Water Resources Research Ctr., *Blacksburg, Virginia* 24061

Field studies will be conducted to ascertain the effects of vertically migrating zooplankton on rates of photosynthesis by natural assemblages of phytoplankton. Phytoplankton will be isolated from or exposed to zooplankton. The quantities of phytoplankton and their rates of photosynthesis then will be measured. Differences between the two groups of phytoplankton will be attributed to effects of zooplankton. The combined as well as individual effects of different species of zooplankton will be estimated.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Virginia Polytechnic Institute
University of Richmond

2.1104, SOIL AND WATER MANAGEMENT AS RELATED TO FORAGE CROP PRODUCTION

R.H. BROWN, Virginia Polytechnic Institute, Agricultural Experiment Sta., *Blacksburg, Virginia* 24061

Objective: To study the establishment and maintenance of forage species and mixtures as influenced by: (1) liming and fertilization, (2) irrigation and drainage, (3) tillage, and (4) fumigation.

These are all small plot investigations conducted in various locations at research stations in Virginia. Data are being obtained on species balance, yield, and the chemical composition of individual species in the plant associations. Present experiments include nitrogen fertilization and the interaction of nitrogen fertilization with potassium on grass-legume mixtures; grasses grown alone and with legumes with different cutting managements; nitrogen fertilization, responses of grasses to 3 levels of nitrogen and 4 of K2O; and one experiment is set up to study the interrelationship of irrigation, cutting management, nitrogen fertilization of orchardgrass.

SUPPORTED BY Virginia State Government

2.1105, INVASION OF THE AQUATIC HABITAT BY AMPHIBIOUS SPECIES OF POLYGONUM

R.S. MITCHELL, Virginia Polytechnic Institute, Graduate School, *Blacksburg, Virginia* 24061

The purpose of this project is to determine the aquatic capabilities of so-called 'semi-aquatic' species of Polygonum of the section Persicaria. Through cloning experiments the properties of these organisms may be compared with those of P. amphibium, the only true aquatic of the group, and a scale of amphibiousness may be drawn up with regard to the species studied.

Through such endeavors, coupled with cytological, anatomical and biosystematic comparisons, it is hoped that a clearer understanding of the relationships between species of Polygonum may be reached, and that putative parents for P. amphibium might be assigned. This study affords an excellent opportunity for comparison of terrestrial and aquatic species in a closely related group.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Virginia Polytechnic Institute

2.1106, CHARACTERIZATION OF THE PHYSICAL PROPERTIES OF THE SOILS OF VIRGINIA

J.E. MOODY, Virginia Polytechnic Institute, Agricultural Experiment Sta., *Blacksburg, Virginia* 24061

OBJECTIVES: (1) To study the physical properties of various soil series of the state and obtain data on the ranges in these properties. (2) to correlate the physical data with field characteristics to provide supporting data to local health directors and other agencies in evaluation of land for sewage disposal and other urban uses. (3) to study the physical properties and their relation to the genesis and morphology of the various soils.

DESCRIPTION OF WORK: This study of soil physical properties will be in the following areas: (1) Permeability measurements of important soil types of Virginia to include in place measurements of restricting layers and laboratory measurement of hydraulic conductivity. (2) Interrelationships of soil characteristics and the seasonal march of the water table in various Virginia soils to include important soils in the Coastal Plains and Piedmont regions. (3) Extent and nature of the shrink-swell properties of Virginia soils, and (4) soil moisture characteristics and related physical properties of the soils of Virginia.

SUPPORTED BY Virginia State Government

2.1107, PHYSICAL PROPERTIES OF IMPORTANT SOIL TYPES OF VIRGINIA AS THEY RELATE TO WATER AND AIR BEHAVIOR AND TILLAGE

J.D. PENDLETON, Virginia Polytechnic Institute, Agricultural Experiment Sta., *Blacksburg, Virginia* 24061

Objectives - 1. To measure the capacity for water intake, storage, and for supplying water to crops of some important soil types. 2. To determine the bulk density of these soil types. 3. To determine these properties for each horizon of the profile of the soil type. 4. To study the depth of a soil type that is effective for water storage and root development. 5. To relate these properties to the productivity of these soil types for crops and to land and earth use for roads, buildings, and other purposes.

To accomplish these objectives the soil types are sampled horizon by horizon using a special core sampler fitted with cylinders to hold cores of definite size. The structure of the soil is not disturbed. These cores are placed on a porous plate in a pressure chamber or on a cellophane membrane in a pressure membrane extractor; the desired pressure is applied and at equilibrium the moisture percentage of the soil is determined. The bulk density is found for other cores of the same horizons. This makes it possible to find how much water for crop use the soil types hold.

SUPPORTED BY Virginia State Government

2.1108, GROUND WATER RESERVOIR RESPONSE TO EARTH TIDES

E.S. ROBINSON, Virginia Polytechnic Institute, Graduate School, *Blacksburg, Virginia* 24061

The proposed research is concerned with the application of measured tidal water level fluctuations in wells for determining aquifer porosity and specific storage. The research involves measurements of well water level fluctuations for 2-3 month periods, computation of the tidal dilatation of the solid earth, and recording of supplementary barometric and seismic data. The project work will attempt to verify recently published theoretical treatments of aquifer response to earth tides.

Field investigations include: a) Well water level recording; b) Tidal gravity recording: c) Borehole temperature logging; d) Seismic refraction surveys; e) Barometric pressure recording at well-sites.

Data analysis and interpretation involve: a) Resolution of principal tidal components by harmonic analysis; b) Computation of solid earth tidal parameters for realistic models; c) Calculation of porosity and specific storage for aquifers characterized by fracture systems, and estimation of volume of large water filled caverns.

From these data and calculations the applicability of tidal parameters to the determination of aquifer characteristics will be evaluated.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Virginia Polytechnic Institute

2.1109, SIMULATION OF THE HYDROLOGIC CYCLE ON SMALL AGRICULTURAL WATERSHEDS BY DIGITAL TECHNIQUES

V.O. SHANHOLTZ, Virginia Polytechnic Institute, School of Engineering, *Blacksburg, Virginia* 24061

The proposed work involves testing the Stanford Watershed Model on small agricultural watersheds in Virginia. The model will be modified when required to make the algorithm functional for studying flow regimes from these watersheds.

The concept of excess precipitation followed by routing through a partial linear storage system to obtain lag time will be used in lieu of the Stanford technique. Storage routing without coefficients will be used in lieu of the semi-graphical technique for reservoir routing.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Virginia Polytechnic Institute

2.1110, SOLAR REFLECTANCE OF MONOLAYER-COVERED WATER SURFACES AS RELATED TO EVAPORATION SUPPRESSION

J.T. BEARD, Univ. of Virginia, School of Engineering, *Charlottesville, Virginia* 22903

The importance of evaporation suppression in conserving water has been noted by many investigators. Most of the evaporation suppression work has been centered around the fact that monolayers of certain hydrocarbons placed on the surface of water act as a barrier which water molecules must penetrate in order to evaporate.

The idea of evaporation suppression by increased solar reflectance has been presented by Beard. An analytical investigation showed that a chemical monolayer or thin film with suitable optical properties (index of refraction and extinction coefficient) could substantially increase the reflectance. Thus the rate of evaporation is reduced due to the decrease in solar energy absorbed by the water.

It is proposed that research be done to determine the chemical substances which will substantially increase the solar reflectance of lake surfaces. As the known values for optical properties are limited to substances in the bulk form rather than a monolayer form, experimental work is necessary.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Virginia

2.1111, POROSITY AND PERMEABILITY OF VIRGINIA AGGREGATES

W.C. SHERWOOD, Virginia Council of Hwy. Inv. , *Charlottesville, Virginia*

Nitrogen permeability studies continue. A special project on the samples showing very low flow rates has just been completed. Flow rate data on very dense, low permeability rocks has been obtained. A classification of the pore size distributions of Virginia aggregates has been developed. The relationship between water and nitrogen permeability is now under consideration.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Virginia State Government

2.1112, BIOLOGICAL AND CHEMICAL STUDY OF VIRGINIAS ESTUARIES

M.L. BREHMER, Virginia Inst. of Marine Sci. , *Gloucester, Virginia*

Virginia's three major estuarine systems--the James, the York, and the Rappahannock--exhibit different biological characteristics both within and between years. These differences have been noted in phytoplankton populations; in shellfish reproduction, growth, and condition; and in finfish populations.

This study will compare the biological, chemical, and physical characteristics of the three systems. Stations will be occupied at 5% intervals from 25 to less than 0.5% in each river at slack before flood tide. Water samples will be collected at 2 m intervals from surface to bottom and the water column described by temperature, salinity, dissolved oxygen, pH, alkalinity, chlorophyll, suspended solids (loss on ignition and fixed residue), transparency, phosphorus (soluble reactive, soluble unreactive, particulate reactive, and particulate unreactive), and nitrogen (soluble organic, ammonia, nitrite, nitrate, and particulate organic). Primary productivity levels will be determined.

Nutrient levels and turn-over rates, phytoplankton standing crop and productivity, and the dependent and independent physical and chemical characteristics of the three systems will be compared. Data collected by the shellfish and finfish departments at the Institute will be utilized to complete the analyses.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Virginia Institute of Marine Science

2.1113, WMO EVAPORATION PAN DATA

R.A. TUCKER, U.S. Dept. of Commerce, Weather Bureau, *Sterling, Virginia* 22170

To collect data for comparison of the various evaporation measuring devices used in different countries and arrive at standards for comparison.

Temperature, dewpoint, radiation, and evaporation measurements are made daily. Test and Evaluation Laboratory is responsible for accuracy and partial processing of the data. These data and associated strip chart records are forwarded monthly to the Office of Hydrology.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.1114, FACTORS AFFECTING THE MOVEMENTS OF WATER AND ORGANISMS WITHIN A REGULATED MULTIPURPOSE LAKE

G.F. KRAFT, Western Washington State Coll. , Graduate School, *Bellingham, Washington* 98225

A four year backlog of limnological information on Lake Whatcom, Washington (5,000 acres; 750,000 acre-feet) has been collected and an intensive three year study is proposed. Recording meteorologic instruments are to be placed at lake level and used together with current, wave, and seiche measuring instrumentation to quantify the relationships between wind and water movement. Total heat, water, and geochemical budgets will be determined. The sources and fates of the several polluting agents (silt, enterococcus and coliform bacteria) will be determined. The pollutability of the lake will be measured, in terms of the survival times of the bacterial agents present under the conditions of water circulation and other limnological conditions which obtain. The project is designed as one which will give limnological base information necessary for the mainpulation of multipurpose water resources.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Western Washington State College

2.1115, VIBRIO PARAHAEMOLYTICUS IN THE ESTUARINE ENVIRONMENT

T.H. ERICKSEN, U.S. Dept. of Hlth. Ed. & Wel. , Pac. Nw. Marine Hlth. Sc. Lab. , *Gig Harbor, Washington* 98335

Recognized tests for the isolation and enumeration of V. parahaemolyticus have been adopted for the surveillance program on sea water and shellfish from Burley Lagoon, Washington. Studies will be continued on the incidence of V. parahaemolyticus in this area. Special emphasis will be placed on seasonal variation.

of the new 'Multipurpose Chemical Agent Detection Kit, E-56.' 091;edg;Edg

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

2.1116, SOIL AND WATER RELATIONSHIPS OF VEGETABLE CROPS

P.C. CRANDALL, Washington State University, Agricultural Experiment Sta. , *Pullman, Washington* 99163

1. To determine the water requirement of the principal vegetable crops in western Washington. 2. To evaluate methods for measuring temporary moisture stress in plants. 3. To increase the concentration of bloom and harvest of bush beans. 4. To determine the interrelationship of cultural practices and varieties as they relate to crop efficiency.

Water column supported lysimeters will be used to measure water requirements and correlate water use with evaporation from standard 4-foot evaporation pans. Mist applications will be evaluated on bush beans for blossom drop control and their effect on yields. Soil and leaf temperatures will be measured. Chemical sprays will be tested for their effect on blossom concentration. Refractometer measurements, diurnal volumetric fluctuations, and thermocouple psychrometers will be compared for their value in determining temporary moisture stress. The interrelationship of fertilizers, cultural practices, and varieties will be determined for vegetable crops common to western Washington.

SUPPORTED BY Washington State Government

2.1117, PHYSICAL CHARACTERISTICS OF BASALT AQUIFERS

J.W. CROSBY, Washington State University, School of Engineering, *Pullman, Washington* 99163

The proposed research is directed toward a detailed study of the basaltic aquifers in the Pullman, Washington area. By utilizing composite geophysical well logging methods, the investigators will evaluate the diminutive features which apparently play such an important role in basalt hydraulics. Utilizing combinations of gamma, spontaneous potential, single point resistivity, short normal resistivity, long normal resistivity, caliper, and neutron logs the following features will be examined in area wells: 1. Lateral continuity of water-bearing zones. 2. Lateral variations in porosity. 3. Bulk porosity of basalt sequences as opposed to horizonal porosities and individual layer porosities. 4. Lateral continuity of basalt flows and techniques for their correlation. 5. Possible relationships between radiation logs and specific capacities of wells. 6. Structural conditions in the basalts which may influence ground-water motion. 7. Relative importance of interflow zones, joints, weathered horizons, buried channels, faults, etc. in groundwater movement. 8. Vertical distribution of aquifers.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Washington State University

2.1118, ORCHARD MANAGEMENT

E.S. DEGMAN, Washington State University, Agricultural Experiment Sta. , *Pullman, Washington* 99163

1) To determine the value of controlling weeds around young trees. 2) To find the most profitable way of filler tree removal. 3) To find a suitable way for a grower to determine when to irrigate. 4) To study methods of pruning, especially pertaining to dwarf trees.

This project covers all the aspects of orchard management. Chemical control of weeds is no better than mechanical control around young trees, but it is less expensive and is more likely to be done correctly. Filler tree removal studies show that it pays a grower to cut his filler trees back and leave them in a little longer (4 years). Many growers irrigate by the calendar, a questionable practice. We are trying to tie evaporation into the program. We feel that mechanical pruning will be an orchard management practice of the future and are growing trees with that, specifically, in mind.

SUPPORTED BY Washington State Government

2.1119, PREDICTION OF WATER MOVEMENT IN UNSATURATED SOILS

W.H. GARDNER, Washington State University, Agricultural Experiment Sta. , *Pullman, Washington* 99163

Regional Obj. hysteresis and to define its role in the movement of water, solutes and energy in soil.

Regional Obj. 3. To delineate the influence of structural and electrostatic differences as well as solute concentration and energy gradients upon the movement of solutes, energy, and water soils.

Soil columns will be sealed in containers with soil initially at uniform water content. Temperature gradients will be established by means of heat and cold reservoirs placed at the column ends. Water content distribution will be followed as equilibrium is established and then the temperature gradient reversed. Hysteresis studies will be based on flow of water and the different equilibrium water content conditions reached on temperature reversal. Water content will be inferred from neutron attenuation measurements.

Soil columns will be set up so that they can shrink or swell in a single dimension at right angles to the direction of water flow. Water will be supplied at one and for study of wetting conditions or dried down from one end for study of drying conditions. Water content will be inferred from neutron attenuation measurements and bulk density changes from gamma ray attenuation measurements in association with the neutron water content measurements.

SUPPORTED BY U.S. Dept. of Agriculture
Washington State Government

2.1120, RUNOFF GENERATION AS A FUNCTION OF PRECIPITATION AND WATERSHED CHARACTERISTICS

J.S. GLADWELL, Washington State University, State Water Research Center, *Pullman, Washington* 99163

A study of the physical and climatological parameters of Western Washington watersheds is to be made in order to define quantitatively their effect on the transformation of effective precipitation into runoff. Through the use of these 'coefficients' it is planned to study the possibility of generating synthetic hydrographs in areas with no runoff gages, and extensions of current gage histories through the use of precipitation information. It is hoped also to explain variations in probability distribution between watersheds relatively close together.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Washington State University

2.1121, THE STORAGE COEFFICIENT AS A FUNCTION OF WATER TABLE CELERITY

D.T. HIGGINS, Washington State University, School of Engineering, *Pullman, Washington* 99163

The application of unsteady, unconfined groundwater flow equations based on the Dupuit assumptions and a constant coefficient of storage yields unsatisfactory results for thick aquifers at early time. Contemporary efforts to improve these equations appear to be concentrating on the inclusion of vertical flow effects in the equations. However, the correlation of field and laboratory data with the newer theory is still weak. The problem may lie in the oversimplified treatment of the storage coefficient.

The release of stored water as the water table drops is thought to be a time dependent gravity drainage phenomenon. Actually, the rate of release of stored water is a function of the water table celerity and reflects all the complexities of unsaturated flow.

It is proposed to first study in the laboratory the functional dependence of the storage release on the water table celerity. Then, using the experimental results as a guide, the extremely complex problem of unsaturated flow with a time dependent boundary condition may be simplified in order to derive a usable expression for the drainage celerity function.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Washington State University

2.1122, CLIMATIC PATTERNS IN WASHINGTON STATE

M.C. JENSEN, Washington State University, Agricultural Experiment Sta., *Pullman, Washington* 99163

Objectives: 1. Record and tabulate on coded machine cards weather data from selected locations in Washington important to agriculture, including forestry. 2. Analyze precipitation data for a network of stations to establish rainfall probabilities of occurrence for weekly and multi-weekly periods for areas in Washington. 3. Analyze evaporation data for a network of stations to establish frequency of occurrence of evaporation extremes.

Description of Work Proposed: Weather data for selected stations in Washington will be entered on machine analysis cards and precipitation and evaporation data will be statistically analyzed for frequency of occurrences to define climate for agricultural areas.

SUPPORTED BY U.S. Dept. of Agriculture
Washington State Government

2.1123, WHEN TO IRRIGATE

M.C. JENSEN, Washington State University, Agricultural Experiment Sta., *Pullman, Washington* 99163

When to irrigate seeks to establish the amount of water that can be used from the soil moisture reservoir between irrigations and obtain optimum production from selected irrigated crops. The crop to be studied in 1962 is potatoes. Five irrigation treatments based on irrigating each day and when 30%, 45%, 60%, and 75% of the available water has been removed from the effective root zone and two irrigation methods (sprinkling and furrow) will be included. Three replications in 40' x 40' random plots will be part of the experimental design.

Two crops will be studied each following year, procedure being modified according to the 1962 experience.

SUPPORTED BY Washington State Government

2.1124, NUTRIENT INPUT TO WASHINGTON SOILS FROM ATMOSPHERIC SOURCES.

C.D. MOODIE, Washington State University, Agricultural Experiment Sta., *Pullman, Washington* 99163

OBJECTIVES: 1. To determine the quantities of nutrients contributed to soil and crops in Washington by rainfall and irrigation waters. 2. To estimate the quantities of nutrients which may be absorbed directly in gaseous form from the atmosphere by plants and soils.

WORK PROPOSED: A precipitation network of 10 to 15 stations will be established to cover rainfall conditions around the state; one is established on each experiment station and adjacent to standard weather stations. Stream and well waters from areas where nutrient imput from irrigation waters appears to be critical will be sampled. The rainwater and irrigation samples will be analysed for Ca, Mg, Na, K, NH4-N, C1, SO4, HCO3, and NO3 routinely. Certain minor elements will be determined on selected samples.

A comprehensive review of published data on water quality will be undertaken if funds are available. Two objectives are sought: (1) an appraisal of the suitability of each water for irrigation purposes and (2) an estimate of its value as a source of nutrients.

Estimates of nutrients in gaseous form in the atmosphere are to be made: Detailed procedures for this phase remain to be worked out.

SUPPORTED BY Washington State Government

2.1125, THE EFFECTS OF IRRIGATION AND FERTILIZATION UPON A PONDEROSA PINE FOREST STAND

M.M. MOSHER, Washington State University, Agricultural Experiment Sta., *Pullman, Washington* 99163

OBJECTIVES: To determine the effects of irrigation and fertilization upon the vegetative and reproductive growth and upon wood quality and to determine what environmental changes may occur with increased water supply.

DESCRIPTION: A 60-year old pure stand of ponderosa pine located in Stevens County, northeastern Washington, will be fertilized with nitrogen, irrigated, and both fertilized and irrigated. The effect of these treatments upon diameter and volume growth, on seed production and on secondary vegetation will be compared to natural conditions by yearly measurements and observations.

SUPPORTED BY Washington State Government

2.1126, BROCCOLI CULTURAL INVESTIGATIONS IN WESTERN WASHINGTON

D.R. TOMPKINS, Washington State University, Agricultural Experiment Sta., *Pullman, Washington* 99163

Objectives: Determine the influence of broccoli plant spacing, supplemental irrigation, and direct seeding on broccoli production, and quality.

Description: Use adapted varieties and appropriate experimental designs to determine the influence of spacing, transplanting, direct- seeding, and irrigation on number of harvests needed, production and size of center heads and side shoots, and toughness of center head stems.

SUPPORTED BY Washington State Government

2.1127, PLANKTON-PERIPHYTON STUDIES IN THE COLUMBIA RIVER

C.E. CUSHING, Battelle Memorial Institute, *Richland, Washington* 99352

Autotrophic organisms assimilate inorganic nutrients directly from the water, thus occupying a basic position in aquatic foodwebs. In this context, they play an important role in the cycling of radioisotopes to higher trophic levels and, in the case of phytoplankton, in the dispersal of radioactivity. Current studies are in progress to further elucidate these functions.

Data on the transport of 32P and 65Zn by net plankton are currently being evaluated. Preliminary calculations reveal that as much as 1.8 Ci of 65Zn and 1.2 Ci of 32P per day are transported downstream from Hanford. Highest concentrations per unit weight are found during the winter months. This study is being expanded to include the role of the nannoplankton in the transport of radionuclides.

Periphyton, especially in smaller, rapidly flowing streams, comprises the main source of primary production in these habitats. Studies are in progress to evaluate the relationships between primary productivity, environmental parameters, and radionuclide uptake and cycling of this community. Data presently being analyzed reveal good correlations between dry weight, ash weight, and chlorophyll a content. Net Production Rate was closely related to chlorophyll a content and solar energy. Phosphorus-32 and 65Zn accumulation were best related to dry and ash weight and chlorophyll a, but poorly related to the river burden index of these isotopes. This anomaly is being investigated further under controlled conditions. Work is now being initiated to study the cycling of radionuclides and the effects of varying environmental parameters on this phenomenon using a specially designed algal growth chamber in conjunction with an in situ radiation detector.

SUPPORTED BY U.S. Atomic Energy Commission

2.1128, CASCADES ATMOSPHERIC WATER RESOURCES PROGRAM

C.L. SIMPSON, Battelle Memorial Institute, *Richland, Washington* 99352

This research is directed toward the design of engineering techniques for accomplishing both augmentation and redistribution of wintertime precipitation in and across the Cascade Mountains of Washington. The two major objectives of this laboratory are to accomplish research to 1) enhance the understanding and detailed knowledge of precipitation mechanisms relative to their frequency and contributions to the total water supply in the area of interest by a program of comprehensive data analysis; and 2) develop and provide plans and specifications for the conduct and evaluation of a field experiment to test the feasibility of accomplishing a trans-sky diversion of water across the Cascade Mountains of Washington.

SUPPORTED BY Washington State Government

2.1129, COLUMBIA RIVER CHINOOK SALMON

D.G. WATSON, Battelle Memorial Institute, *Richland, Washington* 99352

The section of the Columbia River within and immediately adjacent to the Hanford Reservation is the only remaining portion of the Columbia River in which chinook salmon spawn. Changes in the river environment, produced by the construction of hydroelectric dams, have destroyed other main stem salmon spawning habitats.

Population estimates of locally spawning salmon have been made since 1947 by aerial surveys of the spawning grounds. Results of these surveys are compared with these of previous years and with the escapement of salmon to the Columbia River in general, as determined by counts of adult salmon ascending downstream dams.

Comparison of the first (1947-1951) to the last (1960-1964) five year periods of this study shows an approximate threefold increase in the local population while the number of fish ascending Bonneville Dam was reduced by half. Part of this apparent success of the local race of fish is presumed to be due to the barrier effect from Priest Rapids dam, located just upstream from the Hanford Reservation. During the 12 years prior to the construction of this dam an average of 17% of the total number of salmon nests were observed in the area immediately downstream from this dam, since then a mean of 43% of the total were in this area. The mean annual number of salmon nests during 17 years is 600, with a range of 64 to 1485. There is no evidence that the Hanford Operation has affected the local salmon population.

SUPPORTED BY U.S. Atomic Energy Commission

2.1130, TRANSLOCATION OF RADIONUCLIDES BY FISH

D.G. WATSON, Battelle Memorial Institute, *Richland, Washington* 99352

The migration of resident species of Columbia River fish upstream from or into tributaries below the section of the river receiving radioactive effluents provides a route of dispersion of radionuclides in a natural ecosystem. The objects of this study are: 1) determine the season and extent of migration of the various fish species; 2) estimate the amounts and kinds of radioelements translocated by these populations; 3) provide estimates of size of some of the major fish populations.

Results to date show that seasonally as much as 80% of the fish collected upstream from reactor effluent outfalls, and in a stream tributary to the Columbia River downstream from Hanford, have been exposed to radioactive effluents.

Future work will employ an electric fish shocker, as well as nets, for the collection of fish. A portable radiation counter will be used to sub-sample the catch, and specimens not selected for tissue analysis will be marked by a thermal brand and released into the river. The marked individuals will provide the basis for population estimates and rate of movement when they are recaptured. It is anticipated that change in the ratios of the amounts of two biologically important radioisotopes, 65Zn and 32P, in the fish will also give information on rate of movement.

This project is coordinated with a study on the fish disease, C. columnaris, and may provide information on the role fish migration plays in the spreading of this disease.

SUPPORTED BY U.S. Atomic Energy Commission

2.1131, EFFECTS OF INDUSTRIAL EXPANSION ON THE AQUATIC ENVIRONMENT OF ESTUARINE AREAS

G.R. SNYDER, U.S. Dept. of Interior, Biological Laboratory, *Seattle, Washington* 98102

The Lower Columbia River and its estuary plays a critical role in the life cycle of anadromous salmonids. Each year millions of young fish move downstream from native rearing areas and artificial propagation facilities. These fish all pass through the lower river and estuary where they undergo physiological transformations in preparation for their movement from fresh to salt water. The estuary also is an important nursery area and the transition zone for marine species of fish.

Industrial expansion in this area by the thermal electric power, aluminum, and pulp and paper industries can drastically modify the environment. Forecasts indicate that over 2000 MW. of electricity (possibly 4000MW.) could be produced in the Columbia estuary by 1985. The effects of waste heat discharged from these plants could be detrimental to the overall aquatic ecology and specifically to the production of commercial species of fish. Limnological studies are planned to determine the existing ecology at sites known to have potential for industrial expansion. The effects of increases in water temperature on aquatic organisms at specific sites will be studied. Predictions of physical and biological changes will be made. The effects of the environmental changes on fish and on secondary organisms necessary for their survival and growth will receive initial emphasis.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

2.1132, A STUDY OF SERIAL CORRELATION IN ANNUAL STREAM RUNOFF

T.H. CAMPBELL, Univ. of Washington, School of Engineering, *Seattle, Washington* 98122

This research has two primary objectives: (1) To improve existing stochastic models of annual stream runoff by including the variability of the serial correlation coefficient, and to apply the resulting model to methods of studying the probabilities of periods of drought or of excessive runoff, and (2) To relate the serial correlation coefficient to physical watershed parameters.

Streams with sufficiently long historic records will be analyzed for variability of the serial correlation coefficient, which reflects the carryover effect from a relatively wet or dry year into the following year. Methods for determining this variability will be evaluated. Methods for studying periods of drought (or of water excess) will be developed.

Streams in a specific region will be studied to attempt to find a useful relation between the serial correlation coefficients and any gross physical characteristics of the drainage basins.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Washington

2.1133, FAUNAL AND TROPHIC STUDIES OF AN INTERTIDAL COMMUNITY

R.T. PAINE, Univ. of Washington, Graduate School, *Seattle, Washington* 98122

This is a continued study of the ecology of marine rocky intertidal communities. Since 1963, an intensive effort has been made to unite knowledge of the natural history, population bioenergetics, and inter- population interactions into a general scheme of community organization for Mukkaw Bay on the outer coast of Washington State. The current proposal seeks both to continue these studies locally and to extend them to analagous southern hemisphere communities in New Zealand. Similar techniques of individual marking and community manipulation (exclusion, addition, and transplantation) will be followed. The major goal of the work will be an investigation of the degree to which the causal processes (especially predation) known to be important in species distribution and abundance in one community can be generalized to other similar ones.

SUPPORTED BY U.S. National Science Foundation

2.1134, LOW-FLOW ANALYSIS, WASHINGTON STREAMS

F.T. HIDAKA, U.S. Dept. of Interior, Water Resources Division, *Tacoma, Washington*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Washington.

Purpose - To derive methods of using gaging station records for projection of low-flow characteristics to miscellaneous discharge measurement sites.

Methods - Gaging station records will be analyzed for low-flow frequency, flow duration, base flow, and duration hydrograph. Correlation techniques will be used to extend short-term records and miscellaneous discharge measurements to long-term experience. Parameters such as a variability index based on the flow duration curve or baseflow curve will be investigated.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Washington State Government

2.1135, GROUND-WATER HYDROLOGY AND DEVELOPMENT IN EAST-CENTRAL WASHINGTON

J.E. LUZIER, U.S. Dept. of Interior, Water Resources Division, *Tacoma, Washington*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Washington.

Purpose: To determine the hydrologic character of the regional ground-water reservoir and predict its probable response to development.

Method: An inventory of all large-capacity (deeper) wells and a representative group of low-capacity (shallower) wells will be obtained. An extensive network of observation wells will be established and data collected for two years to determine the response of ground-water levels to withdrawls. Intensive collection of data in selected areas will allow preparation of maps showing water level elevations and allow computation of an 'area' storage coefficient. The disposition of withdrawls will be studied to appraise return flow and consumptive use in a 'type' area.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Washington State Government

2.1136, GLACIOLOGICAL RESEARCH

M.F. MEIER, U.S. Dept. of Interior, Water Resources Division, *Tacoma, Washington*

Objectives of this project are to obtain significant index data on climate, mass budget, ice thickness change, and runoff for glacier basins; develop the ability to predict glacier net budgets from data on glacier variations; determine and explain the distinctive characteristics of glacier and snow melt-derived streamflow; derive a reasonable understanding of how specific, predictable meteorological phenomena determine snow accumulation and melt in glacier and high mountain environment; and regularly observe sufficient numbers of glaciers over a large geographic area to obtain statistically valid mass-mudget, variation, and advance/retreat information, and to detect unusual happenings such as sporadic advances and effects of major earthquakes.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.1137, HYDROLOGY AND GEOCHEMISTRY OF CLOSED BASIN LAKES

A.S. VANDENBURGH, U.S. Dept. of Interior, Water Resources Division, *Tacoma, Washington*

A study of the hydrologic and hydrochemical characteristics of a closed lake and its surrounding basin can furnish information on the mechanisms of salt migration and accumulation, the means of salt storage and the stability of the stored salt, and the manner in which a closed- lake system reacts to and records the changes in climate and the activities of man. Abert and Summer lakes with their respective tributary basins provide adjacent environments of hydrologically divergent character ideally suited to an investigation of the various aspects of salt economy. The hydrologic character of Abert Lake is highly sensitive to even slight climatic fluctuation, while at Summer Lake under natural conditions the seasonal and year-to-year uniformity of spring flow has masked all but the extremes of climatic change.

The objectives of this project are to evaluate quantitatively and qualitatively the incoming, outgoing, and stored solutes at the two lakes; to study the effect of climatic changes on the amount and character of solutes within the three realms; and to compare and relate present hydrochemical conditions to those estimated for the pluvial period when a single lake occupied both basins.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

2.1138, RUNOFF STUDIES ON SMALL WATERSHEDS

J.C. BURCHINAL, West Va. University, School of Engineering, *Morgantown, West Virginia* 26506

a. To evaluate the factors affecting the peak discharge of storm runoff. b. To evaluate the factors affecting the volume of storm surface runoff. c. To study the basic factors affecting the hydrograph of surface and ground water flow from soil-cover conditions.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
West Virginia University

2.1139, GEOCHEMICAL BEHAVIOR OF IRON AND MANGANESE IN A RESERVOIR (LAKE LYNN, WEST VIRGINIA) FED BY STREAMS CONTAINING ACID MINE DRAINAGE

R.G. CORBETT, West Va. University, Graduate School, *Morgantown, West Virginia* 26506

Total Program - We proposed to study the geochemical behavior of iron and manganese in a dynamic system involving the impoundment of waters polluted by acid mine drainage. The natural model chosen is Lake Lynn, West Virginia, which has formed behind a dam constructed in 1929. The quality of water and abundance of fauna in the reservoir have deteriorated according to available data. An understanding of the behavior of iron and manganese in this environment should benefit many workers in water resources. The phases of research are ordered such that the project may progress as long as results appear fruitful.

Phase I - Areal Variation in Iron and Manganese Content of Sediments of Lake Lynn. From 150-200 samples of sediment from lake Lynn will be collected and analysed mechanically for particle size and spectrochemically for iron content and manganese content. Any variations present will suggest the course of future phases. Concurrently, the literature will be reviewed for information pertinent to the entire study.

Subsequent researches may involve mineral species in the sediments chemical stratification and seasonal variation thereof of iron and manganese in the impounded water and pore water of the sediment, co- precipitation of other elements with iron and manganese, and a chemical budget involving influx, precipitation, and escape at the reservoir outlet of iron and manganese.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
West Virginia University

2.1140, INFLUENCE OF TOPOGRAPHIC FEATURES ON RAINFALL IN WEST VIRGINIA

W.H. DICKERSON, West Va. University, School of Agriculture, *Morgantown, West Virginia* 26506

Rainfall patterns over the State will be examined in the light of topographic influences (such as, for example, elevation, exposure, rise). Various parameters which are believed to be of importance in determining the rainfall patterns will be selected and a numerical value assigned to each. The parameters will be used in a computer program for deriving multiple regression equations and testing the significance of the terms. In this manner, the original parameters will be eliminated to those which prove to have significance in establishing rainfall patterns. The end result will be an equation or equations that will estimate the rainfall amounts or rates for any locality, based on topographic conditions at the site. Such estimates will provide the basis for the construction of improved isohyetal maps, the isolines of which are now poorly defined for rather extensive areas of the State as a result of the absence of long time observations on precipitation. These procedures can be expected to be of the most significance for determining rainfall conditions in the more mountainous and inaccessible areas which are largely occupied by forests.

2. WATER CYCLE

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
West Virginia University

2.1141, PRECIPITATION INTENSITY-FREQUENCY RELATIONSHIPS FOR WEST VIRGINIA

W.H. DICKERSON, West Va. University, School of Agriculture, *Morgantown, West Virginia* 26506

The work is concerned with the development of rainfall-frequency data for use in the design of small hydraulic structures. Hourly and daily rainfall occurrence will be analyzed by digital-computer programs designed to: (1) establish rainfall intensity-frequency relationships, (2) determine seasonal influences, (3) delineate geographical variations over the State, and (4) establish mathematical models for fitting the frequency relationships. This project will make use of data from intermountain stations within the State, extensive data for which are now available for the first time through the cooperation of the Weather Bureau ESSA, and the West Virginia Agricultural Experiment Station.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
West Virginia University

2.1142, AGRICULTURAL CLIMATOLOGY OF WEST VIRGINIA

W.H. DICKERSON, West Va. University, Agricultural Experiment Sta. , *Morgantown, West Virginia* 26506

1. To develop methods of analyses and utilization of climatological data of the Northeast, 2. to determine by phenological techniques the response of selected plant species to changes in climatic variables, and 3. to ascertain the influence of climatic variables on the growth and development of economically important plant species.

The work in West Virginia will be primarily concerned with statistical studies of the historical weather data, also with working toward the establishment of a network of agricultural weather stations and with efforts to develop new methods of estimating the climate of farms or orchards from data of nearby weather stations. Phenological studies using the Persian lilac will be established. Exploration of the interrelationships of such variables as insolation, temperature in soil, air, and plants, as well as studies of the dynamics of frosts will be undertaken.

SUPPORTED BY U.S. Dept. of Agriculture
West Virginia State Government

2.1143, LABORATORY AND FIELD STUDIES OF FROST HEAVING

C.F. ENGLE, West Va. University, Agricultural Experiment Sta. , *Morgantown, West Virginia* 26506

To relate the physical and mineralogical properties of soils to the extent and severity of heaving; study the relationship between fertility and management practices and the extent of heaving damage to alfalfa; study ice lens formation as affected by physical properties and moisture content of soils.

Measurements of freezing depth, moisture content in and below frozen soil and temperature will be taken in the field on two soils. The data will be related to theoretical equations found in the literature for predicing depth of frost penetration. The relationship between management and fertility practices to alfalfa heaving will be studied statistically. Management practices will consist of three cuttings of alfalfa by September 1 plus the following: no further harvest; harvest October 15; cut on October 15 and clippings left on as mulch. Fertility practices will consist of minimum maintenance surface fertilization in conjunction with deep fertilization with LPK in various combinations. Measurements will be taken on stand, rooting depth and habit, yield, and amount of heaving. Ice lens formation will be studied in a cold room. Major emphasis will be placed on the relationship between soil density and soil layer arrangement on the rate of water movement to the freezing zone and to critical soil moisture contents for maximum soil heaving.

SUPPORTED BY U.S. Dept. of Agriculture
West Virginia State Government

2.1144, MILWAUKEE RIVER WATERSHED LAKE VEGETATION SURVEY

S.J. KLEINERT, State Dept. of Nat. Resources, *Madison, Wisconsin* 53701

An aquatic plant survey was conducted between June 10 and August 30 on the lakes within the Milwaukee River watershed. This was both a quantitative and qualitative study of the present plant communities. Attention was given to the distribution patterns, abundance, and the effect man's activity may play in altering these communities. This survey was also intended to establish a record for future studies. The objectives were determined from data obtained by random sampling of the plant communities within each lake. With the aid of aerial photographs and contour maps the vegetation areas were located and recorded. Twenty-three alkes and several Milwaukee River backwater areas were surveyed. Nine of the lakes were resurveyed, at the end of August, to determine changes in dominance and abundance.

SUPPORTED BY Wisconsin State Government

2.1145, AN ANALYSIS OF WETLANDS VALUES

S.J. KLEINERT, State Dept. of Nat. Resources, *Madison, Wisconsin* 53701

To review and summarize existing information on wetlands and to evaluate their present and potential importance to man from a broad ecological standpoint. As one facet of the evaluation, a determination will be made of wetlands value in terms of dollars and other quantitative units. Intrinsic values of wetlands, such as scenic beauty and scientific utility will be reviewed, as will the work they may perform such as storing water and contributing to ground water recharge. Hazards to occupancy and development also will be reviewed in terms of replacement value, that is, cost of duplicating the facilities of the developed wetland at a future time.

SUPPORTED BY Wisconsin State Government

2.1146, WATER RESOURCES OF CENTRAL WISCONSIN, A WATER-POOR AREA

E.A. BELL, U.S. Dept. of Interior, Water Resources Division, *Madison, Wisconsin*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Wisconsin.

Purpose: To determine the distribution and character of glacial deposits in buried bedrock valleys in the area and make a preliminary appraisal of the potential of artificial recharge to increase water availability in heavily pumped areas.

Methods: Available test drilling results and well log will be assembled and used to plan refraction, seismic, and test drilling programs to delineate buried bedrock valleys which contain saturated sand and gravel deposits. Water samples will be analyzed. Observation wells will be installed to determine water-level variations in areas presently unaffected by pumping. Aquifer tests may be performed using municipal wells tapping the sand and gravel aquifer.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Wisconsin State Government

2.1147, LOW-FLOW STUDY - WISCONSIN

W.A. GEBERT, U.S. Dept. of Interior, Water Resources Division, *Madison, Wisconsin*

This research is part of the program of water resources investigations conducted by the U.S. Geological Survey in cooperation with the State of Wisconsin.

Purpose: To analyze stream flow data and determine low-flow characteristics of streams in Wisconsin which will provide a basis for consideration of diversion requests.

Methods: Daily discharge records for gaging stations on unregulated streams have been processed by Datatron and the flow data are now in a readily usable form. A network of about 300 low-flow, partial-record sites has been established on small streams. Baseflow measurements will be made in each of the five sub-areas of the State for areal studies of base flow.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Wisconsin State Government

2.1148, HYDROLOGIC EFFECTS OF SMALL RESERVOIR ON NEDERLO CREEK, WISCONSIN

J.H. GREEN, U.S. Dept. of Interior, Water Resources Division, *Madison, Wisconsin*

Purpose - To provide hydrologic data necessary to answer questions regarding the effect of small reservoirs on streams in southwestern Wisconsin.

Methods - Ground-water divides and overland runoff divides will be located for the hydrologic basin that contributes water to Nederlo Creek. The hydrologic system will be defined by collecting data on precipitation, temperature, soil moisture, ground-water levels, aquifer characteristics, spring flow, streamflow and stage, water quality and temperature, reservoir stage and suspended sediment. Seepage runs on the stream, altitude surveys, and ground-water flow network studies will be made. All phases of the hydrologic cycle except evapotranspiration will be measured. Evapotranspiration in the basin will be estimated.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Wisconsin State Government

2.1149, WATER RESOURCES OF THE LOWER WISCONSIN RIVER VALLEY, WISCONSIN

L.J. HAMILTON, U.S. Dept. of Interior, Water Resources Division, *Madison, Wisconsin*

Purpose: To provide guidelines for long-range planning of the water-resources development of the lower Wisconsin River valley.

Methods: The quantity, quality, and availability of water in the valley will be determined to define the hydrologic system. The operation of the system under present conditions, the changes that will occur in the system as the water resources are developed, and the limitations of future water-supply development will be described.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Wisconsin State Government

2.1150, HYDROLOGY OF A WETLAND AREA IN THE YELLOW RIVER BASIN, WISCONSIN

L.J. HAMILTON, U.S. Dept. of Interior, Water Resources Division, *Madison, Wisconsin*

Purpose - To provide detailed information on the hydrology of a wetland area, availability of water for development, and effects of development on the hydrologic system.

Methods - The available data on climate, soils, geology, streamflow, ground water, and water quality will be collected and analyzed. Field investigations will be conducted to determine the recharge, movement, discharge, water quality, and hydraulic properties of the aquifers. Inflow, outflow, storage and quality of water in the bogs will be determined.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Wisconsin State Government

2.1151, WATER REOURCES OF SOUTHEASTERN WISCONSIN - RACINE AND KENOSHA COUNTIES

R.D. HUTCHINSON, U.S. Dept. of Interior, Water Resources Division, *Madison, Wisconsin*

This research is part of the program of water resources investigation conducted by the U. S. Geological Survey in cooperation with the State of Wisconsin.

Purpose - To determine the quantity and quality of the ground water resources available for the expanding population and increasing industrialization in southeastern Wisconsin.

Methods - Daily and periodic water-level measurements will be made to supplement current records and gages to record pumpage will be installed on selected wells. Hydrographs of wells will be used to determine the effects of recharge and discharge. Areas of recharge and discharge and the direction of ground-water movement will be determined. Quality of water data will be correlated with geologic information to map the geographic and stratigraphic distribution of chemical constituents that occur in critical quantities.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Wisconsin State Government

2.1152, WATER RESOURCES OF SOUTHEASTERN WISCONSIN - MILWAUKEE RIVER BASIN

R.D. HUTCHINSON, U.S. Dept. of Interior, Water Resources Division, *Madison, Wisconsin*

Purpose: To determine the quantity and quality of water available for use in the Milwaukee River basin in southeastern Wisconsin and determine man's effect on this supply.

Methods: Available information on streamflow, lake stages, ground- water levels, pumpage, climate, water use, geology, and quality of water will be compiled and additional data will be collected to determine the quantity and quality of water available for man's use. Seepage measurements will be made and a ground-water flow map prepared to determine the interrelationship of ground to surface water. Man's effect on the water supply will be determined by relating water use to the piezometric surface, water quality, and surface-and ground-water conditions and by projecting anticipated water use to a definite future date and illustrating effects of alternate water-use possibilities.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Wisconsin State Government

2.1153, PLANT-AVAILABLE PHOSPHORUS STATUS OF LAKES

D.E. ARMSTRONG, Univ. of Wisconsin, School of Engineering, *Madison, Wisconsin*

The proposed research plan involves evaluation of the role of phosphorus in eutrophication through an understanding of the factors controlling the amount of phosphorus available to algae and higher plants in lake waters. The approach will be as follows: 1. Standardize methods for the fractionation and quantitative determination of the major forms of phosphorus in lakes, including soluble inorganic, soluble organic, microbial algal and higher plant and sediment phosphorus. Forms of organic phosphorus and the total organic and inorganic phosphorus in the seston and sediments will also be investigated. 2. Determination of the relative rates of fixation of plant-available phosphorus in lake waters by microorganisms, sediments and higher plants as affected by environmental conditions, employing 32P-labeled phosphorus compounds. 3. Establish relationships between the forms and amounts of fixed phosphorus in lakes and the actual and potential amounts of phosphorus available for aquatic plant uptake.

Experiments will involve simulated lake environments in the laboratory and analyses of samples taken from lakes at different stages of eutrophication.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Wisconsin

2.1154, SIMULTANEOUS RADIATION, CONVECTION AND CONDUCTION IN A TRANSPIRATION PROCESS

W.A. BECKMAN, Univ. of Wisconsin, School of Engineering, *Madison, Wisconsin*

Recent investigations concerning a fluid flowing normal to a porous bed with energy transfer by simultaneous radiation, convection and conduction have neglected the temperature difference between the fluid and the bed. For a large range of the independent parameters which describe transpiration systems, this assumption can lead to significant errors. It is proposed to analytically determine the temperature distributions in both the fluid and bed. From this information, engineering design data such as the maximum fluid and bed temperatures, the net radiant flux leaving the porous bed and the cooling (or heating) effectiveness will be obtained.

SUPPORTED BY U.S. National Science Foundation

2.1155, SIMULATION MODEL FOR THE STUDY OF THE HYDROLOGY OF THE WISCONSIN RIVER

I.K. FOX, Univ. of Wisconsin, Water Resources Center, *Madison, Wisconsin*

The objective of this study is to develope a simulation model dealing with the hydrology of the Wisconsin River system. The model is to be designed to estimate by the use of an electronic computer the stream flow characteristics at any desired location in the basin under different hydrologic conditions and alternative reservoir operation practices. This model is to have three main characteristics, namely (1) the capability for providing a natural simulated hydrology for the main stem and major tributaries, (2) the capability of simulating the operation of the present reservoir system and proposed additional reservoirs, (3) the capability of estimating flow characteristics for desired time scales such as a day or a month, (4) the capability of assimilating specific B.O.D. loadings at various points in the Wisconsin River system.

By the use of hydrologic data for the Wisconsin River Basin a model is to be devised to simulate stream flows and reservoir functions.

SUPPORTED BY Wisconsin State Government

2.1156, THE RELATION OF ENVIRONMENT CONDITIONS TO THE WATER POTENTIAL OF PLANT LEAVES

W.R. GARDNER, Univ. of Wisconsin, Agricultural Experiment Sta., *Madison, Wisconsin*

Water is an important factor in the plant environment. An adequate description of the relation of plants to their environment must take into account the dynamics of water transport, through the plant, from the soil to the atmosphere.

The objective of this project is to obtain a better understanding of this transport process in order to develop a quantitative description which will satisfactorily relate the water potential of plant leaves to the soil water potential and to appropriate atmospheric variables.

The procedure will be to conduct experiments on suitable plants both in controlled environments such as growth chambers, and in the field. The water potential in the soil profile, and in the plant will be monitered. Atmospheric factors will be controlled or measured.

SUPPORTED BY U.S. Dept. of Agriculture
Wisconsin State Government

2.1157, WATERSHED WATER BUDGET

W.R. GARDNER, Univ. of Wisconsin, Agricultural Experiment Sta., *Madison, Wisconsin*

The relation between the rainfall on a watershed and the runoff from it is a fundamental problem in hydrology. The present practice of treating interrelationship between the various components of the water budget empirically is a barrier to further progress in solving this problem. It is the objective of this project to develop relations between the surface and subsurface components based upon the processes involved.

The procedure will be to instrument a small agricultural watershed so that the rainfall, runoff, evapotranspiration, soil water content, and deep percolation can be monitored continuously. The field data will be supplemented by model studies of idealized watersheds and mathematical solutions of relevant water transport problems. Present mathematical theories will be tested and improved where possible.

SUPPORTED BY Wisconsin State Government

2.1158, EFFECT OF METABOLIC ANTITRANSPIRANTS ON INTERNAL WATER BALANCE, GROWTH AND SURVIVAL OF OUTPLANTED TREES

T.L. KOZLOWSKI, Univ. of Wisconsin, Agricultural Experiment Sta., *Madison, Wisconsin*

(1) To characterize the degree of water stress developed in outplanted trees, (2) to determine effects of metabolic antitranspirants on internal water balance, stomatal closure, and root permeability of tree seedlings, (3) to determine effects of metabolic antitranspirants on growth and survival of outplanted nursery stock.

DESCRIPTION OF WORK PROPOSED: Water stress will be determined as leaf water potential or relative turgidity and as leaf and stem shrinkage in both gymnosperm and angiosperm seedlings. After treatment with metabolic antitranspirants water absorption will be determined with potometers. Transpiration will be determined microscopically on silicone rubber leaf impressions. Effects on root permeabiligy will be determined as amount of water moved through roots per unit time under constant suction before and after treatment. Growth and survival of treated, outplanted trees will be studied in nursery and field plots.

SUPPORTED BY U.S. Dept. of Agriculture

2.1159, UNSTEADY FLOW OF GROUNDWATER-- DISPERSION AND SALT WATER INTRUSION IN NON-HOMOGENEOUS MEDIA

P.L. MONKMEYER, Univ. of Wisconsin, School of Engineering, *Madison, Wisconsin*

In the study of dispersion in non-homogeneous porous media, a general solution for the distribution of a contaminant in one dimensional flow through a layered or continuously graded media has been obtained. For two and three layer systems, the solution has compared very well with experimental data. The solution can be adapted to non-uniform flows. Currently, additional experiments are being carried out to verify the theoretical model.

Subsequently, the work will be extended to salt water intrusion in non-homogeneous, coastal aquifers. This investigation will involve analytical and experimental models of the instantaneous and quasi steady salinity and velocity distributions in confined, layered aquifers. The influences of disperson and pumping and recharging wells will be considered.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Wisconsin

2.1160, SOIL EROSION PROBLEMS IN WISCONSIN

A.E. PETERSON, Univ. of Wisconsin, Agricultural Experiment Sta., *Madison, Wisconsin*

Objectives: To develop and determine effectiveness of various methods of controlling water runoff and soil erosion on relatively large fields with moderate slopes. Forage crop and pasture studies and their effect on soil and water yield from watersheds.

Description of Work: New tillage practices in combination with herbicides and fertilizers have changed crop production practices drastically. Studies will be initiated and expanded to include:

1. Minimum soil tillage methods combined with herbicides in growing, rotational or continuous corn. 2. Development of more effective methods of pasture improvement including both mechanical and chemical renovation, each alone and in combination. 3. Maintenance of legume stands and yields as affected by different cropping, fertility and tillage systems. 4. Use of new field test equipment, particularly the 'infiltrometer', to appraise effects of soil and crop practices by applying water in simulated rainfall. 5. Surface evaporation and rates of water use by crops.

SUPPORTED BY Wisconsin State Government

2.1161, INVESTIGATION OF THE CIRCULATION OF LAKE SUPERIOR

R.A. RAGOTZKIE, Univ. of Wisconsin, Graduate School, *Madison, Wisconsin*

The overall goal is to describe and explain the general circulation of Lake Superior throughout the year. Studies have revealed that there are persistent cold cells in Superior, at least until early August, and a narrow and relatively fast surface current flowing northeast along the Keweenaw Peninsula.

Gradient currents calculated from temperature cross-sections in the nearshore region north of the Keweenaw Peninsula indicate currents velocities excess of 1 knot flowing in a northeastward direction. Current measurements from buoys confirm these calculated currents. This boundary current flows from mid-June until at least early September.

Theorectical studies have shown that for a stratified fluid in an enclosed basin the size of Lake Superior, the natural free mode of circulation includes high velocity boundary currents in a cyclonic direction. These may also occur in Lakes Huron and Ontario.

Circulation studies in a rotating laboratory model of Lake Superior also suggest this circulation in the epilimnion. Further analysis of field observations and laboratory experiments is continuing. Additional airborne infrared temperature mapping and in situ current measurements are planned.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Wisconsin

2.1162, ECOLOGY OF CLOSTRIDIUM BOTULINUM TYPE E IN GREEN BAY

H. SUGIYAMA, Univ. of Wisconsin, Graduate School, *Madison, Wisconsin*

The presence of Clostridium botulinum type E in and on the fish of the Great Lakes constitutes a botulism hazard. The organism is particularly prevalent in Green Bay, not only in fish but also in environmental samples. The very low incidence of type E in the soil away from the aquatic environment suggests that passive accumulation of the organisms being carried down from the surrounding land mass is not the only explanation for this distribution. Attempts will be made to show the multiplication of type E in the bay itself. Other sources of the organism which contribute to the maintenance of the type E population in Green Bay will be studied. Effects of other microflora in limiting the growth of type E will be investigated. Contributions of industrial wastes and treated sewage to the growth of type E will be sought. Factors which prevent the multiplication of the botulinal organism in the living fish will be studied. Improvements in the procedures for the detection and isolation of type E from natural samples will be attempted. The relationship between C. botulinum type E and nontoxigenic 'E-likes' will be studied.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

2.1163, ESTIMATE OF ACTUAL DAILY EVAPOTRANSPIRATION AS A FUNCTION OF SOIL WATERFLOW, PLANT CANOPY AND POTENTIAL EVAPOTRANSPIRATION

C.B. TANNER, Univ. of Wisconsin, School of Agriculture, *Madison, Wisconsin*

A thorough effort to combine knowledge of atmospheric stress, plant characteristics, and soil influence on adsorbed water into a rational estimate of evapotranspiration.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

2.1164, EVAPORATION MECHANISMS

C.B. TANNER, Univ. of Wisconsin, Agricultural Experiment Sta. , *Madison, Wisconsin*

Objectives: 1. Determine the evaporation mechanism and cause of diurnal evaporation variation at bare soil surfaces when evaporation is limited primarily by capillary flow to the surface.

2. Determine the vapor diffusion resistances at plant leaves and in plant canopies and how they depend upon the leaf properties, canopy structure characteristics, and the major microenvironment properties.

Description: We will measure the vapor diffusion resistances at the soil surface-atmosphere boundary and determine how this is affected by thermal stratification, pressure fluctuations of the turbulent atmosphere and by heat supply. We will follow a similar approach with leaves, but must also be concerned with stomata distribution, leaf roughness.

SUPPORTED BY U.S. Dept. of Agriculture
Wisconsin State Government

2.1165, THE EFFECT OF HETEROGENEITIES OF THE SOIL UPON INFILTRATION

G.W. THURTELL, Univ. of Wisconsin, Agricultural Experiment Sta. , *Madison, Wisconsin*

Objectives: To develop a new model to describe infiltration as effected by soil heterogeneities, by using recent advances in continuum mechanics of mixtures, and to test the model with data from the literature and from laboratory and field experiments as needed.

Description: Current theories and models which describe infiltration into either hemogeneous or layered soil, fail when applied to a soil which contains heterogeneities such as cracks, aggregates, worm holes, roots, pockets of clay.

We propose to apply to the infiltration model recent developments in continuum mechanics of mixtures used in petroleum engineering to describe the flow of petroleum in cracked rocks.

SUPPORTED BY U.S. Dept. of Agriculture
Wisconsin State Government

2.1166, APPLICATION OF MAGNETOHYDRODYNAMICS TO MEASUREMENT OF LIQUID VELOCITY AND TURBULENCE

J.R. VILLEMONTE, Univ. of Wisconsin, School of Engineering, *Madison, Wisconsin*

This project deals with studies to determine the feasibility of applying the basic principles of magnethodrodynamics to the measurement of turbulence in liquid flow, the measurement of time-smoothed liquid flow velocities, and the measurement of eddy diffusion. A three element, two-dimensional probe is being developed which will permit the observation of two components of the velocity fluctuations simultaneously and analyze them with analog techniques in such a way that three Reynolds' stresses can be calculated. These stresses will be used to check the validity of the Reynolds, equations for turbulent motion for flow in circular closed ducts, assuming that the turbulance is isotropic normal to the flow direction.

A special drogue is being developed to yield a magnetohydrodynamic signal which will be used to measure the time-smoothed local velocity. This device will be used as a current meter and also as a velocity meter in lakes and oceans as well as in large pipes.

A one-dimensional probe will be developed for the measurement of turbulent mass transfer. It will be used with the two-dimensional probe to study the spreading of buoyant jets discharged into stratified fluids (e.g. jet diffusers in sewage outfalls) and also the mixing between horizontally moving stratified layers, such as density currents in lakes, rivers, and estuaries.

As a result of the objectives of this program, it is hoped that a more detailed understanding of the mechanism of turbulence and its analysis will lead to useful solutions of a wider variety of problems involving turbulent motion in many areas of water resources engineering.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Wisconsin

2.1167, RELATION OF SILVICULTURAL CUTTINGS TO SOILS

S.A. WILDE, Univ. of Wisconsin, Agricultural Experiment Sta. , *Madison, Wisconsin*

Partial cuttings remove the unwanted members of the stand, stimulate the diameter growth of trees and permit production of merchantable timber in a shorter period. However, partial cuttings conducted without regard to site and soil conditions, may cause invasion of weeds, depletion of soil water, a loss of nutrients through leaching or biological fixation, compaction of soil surface, soil waterlogging, increased run-off, and a rise of water table. This study records the growth of trees and changes of environmental factors resulting from partial cuttings of different intensities. Investigated stands of jack, red and white pine, black spruce and hemlock--yellow birch, are located in 5 counties of northern, central and southern Wisconsin.

SUPPORTED BY Wisconsin State Government

2.1168, PARTIAL CUTTINGS OF FOREST PLANTATIONS, INCLUDING EFFECT OF GROUND VEGETATION ON SUPPLY OF SOIL MOISTURE

S.A. WILDE, Univ. of Wisconsin, School of Agriculture, *Madison, Wisconsin*

Plots have been established on soil supporting a 30 year red pine plantation with a heavy cover of ground vegetation. Additional plots established on open areas with same soil type and similar ground vegetation. Ground cover and litter was removed by hoeing on one of the duplicate plots - the other left underlied.

The test areas will be thinned and measurements made of the available moisture supply. Effects of competing weeds on water supply to be determined. Project started 1965 - Completion 1968.

SUPPORTED BY Wisconsin State Government
University of Wisconsin

2.1169, SEDIMENTARY FACIES IN LAKE BUTTE DES MORTS, WISCONSIN

J.W. MCKEE, Wisc. State University, Graduate School, *Oshkosh, Wisconsin* 54902

Lake Butte des Morts is a shallow, highly eutrophic lake which is undergoing rapid changes--some natural, some caused by man. Because of the importance of this and adjoining lakes to the large number of people who live nearby, management programs are desirable. But many of these should not be attempted until a greater understanding of physical processes in this lake is attained.

Toward this end a series of studies is being planned. This study (the first of the series) will result in a description of the present distribution of sediment types in Lake Butte des Morts. Samples will be taken from short cores, then subjected to standard laboratory procedures for determination of composition and of grain size mineral sediments. Isopleth maps will be constructed to show: 1. Proporation of organic matter or of mineral matter. 2. Mean grain size of sands. 3. Sorting.

A bathymetric chart will be constructed for comparison with previous data in order that the filling rate may be estimated.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Wisconsin State University

2.1170, MICROCLIMATIC FACTORS FOR FOUR PLANT COMMUNITIES ON ELK MOUNTAIN

T.L. LOUDON, Univ. of Wyoming, Agricultural Experiment Sta. , *Laramie, Wyoming* 82071

Objectives: To study the effect of sagebrush control on (1) moisture retention and depletion in the soil, (2) the total energy balance over the plant canopy, and (3) stands and production of native forage and weedy species, and to describe and map various plant communities at four different elevations on the Northwest exposure of Elk Mountain and to relate them to certain hydrologic parameters within these plant communities.

Description of work: Periodic measurements of soil moisture will be taken with a neutron probe at 3 locations in each of 5 replicated plots in unsprayed and sprayed sagebrush. Periodic data on solar radiation, net radiation, reflected short wave radiation and soil heat flow will be measured and a vertical energy balance will be made. The major plant communities at four elevations on Elk Mountain will be determined and mapped and correlated with measured precipitation, air and soil temperature, wind velocity, soil moisture and snow accumulation at the four sites at different elevations.

SUPPORTED BY Wyoming State Government

2.1171, MINERAL NUTRITION AND PLANT GENETIC VARIABILITY

M. SARIC, Fed. Inst. For Int. Tec. Coop. , *Belgrade, Yugoslavia*

Object: To study the effect of mineral nutrition and the genetic variation of plant species on transpiration and the forms of water found in plants and the relation of mineral nutrition and water levels to plant growth.

Plan of work: Transpiration, water-forms in the plant, and plant growth will be evaluated under controlled conditions and different moisture and plant nutrient levels on a number of genotypes of wheat. Transpiration will be measured by direct loss of weight procedures and reported as water loss per unit of leaf area. Free and bound water will be measured by placing leaves in a sugar solution and determining the concentration of the sugar in the solutions with a refractometer before and after immersion of the leaves. Dry matter gain on a weight basis will be used as an index of growth. Chemical composition of plants and soil will be made using standard analytical methods. Histological studies to determine the number and size of leaf stomata will be made.

SUPPORTED BY U.S. Dept. of Agriculture

3. WATER SUPPLY AUGMENTATION AND CONSERVATION

Saline Water Conversion; Water Yield Improvement; Use of Water ofImpaired Quality; Conservation in Domestic Use; Conservation inIndustry; Conservation in Agriculture.

3.0001, SOYBEAN YIELD AND QUALITY AS AFFECTED BY CLIMATIC, CULTURAL AND SOIL FACTORS

D.I. THURLOW, Auburn University, Agricultural Experiment Sta. , *Auburn, Alabama* 36830

Objectives: (1) To determine effects of environmental conditions (Soil moisture stress, temperature, daylength) and weed competition on soybean yield and quality, and to relate these effects to long term climatic data by regions in Alabama in predicting crop performance. (2) To determine influence of cultural factors on soybeans, including plant population and irrigation for double cropping and full-season plantings, and use of selected growth regulators. (3) To determine influence of certain soil factors on soybeans, including fertility levels, placement of fertilizers and lime in subsoils in mulch planting, and traffic pan disruption; and to obtain soil productivity indices.

Description of Work: Investigate moisture stress at different stages of growth and microclimate in growth chambers and relate long- term climate records to crop peroormance by regions of the State. Field studies on weed competition for moisture, growth regulators and plant populations in double cropping and full-season plantings. Investigate feasibility of irrigation for double cropping of soyheans with other crops. Calibrate soil tests by crop response on wide range of fertility levels. Vary placement of fertilizer and lime in subsoils for mulch planting, and study effects of traffic pan disruption. Conduct maximum yield tests for productivity indices.

SUPPORTED BY U.S. Dept. of Agriculture
Alabama State Government

3.0002, DEVELOPMENT OF ADVANCED TRANSPORT DEPLETION PROCESSES

E.W. LANG, Southern Research Institute, *Birmingham, Alabama*

The most recent tasks of this contract are for the purpose of comparing the performance of transport depletion with electrodialysis on natural brackish waters through operation of the second-generation bench-scale demineralizer and a commercial electrodialysis small pilot plant unit. The best ion selective membranes will be selected to use in this evaluation. The three phases of work in the contract are: operation of the HV-B stack; operation of the small pilot plant unit on natural brackish waters, and analysis of the results.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0003, DEMINERALIZATION BY FORCED-FLOW ELECTRO-DESALINATION

E.W. LANG, Southern Research Institute, *Birmingham, Alabama*

We will continue the development of the forced-flow electromembrane process in which solution is demineralized in very thin compartments (5 to 20 mils) formed by cation- and anion-selective membranes. Bench- scale units that utilize multimembrane stacks with compartment dimensions of 5 x 12 inches and about 18 x 20 inches will be used in developing the process to the point it will be ready for evaluation on a pilot-plant scale. The major effort will be on development of designs for forced-flow compartments and stacks that will permit realization of the economic advantages provided by the high limiting current density of the process.

Studies will be made of the effects of design and operating variables on demineralization performance. We expect to develop empirical expressions by statistical analysis of the results that will permit prediction of the performances of forced-flow demineralizers when operated under a wide range of conditions.

We will develop and evaluate promising design concepts and select the designs and levels of operating parameters that give lowest fixed and operating costs. Demineralization runs will be made with a number of different synthetic brackish waters and a wide range of operating conditions to more fully evaluate designs and performance.

Economic analyses of the process will be made as experimental data becomes available, and preliminary cost estimates for a full-scale plant will be prepared. Plans will be presented for a pilot-plant evaluation program.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0004, INVESTIGATION OF WATER SUPPLY PROBLEMS IN ARCTIC AND SUB-ARCTIC AREAS

J.B. COHEN, U.S. Dept. of Hlth. Ed. & Wel. , P.H.S. Artic Health Res. Lab. , *College, Alaska* 99701

This project is designed to identify and solve problems of water supply and storage in Arctic and sub-Arctic communities. The project includes studies of storage distribution and treatment of surface and groundwaters. Current treatment approaches are considering the utilization of hydrocyclones to remove iron from water supplies. (This project was started in 1954, and is continuing.) Studies of the design and operation of water storage tanks are also in progress.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

3.0005, SPREADING TREATED SEWAGE FOR GROUND-WATER RECHARGE

H. SHIPLEY, Phoenix City Government, *Phoenix, Arizona* 85003

This project is to determine the feasibility of groundwater recharge by spreading treated sewage as part of future programs for waster water utilization, and to collect information for optimum design, management, and operation of spreading basins. A pilot project will be installed in the Salt River bed West of Phoenix. Effluent from a new activated-sludge plant will be pumped to the site and inflow and outflow for each test area will be recorded and observation wells will be installed. Studies will include loading rates, quality aspects in the percolation zone, etc.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Phoenix City Government - Arizona

3.0006, PRINCIPLES, FACILITIES, AND SYSTEMS FOR WATER HARVEST

L.E. MYERS, U.S. Dept. of Agriculture, *Phoenix, Arizona*

Objective: Develop and evaluate principles, methods, materials, and design criteria for collecting and storing precipitation for agricultural and rural water supplies.

Plan of Work: Develop mathematical and physical models, including rainfall simulation, to determine the influence of catchment size, shape, roughness, permeability and location on precipitation runoff. Test laboratory developments, new construction materials, and catchment and storage designs with field installations with cost methods and materials.

SUPPORTED BY U.S. Dept. of Agriculture

3.0007, GROUND WATER IN RELATION TO USE AND MANAGEMENT OF RANGELAND WATERSHEDS IN THE SOUTHWEST

R.B. HICKOK, U.S. Dept. of Agriculture, *Tucson, Arizona*

Objective: Develop methods for predicting ground water recharge from runoff transmission losses, for reducing non-beneficial comsumption of such water detained in valley alluviums, and for evaluating potentials for local water supplies from runoff transmission losses geologically excluded from a regional aquifer.

Plan of Work: Maintain observations of ground water levels in and adjacent to experimental watersheds as related to storm flows and evaporation from dry channel surfaces and transportation of riparian vegetation, determine hydraulic character of aquifers and estimate ground water storage changes and subsurface flows affecting the total water budget.

SUPPORTED BY U.S. Dept. of Agriculture

3.0008, VEGETATION MANIPULATION EFFECTS ON RUNOFF - SYCAMORE CREEK, ARIZ

H.W. HJALMARSON, U.S. Dept. of Interior, Water Resources Division, *Tucson, Arizona*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with State and local agencies in Arizona.

Purpose - To evaluate the effects of watershed treatment upon water-yield and sediment-yield characteristics of the East Fork Sycamore Creek watershed.

Methods - Runoff from the East Fork Sycamore Creek watershed where it is proposed to eradicate some of the vegetation will be determined and compared with the runoff from two adjacent watersheds of approximately equal size which will not be treated.

A rain gage network of about 10 recording and 6 nonrecording gages will be established along the rims of the watersheds and at various altitudes within each watershed.

Data from the watersheds will be collected before and after treatment of the East Fork Sycamore Creek to allow computation of total sediment loads and also to determine the particle-size distribution of the fluvial sediment.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Arizona State Government

3.0009, HYDROLOGIC EFFECT OF VEGETATION MODIFICATION

R.M. MYRICK, U.S. Dept. of Interior, Water Resources Division, *Tucson, Arizona*

The intense and increasing demand for water in the Salt River basin indicates the need for developing all possible sources. Substitution of short rooted grasses for deep rooted trees has been proposed as a method of increasing water yield.

The purpose is to evaluate the change in water yield produced by the proposed vegetation modification and to develop a more comprehensive understanding of the function of vegetation within the hydrologic regime under semiarid conditions.

Data are collected on two adjacent basins in Arizona; one basin will be cleared after a satisfactory calibration for the digital computer model has been obtained. The second basin will remain unaltered and used to improve the model and test the accuracy of the hydrologic equation that has been established. If further investigations are warranted the second basin will be cleared at a later date.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

3.0010, GENETIC AND CYTOGENIC STUDIES OF HORTICULTURAL CROPS-BREEDING XEROPHYTIC CUCURBITA

W.P. BEMIS, Univ. of Arizona, School of Agriculture, *Tucson, Arizona* 85721

Six xerophytic species of Cucurbita (C. digitata, C. cylindrata, C. palmata and C. foetidissima) indigenous to southwestern United States and northwestern Mexico are being studied from the viewpoint of (1) their intrinsic properties as associated with arid environments, (2) their interspecific relationships within the xerophytic group and (3) their interspecific relationship with cultivated mesophytic species.

A permanent colony of the xerophytic species is being developed on a marginal (sandy) soil area at the Campbell Avenue Farm of the University of Arizona, Tucson. The purpose of this planting is to observe the mode and rate of colony establishment, proliferation and longevity under minimal water applications.

Preliminary data on species relationships indicate the xerophytic comples, with the exception of C. foetidissima, to be variants within a common species.

Interspecific crosses to cultivated mesophytic species have resulted in sterile F1 hybrids. Progress is proceeding toward the development of amphidiploids in these sterile hybrids as a means of restoring fertility.

SUPPORTED BY University of Arizona

3.0011, SPRINKLER IRRIGATION OF COTTON WITH HIGH SALT-CONTENT WATER

C.D. BUSCH, Univ. of Arizona, Agricultural Experiment Sta., *Tucson, Arizona* 85721

Objectives: To determine if cotton can be sucessfully irrigated with highly saline water under the conditions of the Upper Gila Valley.

Cotton plots will be sprinkler irrigated with water in the range of 4.2 to, 4.6 millimhos/cm. Salt accumulation on foliage and in the surface soil and its effect on plant performance will be measured. Comparison will be made of salt effects in response to temperature and humidity at the time of sprinkling, soil surface geometry and cotton species.

SUPPORTED BY U.S. Dept. of Agriculture
Arizona State Government

3.0012, DEVELOPMENT OF ECONOMIC WATER HARVEST SYSTEMS FOR INCREASING WATER SUPPLY

C.B. CLUFF, Univ. of Arizona, Water Resources Research Ctr., *Tucson, Arizona* 85721

Initial investigations have indicated that gravel covered membranes and sodium treated soil provide an economical method for increasing water yields.

For practical application, methods will be developed to lay a membrane and cover it with gravel extracted from the soil. Gravel can also be used to provide erosion control for a heavy treatment of sodium chloride. Considerable emphasis will be made to evaluate the possibility of a lighter rate of application of sodium chloride to increase water yield without appreciably affecting plant growth. Thus the plant cover would serve to minimize erosion. The use of fertilizer to offset the reduction in plant growth will be studied.

The proposed research plan will involve laboratory and field investigations. Laboratory investigations will be used to determine effect of various levels of sodium chloride on the infiltration rate of distilled water on various range soils in Arizona. These will be coordinated with infiltration tests in the field using a rainfall simulator. Field tests will also be made using a sodium treatment with a gravel cover for erosion control. The effects of sodium chloride treatment on grasses and the use of fertilizer to offset this effect, will be studied on field plots. Gravel covered membrane catchments will be installed and evaluated.

A computer model will be developed in an attempt to predict salt treatment rates and expected water yields.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Arizona

3.0013, PREDICTING THE EFFECT OF WATER QUALITY AND GYPSUM ON THE CHEMICAL AND PHYSICAL PROPERTIES OF SALINE AND ALKALI SOILS

G.R. DUTT, Univ. of Arizona, Agricultural Experiment Sta., *Tucson, Arizona* 85721

Objectives: a. To establish basic principles interrelating cation distribution in irrigation waters, soils and soil solution at the bottom of the root zone with certain physical properties of the soil. b. To develop a method to calculate the amount of gypsum and irrigation waters of different qualities to reclaim sodium affected soils.

Procedures: Several soils from Arizona will be tested to see if there is a reasonable fit between the soils and a mathematical model which has been developed to calculate distributions of ions in soil systems. If there is a fit, a computer procedure will be developed to calculate the amount of gypsum that must be added to a soil to achieve a desired Ca distribution. This procedure would consider irrigation waters of different qualities. Also, a laboratory column study will be initiated to see if the method can be used for the purpose indicated above. Upon completion of the column study a field evaluation of the method will be made.

SUPPORTED BY U.S. Dept. of Agriculture
Arizona State Government

3.0014, MANAGEMENT OF SALINE WATER FOR CROP PRODUCTION

W.H. FULLER, Univ. of Arizona, Agricultural Experiment Sta., *Tucson, Arizona* 85721

Both surface waters collected and stored behind dams as well as certain underground waters are becoming increasingly saltier with time. Such waters must either be managed more carefully if economic crop production is to be maintained or supplemented by waters of better quality. In either instance new and more effective water management principles must be developed to overcome detrimental effects on crop production associated with change in water quality.

In the Southwest it is not always possible to obtain new sources of water of good quality to supplement or replace poor sources. The exception to this, however, is the South Gila River valley where Colorado water is now just being introduced. The effect of this good quality water on the soils that have accumulated high concentrations of salts, including sodium, is being studied. Most of the research is designed to avoid any dominance of the monovalent cations over the divalent cations which would result in impedance of infiltration and poor internal soil drainage. In such areas as the upper Gila, Santa Cruz and Pecos Rivers good quality of waters are being rapidly depleted. Poor quality waters must be used. Basic principles are being developed in the use of these waters. Research is centering around water management to prevent excessive accumulation of salts in the root zone and maintenance of a favorable balance of divalent over monovalent cations.

The research is being continued on State funds for which there has been no project number assigned as yet.

SUPPORTED BY University of Arizona

3.0015, A UNIFIED APPROACH TO WATER, FOOD AND POWER IN A COASTAL DESERT COMMUNITY

C.N. HODGES, Univ. of Arizona, Inst. of Atmospheric Physics, *Tucson, Arizona* 85721

The University of Arizona is developing a combination system for providing power, water and food. The system is designed for use, initially at least, in a coastal desert area.

Power is generated by a diesel-electric set. Waste energy from the diesel engine is utilized to heat seawater for a humidification desalination plant. The waste seawater from the desalination plant is used to provide the temperature and humidity control for a closed- environment greenhouse. Carbon dioxide from the diesel engine exhaust is used in the closed greenhouse to accelerate plant growth.

Various experimental components of the system have been constructed and tested at the Environmental Research Laboratory, Tucson, Arizona. A pilot facility is being developed at Puerto Penasco, Sonora, Mexico, in cooperation with the University of Sonora.

SUPPORTED BY Rockefeller Foundation

3.0016, CORRELATION OF GROUND SUBSIDENCE FEATURES, FOUNDATION FAILURES AND EARTH CRACKS WITH WATER TABLE DRAWDOWN IN ALLUVIAL BASINS

W.C. LACY, Univ. of Arizona, Graduate School, *Tucson, Arizona* 85721

Patterns of the areas of foundation failures in the Tucson Area have been mapped, and features indicative of ancient earth cracks have been defined. Data as to the nature of alluvial fill is being compiled from drillers' logs, foundation excavations, and surface exposures. Undisturbed samples are being tested to determine their engineering properties. It is anticipated that it may be possible to predict zones of differential ground settlement and the magnitude to be expected. Thus, urban zoning and building codes can be adjusted in accordance with the problems that are developing.

Geophysical work being done by the Department of Geology supplements this study.

SUPPORTED BY University of Arizona

3.0017, SEISMIC EVALUATION OF PERMEABILITY OF FRACTURE ZONES IN ROCK

W.C. LACY, Univ. of Arizona, Graduate School, *Tucson, Arizona* 85721

In tunnel driving costs increase very rapidly with the encounter of heavy water flow that is a function of the degree of fracturing of the rock and the width of these fractures.

Many areas in the Southwest must depend upon water supplies derived from fracture zones in rock. It is likely that these zones can be located by the use of shallow seismic equipment and the yield of the zone predicted from velocity data and wave analysis.

No knowledge of parallel work by any other department.

SUPPORTED BY University of Arizona

3.0018, METHODS FOR IMPROVING ROCK PERMEABILITY

W.C. LACY, Univ. of Arizona, Graduate School, *Tucson, Arizona* 85721

Various methods are being investigated - electrical and explosive fracturing and hydrofracturing - to induce or to improve permeability in mineralized rock to permit in place leaching of metal values.

SUPPORTED BY University of Arizona

3.0019, OPTIMIZING SALVAGEABLE WATER RESOURCES IN A SEMI-ARID INLAND BASIN

W.G. MATLOCK, Univ. of Arizona, School of Agriculture, *Tucson, Arizona* 85721

The purpose of the proposed study is to optimize salvageable water resources in a semi-arid inland basin.

Salvageable water resources, namely, flood runoff and industrial and municipal waste water, will be characterized, according to sources, quantity and quality (physical, chemical, and bacteriological). Treatment procedures required to make the potentially salvageable water suitable for municipal (including recreation) and industrial use will be evaluated.

The hydraulics of natural recharge from sandy ephemeral stream channels will be studied. Analytical theories for defining the growth and dissipation of a ground-water mound will be evaluated.

The management alternatives, within the framework of existing studies, for optimizing and conservation, use and reuse of salvageable water supplies will be determined and evaluated for the Tucson Basin.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Arizona

3.0020, PROBABLE EFFECTS ON MARINE ENVIRONMENTS OF DISPERSING BRINE EFFLUENTS FROM LARGE DESALINATION PLANTS IN THE GULF OF CALIFORNIA

A.R. MEAD, Univ. of Arizona, Graduate School, *Tucson, Arizona* 85721

The mission of this project has been: (i) to collate all known information from the limited literature, official reports, collections of unpublished data, and current projects both in the United States and Mexico; (ii) to supplement this information with selected collections of new data in the Colorado River delta area to form a basis of extrapolation from more extensive data taken at Puerto Penasco, San Filipe and elsewhere; (iii) to calculate effluent discharge models based on all available data; (iv) to make estimations and predictions on the basis of this collected information and field experience; (v) to recommend future projects that will yield basic data required to provide the answers to problems that must be understood and adequately allowed for before the location and design of the nuclear powered plant can feasibly be finalized; and (vi) to provide a selected bibliography of the references which are judged to be the best sources of additional information pertinent to this study.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0021, MANIPULATION AND MANAGEMENT OF SECOND GROWTH PONDEROSA PINE FOR OPTIMUM YIELDS OF WATER AND/OR WOOD AND FORAGE

P.B. ROWE, Univ. of Arizona, Agricultural Experiment Sta. , *Tucson, Arizona* 85721

Objectives: To determine how much and under what conditions water, wood and forage yields can be improved by manipulation and/or control of vegetation.

Specific objectives are: 1. To determine how precipitation is distributed among interception, infiltration surface runoff, evaporation, transpiration and effluent soil seepage under conditions of natural, undisturbed vegetation. 2. To determine how much, in what way, and under what conditions of climate, soils, geology, and topography yields of water, wood and forage can be modified by manipulation and management of vegetation. 3. To determine the interrelations among water, wood and forage yields as modified by vegetation manipulation.

Work Proposed: This project will be concerned primarily with quantitative evaluations of basic processes influencing (1) the factors involved in the disposition of precipitation and (2) the effects of the physical conditions of the environment, and changes in these conditions by vegetation, manipulation, on water yields, and wood and forage production. Such information should have direct application to other areas where adequate inventories of climate, soil, water and vegetation conditions are available. Methods employed will include analytical field and laboratory techniques, the former to be carried out on small plots or similar unit controls.

SUPPORTED BY U.S. Dept. of Agriculture
Arizona State Government

3.0022, INVESTIGATIONS ON THE SUBSURFACE DISPOSAL OF WASTE EFFLUENTS AT INLAND SITES

L.G. WILSON, Univ. of Arizona, Water Resources Research Ctr. , *Tucson, Arizona* 85721

Artificial groundwater recharge investigations will be conducted to evaluate the applicability of recent theoretical, laboratory and field studies on mixing during miscible displacement, to waste disposal operations in inland alluvial sediments. The results will facilitate the establishment of rational guidelines for the selection and operation of artificial recharge facilities to preclude the impairment of native groundwater supplies during subsurface disposal of waste effluent in inalnd areas with physical controls similar to those at the experimental site.

Recharge studies will be initiated at The Water Resources Research Center Field Laboratory, The University of Arizona, Tucson, using a blended, cooling-tower blowdown effluent. A series of 'single-well' recharge-pumping trials will be conducted on a 150 ft deep, 20 inch diameter recharge well. 'Two-well' tests will consist of injecting effluent into the recharge well and, simultaneously, pumping from a downstream observation well. Recharge water will be tagged with fluorescent dye to facilitate preparation of breakthrough curves, using a recording fluorometer, during pumping. Tracer studies will also be conducted during recharge in a pit (100 ft x 50 ft x 10 ft, 2 1/2:1 side slopes). Water samples will be obtained from wells in the vadose and phreatic zones for preparation of breakthrough curves.

transfer coefficient is about five times higher than the evaporating heat transfer coefficient. Additional studies will further define the

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3.0023, SALT TOLERANCE IN BLUE PANICGRASS, PANICUM ANTIDOTALE

L.N. WRIGHT, Univ. of Arizona, School of Agriculture, *Tucson, Arizona* 85721

The objectives of the research are to: (a) develop techniques to evaluate large numbers of genotypes for salt tolerance within a given species, Panicum antidotale, blue panicgrass, (b) isolate salt- tolerant genotypes, and (c) determine the factor(s) affecting salt tolerance of blue panicgrass.

Forty-three sources of blue panicgrass have been collected. Seed will be germinated in a germinator using several salinizing agents individually and in combination (NaCl, CaCl2, and MgCl2). Vigorous seedlings of each accession will be placed in soil. After establishment, the plants will be transplanted to the field in restricted recombination crossing blocks for each salinizing agent or combination. Seed from each spaced plant will be progeny tested in the germinator using the same chemicals. Recurrent selection will be made among progeny plants. The procedure will be repeated to attain maximum salt-tolerant genotypes.

Once salt-tolerant progeny have been isolated within the species, then parent and progeny plants will be compared for the physiological processes and morphological characteristics to determine the changes that may have occurred within the species.

SUPPORTED BY University of Arizona

3.0024, DEVELOPMENT OF AUTOMATED SUBIRRIGATION SYSTEM

B.B. BRYAN, Univ. of Arkansas, Agricultural Experiment Sta. , *Fayetteville, Arkansas* 72701

Objectives: To determine, develop and evaluate: (1) Hydraulic problems involved in distributing water subterraneously at low pressures in small-diameter, perforated, plastic pipe for irrigation of horticultural food crops and field crops; (2) Criteria, from (1) above, for design of subirrigation systems which approach the ultimate in efficiency of water use; (3) Hydraulic criteria for distribution of fertilizers, soil fumigants, and systemic pesticides in the same irrigation system; (4) Control techniques for completely automating the agricultural irrigation system.

Description: Hydraulic problems associated with orifice preparation and spacing, and depth and spacing of plastic pipes will be done in laboratory and greenhouse. Irrigation-system-design procedure will be developed from results of laboratory data and field system will be installed and evaluated as to efficiency. Methods of introducing fertilizers and other water-soluble materials will be evaluated and developed using the field system. Automated controls, including a soil-moisture-sensing system, will be developed for the field system.

SUPPORTED BY Arkansas State Government

3.0025, DEVELOPMENT OF AUTOMATED SUBIRRIGATION SYSTEM

J.P. HOSKYN, Univ. of Arkansas, Water Resources Research Ctr. , *Fayetteville, Arkansas* 72701

The objectives of this work are to determine, develop and evaluate: (1) hydraulic problems involved in distributing water subterraneously at low pressures in small diameter, perforated plastic pipe for irrigation of horticultural food crops and field crops; (2) criteria, from (1) above, for design of subirrigation systems which approach the ultimate in efficiency of water use; (3) hydraulic criteria for distribution of fertilizers, soil fumigants, and systematic pesticides in the same irrigation system; (4) control techniques for completely automating the agricultural irrigation system.

Field evaluation will be accomplished at Vegetable Substation, Van Buren, Arkansas.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Arkansas

3.0026, RICE FARMS IN ARKANSAS

J.H. WHITE, Univ. of Arkansas, Agricultural Experiment Sta. , *Fayetteville, Arkansas* 72701

(1) Relate relative efficiency of producing rice and other adapted crops to the major soil and water resources situations on rice farms. (2) Appraise costs and returns effect of irrigation of crops other than rice for each major resource situation. (3) Apraise cost and returns potentials from adoption of the best combination of improved production practices and techniques for each major resources situation. (4) Evaluate costs and returns aspects of rotations on rice farms for each major resource situation. (5) Determine relative inputs and yields for long, medium and short grain varieties of rice.

Description of Work. Work on this project involves the compiling of information from farmers, agricultural workers, service groups, and research technicians pertaining to cultural practices followed; the labor, equipment, and materials used; and the production and incomes for the established enterprises on representatives farms in the rice areas of Arkansas. The objective is to discover opportunities for increasing the incomes of farmers either through more efficient management practices with the different enterprises, through shifts in the allocation of resources between enterprises, or through the use of different rotation systems. After the opportunities that appear most promising have been determined whole farm budgets of representative farms (small, medium, and large) are developed to reflect the effects which the adjustments would have on the incomes of the farmers.

SUPPORTED BY U.S. Dept. of Agriculture
Arkansas State Government

3.0027, SOIL-WATER-VEGETATION RELATIONS IN THE DOUGLAS FIR ZONE

E.E. STURGEON, Humboldt State College, Graduate School, *Arcata, California* 95521

To initiate basic forest and watershed research in the Elder and Fox Creek watersheds so as to ascertain fundamental relationships between natural cover, stream flow and soil moisture.

Procedure: Initial research will be (1) a precipitation distribution study; (2) installation of soil moisture access tubes and measurement of soil moisture on selected plots; and (3) attendant preliminary analysis of the water balance of the area. Plans call for stream -gaging in order 1) to assess the precipitation-runoff relation under undisturbed conditions, 2) to see how it is influenced by various watershed parameters such as elevation, aspect, slope, etc., and 3) to use the area as a control against which the effects of land use on the precipitation-runoff relationships may be checked. Intensive study will be made of some of the minor drainages so as to fully assess the wildland hydrologic cycle.

SUPPORTED BY U.S. Dept. of Agriculture

3.0028, DESIGN, CONSTRUCT AND EVALUATE A 1,000 GALLON PER DAY REVERSE OSMOSIS UNIT OF RECTANGULAR CONFIGURATION

W.J. FLAHERTY, Aerojet General Corporation, *Azusa, California*

This contract includes three main tasks. Under economic investigations, a parametric study will be conducted and alternate materials and manufacturing methods for membrane support plates will be examined. The parametric study is for the purpose of determining the capital costs for a mgd capacity Reverse Osmosis plant based on plate and frame design. Cost breakdown on a system component basis will be provided. Under rectangular plate development, an experimental program to determine commercial materials for use as porous membrane supports will be conducted as well as long-term tests to establish pressure drop with time at different feed water pressures. Hydrodynamics for the materials tested will also be determined. The third task is to develop membrane spacers for the rectangular plate design. Test fixtures and dies to evaluate molding of these supports in 18-inch square modules will be fabricated.

Finally, based on Tasks II and III, a 1000 gpd rectangular pilot plant will be designed and constructed for feeds varying from 2,000 to 25,000 ppm TDS and pressures varying from 600 to 1500 psi.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0029, OPERATION OF A 50,000 GPD PORTABLE PILOT PLANT

B. KEILIN, Aerojet General Corporation, *Azusa, California*

The objectives of this contract are to design and fabricate a trailer- mounted pilot plant which will produce 50,000 gpd of purified water by the reverse osmosis process; to design and fabricate pretreatment facilities to prepare raw well water for use in the pilot plant; to prepare a test site; and to conduct field testing of this equipment fabricated.

Last year, performance tests were conducted to arrest the rapid flux decline and to test the use of wash solutions in removing accumulated membrane deposits. A bench-scale test program and the construction of a 14-inch reverse osmosis unit used to field test the manganese zeolite on a small scale are recent projects.

New membranes have been installed in the unit in preparation for a demonstration on manganese zeolite treated feed.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0030, A STUDY OF MEMBRANES FOR DESALINATION BY REVERSE OSMOSIS

C.W. SALTONSTALL, Aerojet General Corporation, *Azusa, California*

A fundamental investigation of reverse osmosis membranes is being continued in order to gain a broad basic understanding of the relationship between membrane fabrication techniques, chemical and physical characteristics of the membrane, and the reverse-osmosis transport properties.

In previous work it was discovered that the diffusion coefficient of salt in cellulose acetate depended upon the drying conditions used in preparing the dense films; this dependence is being more completely examined. The relationship of the salt permeation of membranes heat- treated at different temperatures to the electrical conductivity of the membranes is being determined.

Previous work was conducted to relate the rate of flux decline and the compressive mechanical properties of the membrane. In the current work the dependency of the rate of flux decline upon the initial membrane flux and the method of membrane fabrication is being examined.

Work is being conducted to determine if better or more uniform membranes can be prepared by gelling the casting solution in different types of organic solvents rather than in water.

New methods to measure properties of the active layer surface of anisotropic membranes are being examined. For example, attenuated total-reflectance, infrared spectroscopy is under investigation as a means to determine the chemical composition of the surface.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0031, RESEARCH AND DEVELOPMENT OF NEW POLYMER SYSTEMS FOR REVERSE OSMOSIS MEMBRANES

C.W. SALTONSTALL, Aerojet General Corporation, *Azusa, California*

A program of polymer synthesis for new osmotic membranes is being continued. The objective of the program is to discover polymers which will provide reverse osmosis membranes superior to the current cellulose acetate membranes.

In earlier work on this program, polyacrylonitrile and poly(vinylene carbonate), selected for their chemical stability and mechanical strength, were investigated in the preparation of new membranes. Films (about 7 microns or thicker) of poly(vinylene carbonate) were found to have water transport properties superior to those of cellulose acetate and a theoretical salt rejection capability of greater than 98%. Thinner films of the new polymer, however, showed mechanical break-down under reverse osmosis testing because of brittleness. Therefore, in current work, efforts are being made to prepare internally plasticized polymers of vinylene carbonate through copolymerization with vinyl acetate and vinylpyrrolidone. Externally plasticized films of poly(vinylene carbonate) will also be examined for mechanical and reverse osmosis properties.

Polymers based on methacrylonitrile and comonomers such as acrylamide, methyl vinyl ketone and vinylpyrrolidone will also be investigated for use in the preparation of membranes.

SUPPORTED BY U.S. Dept. of Interior - Off Saline Water

3.0032, MANAGEMENT FOR IMPROVEMENT OF WATER YIELD IN THE CONIFER ZONE OF CALIFORNIA

J.L. SMITH, U.S. Dept. of Agriculture, Pac. Sw. For. & Rg. Expt. Sta. , *Berkeley, California*

Object: To develop a hydrologic base for land management decisions, including understanding of the physical processes affecting snow accumulation and melt, interception of precipitation, and evapotranspiration as affected by vegetation, forest conditions, terrain and soil.

Plan of Work: The project staff is perfecting a radioactive snow gage that has recently been developed by the project. With it they will continue to study snow accumulation and melt as affected by the forest and by timber-cutting patterns. They are also studying water movement in soils and plants. The studies are conducted in the laboratory on sample plots and on experimental watersheds. Phosphorescent (ultraviolet) and nuclear tracers are used in snow studies and water movement studies.

SUPPORTED BY U.S. Dept. of Agriculture

3.0033, A MASS TRANSFER STUDY OF CURRENT REQUIREMENTS FOR CATHODIC PROTECTION

I. CORNET, Univ. of California, School of Engineering, *Berkeley, California* 94720

Work completed to date (Cornet, I., Pross, T. W., Jr. and Bloom, R. C., 'Current Requirements for Cathodic Protection of Disks Rotating in Salt Water -- A Mass Transfer Analysis,' International Congress on Fouling and Marine Corrosion, Cannes, France, June 1964 -in press-). shows quantitatively that the current required for cathodic protection of rotating disks in salt water and in sea water is proportional to mass transfer of oxygen to cathodic surfaces. This work has however been limited in range of temperature and flow conditions. It is proposed to extend the investigation to a range of temperatures, and to Reynolds numbers beyond the capabilities of the present experimental equipment, into a range where cavitation may occur.

It is proposed to use a rotating disk apparatus at the beginning. Equipment and experience are already available, and results may be correlated with hydrodynamic, heat transfer, and mass transfer studies which have been published for rotating disk systems. It is proposed, however, to extend this investigation to the cathodic protection of other than rotating surfaces. The need for knowledge of cathodic protection requirements under heat transfer conditions will be kept in mind, and preliminary experiments will be undertaken.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0034, RELATIONSHIP BETWEEN IRRIGATION WATER COMPOSITION AND SOIL PROPERTIES

R.K. SCHULZ, Univ. of California, Agricultural Experiment Sta. , *Berkeley, California* 94720

It is the purpose of this research to examine, in a highly instrumented and carefully controlled intermediate field study, various theories which have been proposed and tested in the laboratory and to establish principles and procedures that can be used in coping with agricultural problems relating to the use of irrigation water on arid lands. Where necessary, new theories will be formulated and tested. It is the primary concern of this project to aid in obtaining permanence of agriculture on irrigated arid soils by developing an understanding of the mechanisms of salinity accumulation and permeability problems resulting from increases in the level of adsorbed sodium.

A long term field experiment is to be carried out at the Kearney Horticultural Field Station, near Reedley, California. Forty eight plots, 1/100 acre each, have been constructed by bordering the soil to a depth of five feet with concrete and a plastic membrane. Each plot is to be a completely defined system with all important measurements recorded, and this data is to be handled by computer techniques, that is, the amount of water and salt entering the system, rate of infiltration into the soil, movement of water, salts, oxygen and carbon dioxide within the soil, and losses of salts by leaching and crop removal. A building containing a controlled temperature instrument room and facilities for preparing synthetic irrigation waters has been constructed. Instrument development is now underway.

The first experiments will be carried out in nine plots planted to ladino clover. The plots will be irrigated with nine different irrigation waters which contain varying amounts of sodium, calcium, bicarbonate, chloride and sulfate ions.

SUPPORTED BY University of California

3.0035, STUDY OF MASS TRANSFER THROUGH MEMBRAMES

K.S. SPIEGLER, Univ. of California, School of Engineering, *Berkeley, California* 94720

Study of polarization phenomena at membrane-solution interfaces by electrochemical and optical methods. The study is to cover both reverse osmosis (hyperfiltration) and electrically driven processes (e.g., electrodialysis), and will stress the physico-chemical hydrodynamics of membrane-solution interfaces, which are a common feature of all membrane separation methods.

Specifically it is planned to perform (a) a detailed mass-transfer study in a large single ion-exchange membrane module which simulates the conditions in a plant-size electrodialysis stack, and thus determine the influence of turbulence-promoter geometry on polarization (b) a study of electrical potential differences which develop across reverse- osmosis membranes, as a function of pressure, hydrodynamic factors and solution type and (c) optical studies, by laser interferometry, in small membrane cells, designed to lead to the development of large cells for the observation of the interfacial phenomena at normal and high pressures.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0036, RESOURCE CONSERVATION

S.V. WANTRUP, Univ. of California, Agricultural Experiment Sta., *Berkeley, California* 94720

Objectives: The Economics and Policies of Environ. Mgt. 1. To identify the conceptually and operationally significant characteristics of the economics of natural resources. 2. To analyze the economic interrelations between different uses of natural resources with particular emphasis on dynamic aspects. 3. To appraise public policies affecting natural resources.

Work Proposed: The project will continue to be undertaken in separate but related phases. Phases active during 1962 are the following: 1. Multiple Use as a Concept for Water and Range Policy. 2. The Economics of 'Quality' in Natural Resources. 3. Consultant, Land and Water Research, U.S.D.A.

SUPPORTED BY California State Government

3.0037, MANAGEMENT PRACTICES FOR SALINE AND SODIC SOILS IN IMPERIAL VALLEY

W.F. SPENCER, U.S. Dept. of Agriculture, *Brawley, California*

Objective: To develop soil, water, and crop management practices for optimun production and high water use efficiency, of crops growing on salt-affected soils in the Imperial Valley.

Plan of Work: The distribution and quantity of salts and exchangeable cations in saline soils as affected by water quality, drainage, amendments, crops, and soil management practices and the resultant effect on crop production and water-use efficiency will be evaluated. For this purpose field experiments with controlled variables of amendments, crop culture, irrigation, or drainage practices will be used. Salt distribution variability will be evaluated in order to develop sampling procedures for evaluating the salinity status of farming units accurately enough for making decisions concerning effectiveness of management practices for removal of soluble salts and exchangeable sodium. Practices which will be evaluated for growing crops on highly saline soils are tillage and residue management, deep profile modification, surface stabilization for water infiltration improvement, planting methods, bed shapes, and methods and timing of irrigations.

Cooperation: Agricultural Experiment Stations, SCS, U. S. Bureau of Reclamation, State Engineers, State Water Resources Agencies, and other irrigation, water management, or soil conservation district agencies.

SUPPORTED BY U.S. Dept. of Agriculture

3.0038, IRRIGATION AND EVAPOTRANSPIRATION OF WATER FOR CROPS IN IMPERIAL VALLEY

L. WILLARDSON, U.S. Dept. of Agriculture, *Brawley, California*

Objective: To determine optimum water application rate for slope, soil type, intake rate, crop and root-zone water storage capacity. Relate energy budget to seasonal, monthly, and peak consumptive-use rates. Design semiautomated irrigation systems for these circumstances.

Plan of Work: Determine crop, soil, and topographic adaptability of different water application techniques and overall system efficiency. Study hydraulic factors governing flow in irrigation furrows and borders to develop equations for rate of advance and row length-grade criteria for control of erosion. Develop methods for metering water intake rates, water holding capacities, and internal transmission rates of moisture for different soils. Determine proper timing and amount of irrigation for efficient use of water supplies using lysimeters. Gather data on energy budget and develop prediction methods for water requirements of crops. Design improved equipment and systems for measurement and application of water including automatic systems.

SUPPORTED BY U.S. Dept. of Agriculture

3.0039, ELECTROCHEMICAL DEMINERALIZATION OF BRACKISH WATER

S. EVANS, North Amer. Rockwell Corp. , *Canoga Park, California*

This process is best defined as electrochemically controlled ion- exchange.

The objective of this effort is the development of a prototype cell with 100 sq. cm. electrodes.

Work at present is focused on the selection of the most suitable ion-exchange materials for this process. This is being accomplished by kinetic studies on weak acid, and weak base ion-exchange resins, a literature search, and consultation with manufacturer's representatives.

The research that must precede the design of a prototype cell involves the development of a reliable and reproducible test electrode followed by the optimization of electrode exchange characteristics with respect to: 1. Ratio of ingredients (e.g., Norit, graphite, binder, ion-exchange resin). 2. Current. 3. Potential. 4. Electrochemical capacity.

The purpose of the prototype cell study is to investigate scale- up factors such as current, capacity, ratio of times required for demineralization and regeneration, and response to ions in brackish water.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0040, DEVELOPMENT OF DIRECT CONTACT CONDENSATION MULTISTAGE FLASH (DCC-MSF) DISTILLATION PROCESS

R.D. KEEN, North Amer. Rockwell Corp. , *Canoga Park, California*

The program consists of analytical and experimental studies aimed at evaluating the feasibility of the Atomics International Direct Contact Condensation - Multistage Flash (AI-DCC-MSF) Distillation Desalination Process for Saline Water Conversion.

The AI-DCC-MSF process differs from conventional MSF processes in that (1) flahsed vapor is condensed by direct contact with flowing fresh water instead of by contact with metal tubes containing flowing brine, and (2) the brine is heated external to the flash chambers by indirect contact with the hot fresh water in a simple heat exchanger employing low cost plastic film heat transfer surfaces.

The principal effort under the current program consists of the design, fabrication, and initial operation of two test units to demonstrate (a) direct contact condensation heat transfer rates and (b) plastic film heat exchanger operating feasibility. The program also includes an analytical study of direct contact condensation for high velocity cross current flows of steam and water, and the evaluation of plastic films which are potentially useful for the brine-to-fresh water heat exchanger.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0041, NUCLEATION AND GROWTH OF ICE CRYSTALS

G.R. SCHNEIDER, North Amer. Rockwell Corp. , *Canoga Park, California*

An experimental program is being conducted to investigate (a) the growth of ice crystals in ice-brine slurries for secondary refrigerant freeze desalination processes and (b) hydrate formation in secondary refrigerant processes, as a possible undesirable feature of the process.

A technique for counting and sizing ice particles is being developed and will be utilized to determine size distributions in ice slurries as a function of crystallizer operating variables. In addition, the effect of natural organic contaminants and crystal habit modifiers present in sea water on the particle size distribution of ice will be assessed. The relative rates at which ice and hydrate crystals form in a secondary refrigerant process will also be investigated in order to determine techniques for minimizing hydrate formation.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0042, ROOT-KNOT NEMATODE CONTROL (MELOIDOGYNE NAASI-FRANKLIN)

M.W. ALLEN, Univ. of California, School of Agriculture, *Davis, California* 95616

Research on the control of the root-knot nematode Meloidogyne neasi Franklin, 1965. The study will involve the use of various nematocidal chemicals at several dosage rates. Various crops will be grown to determine their effect upon nematode populations. Crops included are barley varieties (spring and winter), wheat (spring and winter), oats, alfalfa, peas, onion and potato. The effect upon nematode populations of fallow and fallow combined with deep plowing will be studied. Soil and root samples will be collected several times during the cropping season to determine the effect of treatments on the nematode population. Field studies will be supplemented by greenhouse investigation of host range, biology and pathogenicity.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

3.0043, IMPURITIES OF IRRIGATION WATERS AFFECTING SOIL PROPERTIES

L.D. DONEEN, Univ. of California, Agricultural Experiment Sta. , *Davis, California* 95616

Investigate effects of kinds and concentrations of salts on soil structure and penetration of irrigation waters into soil; effects on plants of materials dissolved in irrigation waters, degree of accumulation of harmful salines in the soil as affected by kinds and concentrations of salts in the water, soil conditions, climatic conditions, and practices of growers; study of the suitability of sewage effluents and drainage waters as irrigation waters.

Description of Work: Previous work has indicated that slightly soluble salts of Ca-MgHCO3 and CaSO4 in the irrigation water does not produce salines in the soil and, furthermore, the permeability of the soil is determined by the concentration of salt in the water, the sodium content, and the bicarbonate. To evaluate these many and interrelated components, 2 lysimeter studies are under way. One in the greenhouse includes 2 soils and 13 waters of varying quality. The other is a large outdoor installation employing 9 waters of varying quality from which yield can be obtained. These studies are concerned with infiltration rates, salt balance, leaching requirements for chloride and bicarbonate waters and their effect on soil properties.

Miscible displacement is being investigated. This is fundamental to understanding the simultaneous solute and fluid transfer processes. Both velocity and diffusional mixing are important, as well as the media itself, in determining the distribution of the solute.

SUPPORTED BY U.S. Dept. of Agriculture
California State Government

3.0044, SALINITY AND ION TRANSPORT MECHANISMS OF PLANT CELL MEMBRANES

E. EPSTEIN, Univ. of California, School of Agriculture, *Davis, California* 95616

1. According to many reports recently summarized (Nature 212:1324- 27. 1966) selective absorption of mineral ions by plant cells is effected through dual mechanisms which differ in many characteristics. It is planned to compare this dual pattern in conventional, i.e., salt- sensitive species and in 'halophytes', plants which are native to saline habitats.

2. The location of the two mechanisms of ion transport will be investigated. There is agreement that the first of these mechanisms is located in the external cytoplasmic membrane, the plasmalemma. The location of the second mechanism, however, is problematical.

3. The connection between ion transport and metabolism will be investigated. Experiments will be done with photosynthetic tissue in the light and in the dark, and the results compared with those of experiments of non-photosynthetic tissue.

4. Experiments will be done on binding of ions to plant cell components. These experiments are meant to supplement those dealing with rates of absorption.

5. Experiments will be done to correlate findings on ion transport with those on salt toleration in salt-toletant and salt-sensitive species. Attempts will be made to establish whether salt damage to plant cells involves an initial damage to their membranes.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0045, POTENTIAL USEFULNESS OF ANTITRANSPIRANTS FOR INCREASING WATER USE EFFICIENCY OF PLANTS

R.M. HAGAN, Univ. of California, School of Agriculture, *Davis, California* 95616

Numerous efforts have been made over the past decade to reduce evaporation from water surfaces, but there has been relatively little research on methods for decreasing the transpirational loss of waters from plant leaves. Less than 1% of the water absorbed by plant roots is retained within the plant.

This project has the following objectives: 1. Continue evaluation of new antitranspirant materials (e.g., semipermeable films, reflectants and metabolic inhibitors) for phytotoxicity and their effects on transpiration, relative turgidity, leaf temperature, net photosynthesis and growth. 2. Determine relative permeabilities of film antitranspirants to water vapor, carbon dioxide and oxygen. 3. Study plant and environmental factors which may influence the effects of antitranspirants on transpiration, relative turgidity, and plant growth processes. 4. Develop techniques for supplying antitranspirants and for evaluating the completeness of their coverage on plant leaves, their stability and specific effects on stomatal movement. 5. Investigate the potential usefulness of various combinations of antitranspirant materials as a means of increasing the water-use efficiency of plants. 6. Study special uses of antitranspirants in agriculture, ornamental horticulture, and watershed management.

Full use will be made of basic biochemical research on stomatal regulators by Dr. I. Zelitch and associates at New Haven, Connecticut and on external films by Dr. J. Gale at Jerusalem, Israel. Water use will be assessed by meteorological instrumentation, soil moisture studies, and lysometric techniques. Other observations may include stomatal measurements, relative turgidity of leaves, cell sap concentration, and diurnal measurements of tree trunk radius as indications of internal water stress. Field experiments will be conducted to determine effects of antitranspirant materials on water use efficiency of crops and also on their growth, yield and quality.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of California

3.0046, DRAINAGE DESIGN IN RELATION TO SOIL SALINITY

J.N. LUTHIN, Univ. of California, School of Agriculture, *Davis, California* 95616

The relationships between the drainage design and the control of the soil salinity will be studied. Various methods of leaching will be investigated and the rate of accumulation of salt in the soil will be studied as a function of several variables. Field work will be done at the Imperial Valley Field Station in El Centro, California. Laboratory analyses will be performed in Davis. Measurements will be made of the dispersion characteristics of the soils investigated in the field. Movement of soil salts will be studied in soil-filled tanks located at Davis. The relative efficiency of ponded-leaching and irrigation-leaching will be investigated.

SUPPORTED BY University of California

3.0047, PROCEDURES FOR ESTIMATING CROP WATER REQUIREMENTS FOR USE IN WATER ALLOCATIONS AND FOR IMPROVEMENT OF IRRIGATION EFFICIENCY

W.O. PRUITT, Univ. of California, School of Agriculture, *Davis, California* 95616

Using a 6.1-meter diameter, highly sensitive lysimeter equipped with moisture tension and temperature control systems, determine evapotranspiration, ET, on a continuous basis for a 10-15 cm tall turf grass. Also obtain measurements over the grass of net radiation and air temperature, humidity and wind speed. Using another 6.1-meter lysimeter of the floating type determine ET for another crop (field beans in 1968).

Using a mobile hydrometeorological laboratory and associated instrumentation, take measurements of temperature, humidity and wind gradients above a number of crops in California along with net radiation, soil heat flux, surface temperatures, albedo, etc. Using Bowen-ratio techniques as wlll as other meteorological approaches, determine evapotranspiration at several stages of growth for the crops concerned (rice, sugar beets, pasture, alfalfa and beans in 1968).

SUPPORTED BY University of California

3.0048, IMPROVEMENT OF IRRIGATION MANAGEMENT AND SALINITY CONTROL IN THE IMPERIAL VALLEY.

F.E. ROBINSON, Univ. of California, Agricultural Experiment Sta., *Davis, California* 95616

Objectives: (1) To define the influence of present irrigation methods upon crops and explore means of improvement; (2) To investigate the feasibility of sprinkler irrigation as a means of improving efficiency of water management and salinity control; (3) To investigate means of improving drainage of water tables as a means of salt removal.

Description: (1) Study the present irrigation regime of the Imperial Valley as recorded in District records; (2) Conduct series of field experiments comparing sprinkler and furrow irrigation and associated salt accumulation; (3) Determine the best method of irrigation to facilitate mechanical cropping (4) Conduct field trials of tiling methods.

SUPPORTED BY California State Government

3.0049, FOLIAR PENETRATION OF CHEMICALS WHICH INCREASE DROUGHT AND SALT TOLERANCE

R.M. SACHS, Univ. of California, School of Agriculture, *Davis, California* 95616

Plant growth retardants have decreased water requirments of some species but the response is highly variable under field conditions. The reduction in water use appears to be linked to the reduced vegetative growth. The major factor accounting for variable response is penetration of the chemical. Two foliar applied growth retardants, Alar and MH, are most effective when applied shortly after bud break. Studies with C14 labelled materials show that penetration is greatest through the youngest leaves, such as those appearing shortly after bud break. Surfactant-induced and alcohol-induced enhancement of penetration has been demonstrated. The alcohol (isopropyl, ethyl, or methyl) effect appears to be the result of better wetting of the leaf surfaces and not due to solvent action on the cuticular surface.

SUPPORTED BY University of California

3.0050, DEVELOPMENT OF REVERSE OSMOSIS MEMBRANES

S. MANJIKIAN, Univ. Water Corporation, *Del Mar, California* 92014 (14-01-0001-2093)

The objective of research undertaken under this contract is to develop new and improved membranes from casting formulations based on cellulose esters. It is proposed to investigate various cellulose esters, specially cellulose acetate butyrate, in a variety of casting solution formulations. These formulations will include various solvents, flux promoters, coupling agents and plasticizers. The effect of pyridine, monohydroxy fatty acids and alcohols as possible couplers in cellulosic solutions will be investigated. Fabrication procedures will be studied to develop optimum methods for fabricating membranes from new formulations.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0051, DESIGN AND CONSTRUCTION OF A REVERSE OSMOSIS PILOT PLANT FOR THE DESALINATION OF SEA WATER

S. MANJIKIAN, Univ. Water Corporation, *Del Mar, California* 92014

The purpose of this contract is: to design and construct a 2,500 gpd tubular sea water reverse osmosis unit based on pyridine membranes; to test operate the pilot plant with sea water in order to establish the performance characteristics of the unit at various conditions; and to establish optimum economic mode of operation. The program will be conducted in two phases which are, generally: the pilot plant design and construction, and the pilot plant evaluation.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0052, EVALUATION OF DESALINATION PROPERTIES OF CELLULOSE ACETATE MEMBRANES IN FLAT, TUBULAR AND SPIRAL WOUND CONFIGURATIONS

S. MANJIKIAN, Univ. Water Corporation, *Del Mar, California* 92014

The purpose of this contract is to evaluate the effects of physical stress or strain to which cellulose acetate membranes may be subjected in fabrication or operation; and to determine how these effects are influenced by casting solution composition, conditions imposed during casting and fabrication of the membranes, and the configuration in which the membrane if operated. Laboratory and bench scale tests will be conducted to determine the comparative effects on membrane performance when operated in the flat, tubular and spiral module configurations. Membranes for testing in these configurations will be varied according to the type of casting solution and the methods for fabricating the membranes. The test program will include: membrane formulation; membrane fabrication; and testing.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0053, OPTIMIZATION STUDY OF HIGH RECOVERY REVERSE OSMOSIS PLANTS

S.T. BRAUNHEIM, Aerojet General Corporation, *El Monte, California* 91734

The chief objective of this program is to develop an optimum economic reverse osmosis process scheme for maximum product recovery and minimum brine disposal. A mathematical model and an optimized plant system to predict product water cost at product water recoveries ranging from 50 to 98 percent will be developed. Based on this model, detailed cost estimates for desalting four typical brackish waters in the 10 mgd plant size will be prepared. Specific tasks in this contract include process studies, optimization studies, and analysis and presentation.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0054, REVERSE OSMOSIS MEMBRANE REGENERATION

P.A. CANTOR, Aerojet General Corporation, *El Monte, California* 91734

The purpose of this contract is to develop novel methods of extending the economical service life of currently available acetate reverse osmosis membranes. These techniques will cause state-of-the- art systems employing current membranes to become much more economically competitive, and will also effect similiar cost savings upon more economical future systems. Through several modifications and the evaluation of these modifications' technical and economic feasibility, recreation of the new membrane structure may be adopted as a standard practice in reverse osmosis plants to maintain high water flux in the membranes.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0055, DEVELOPMENT OF A CALIBRATION MODULE FOR TRACE OXYGEN ANALYZERS

H.C. EDGINGTON, Aerojet General Corporation, *El Monte, California* 91734

The program encompasses research and development to produce a prototype calibration module. The purpose of this module would be to provide a stream of water having an accurately known dissolved concentration for calibration of dissolved oxygen analyzers in the parts per billion concentration level.

Laboratory tests will be conducted to study techniques for use in the Dissolved Oxygen Calibrator. Experimental setups will be used to evaluate de-oxygenation of the sample stream. Tests will be conducted to evaluate gas equilibration and direct injection for the production of accurately known dissolved oxygen concentrations. Gas mixing and coulometric (electrical) generation will be examined as approaches for preparation of gas mixtures for equilibration studies. Coulometric generation will also be investigated as a means for production of measured quantities of oxygen for direct injection as a gas or solution. Concurrently a screening review will be made of candidate analytical methods that can be used to verify the accuracy of the dissolved oxygen levels produced by the calibration module.

Following the above research, a prototype calibration module will be designed and fabricated. Finally, the operating characteristics of the prototype model will be determined.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0056, REVERSE OSMOSIS PILOT PLANT INVESTIGATIONS

G.A. FLUKE, Aerojet General Corporation, *El Monte, California* 91734

The objectives of this program are to develop engineering and plant operation data to improve the economics of plate and frame design reverse osmosis systems, and to establish the desalination properties of newly developed high salt retention membranes. The various investigations to be conducted include pretreatment studies, evaluation of a 14-inch diameter reverse osmosis unit, membrane substrate evaluation, baffle system evaluation, and the field evaluation of high retention membranes.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0057, PROCESS AND CONFIGURATION DEVELOPMENT FOR TUBULAR REVERSE OSMOSIS UNITS

G.A. FLUKE, Aerojet General Corporation, *El Monte, California* 91734

The chief objective of this program is to develop an economical tubular design reverse osmosis system for brackish water desalination. Major emphasis will be placed on (1) engineering and parametric studies to optimize process and plant design parameters, (2) design and development of tube header and feed and product water manifold system, and (3) material selection and development of manufacturing techniques to produce reverse osmosis tubular elements on a continuous basis in an automated assembly shop.

Within the scope of work there are three planned phases: Plant Design Optimization Studies, Component Development, and Construction and Evaluation of the 1000 gpd Pilot Plant (based on the first two phases).

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0058, DEVELOPMENT OF STORAGE TECHNIQUES FOR REVERSE OSMOSIS MEMBRANES

R.W. LAWRENCE, Aerojet General Corporation, *El Monte, California* 91734

The objective of this program is to develop a workable system for the protection of membranes, membrane assemblies and whole reverse osmosis units against the effects of exposure to microorganisms and other potentially deleterious environmental conditions. Efforts will be made to generalize the procedures developed in order that they may be applied to any reverse osmosis system employing cellulose acetate membranes.

The following developmental tasks are included in the contract: I - Biocide and Biostat Solution, II - Low-Temperature Exposure, III - Dry Membrane Systems, IV - Shipping and Storage Procedures, and V - Standard Shipping and Storage Procedures.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0059, PRELIMINARY EVALUATION OF HIGH RETENTION MEMBRANES

E.R. ROBERTS, Aerojet General Corporation, *El Monte, California* 91734

The purpose of this contract is to evaluate the performance of high retention reverse osmosis membranes on sea water under field conditions. Work to be achieved under this contract includes refitting the 14-inch reverse osmosis cell, setting up sea water pretreatment facilities, installing the cell assembly, relocating the trailer to the San Diego Saline Facility, and making the necessary calculation on and analyzations of the data required.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0060, DEVELOPMENT OF NEW AND IMPROVED CELLULOSE ESTER REVERSE OSMOSIS MEMBRANES

C.W. SALTONSTALL, Aerojet General Corporation, *El Monte, California* 91734

This research project is to develop new and improved cellulose ester membranes for the desalination of sea water in one pass by reverse osmosis. Major emphasis is to be placed on improving the compaction resistance of current cellulose acetate membranes so that an average flux of no less than 10 gallons per square foot per day of a product water containing 500 ppm or less of salt can be obtained from sea water in 50% recovery. This is to be achieved by continuous use of the membrane in a one-stage reverse osmosis process.

The program is to include the development of new and improved cellulose ester polymer blend membranes; the development of homopolymer mixed ester membranes based on E 398-3; development of homopolymer mixed ester membranes based on E 360-60; development of crosslinked membranes derived from E 398-3, E 398-10, and E 360-60. These membranes will then be biostabilized and basic and analytical studies will be conducted.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0061, OPERATION AND EVALUATION OF A 50,000 GALLONS PER DAY REVERSE OSMOSIS PILOT PLANT

E.R. WATSON, Aerojet General Corporation, *El Monte, California* 91734

This contract was undertaken to establish the capability of the pilot plant to operate over long periods of time virtually unattended. This does not include attention as to preventative maintenance of periodic surveillance for purposes of inspection and data gathering.

Proposed tasks for the plate and frame reverse osmosis plant operation and evaluation include: 1. Making a continuous test run utilizing the feed water pretreatment method and specific equipment. 2. Analyzing samples for the various constituents 3. Closely monitoring the operation of the pilot plant by means of the acquired data. 4. Keeping a detailed operating log on the plant during the test period. 5. Establishing the effect of changes in operating variables. 6. Preparing cost estimates (capital and operating for 1 and 10 mgd capacity) plate and frame reverse osmosis brackish water desalting plants. 7. Preparing a final report.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0062, WATER YIELD IMPROVEMENT IN THE BRUSHLANDS OF THE SOUTHWEST

L.F. DEBANO, U.S. Dept. of Agriculture, Pac. Sw. For. & Rg. Expt. Sta., *Glendora, California*

Object: To establish fundamental plant, soil and water relations as they influence water losses and yields and to develop cultural practices for improving water yield in bushlands.

Plan of Work: Research activities are directed toward studying soil moisture movement in bushland soils. The staff is evaluating unsaturated flow rates during infiltration, evaporation, and other capillary movement through wettable and nonwettable soils, in laboratory and field studies. They are conducting studies comparing consumptive use of brush and grass. Investigations will be made of lateral flow in steep brushlands.

SUPPORTED BY U.S. Dept. of Agriculture

3.0063, NATURAL RECHARGE OF GROUND WATER IN CENTRAL AND SOUTHERN CALIFORNIA

R.B. HICKOK, U.S. Dept. of Agriculture, *Lompoc, California*

Objective: Prediction of ground water recharge by direct rainfall penetration and absorption of runoff.

Plan of Work: Trace movement of infiltrated rainfall and runoff abstractions through upland soils and valley fill materials, relating amounts penetrating beyond root zones to climate and watershed conditions.

SUPPORTED BY U.S. Dept. of Agriculture

3.0064, ENGINEERING SERVICES - 50-150 MM GALLON PER DAY MULTISTAGE, MULTIFLASH DESALINATION PROCESS

F.J. DONNELLY, Fluor Corporation, *Los Angeles, California* 90022

Act as technical representative for the Office of Saline Water to review engineering, design, drawings, specifications and schedules for a 50-150 MM gallon per day multistage, multiflash desalination process. Work includes investigations pertaining to desalting technology as follows: 1. Process optimization considering brine concentration, tubeside brine velocity, brine blowdown temperature, stage lengths, fouling factors, heat transfer coefficients, flow distributions and stage equalization. 2. Study part load operation, including economic studies, as influenced by number of pumps, isolating valves, use of variable orifices and brine velocities. 3. Evaluate materials. 4. Study use of multistage versus single stage vertical centrifugal pumps and wet pit versus dry pit applications. 5. Monitor and consult with OSW on a simulation program now under development. 6. Study alternative noncondensible gas removal systems as they relate to operation, maintenance and compatibility with power plant requirements. 7. Evaluate technology for application to large desalting plants including decarbonation techniques, flash chamber performance and test module operating results.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0065, THE EFFECT OF ORGANIC INHIBITORS ON THE DISSOLUTION KINETICS OF IRON

K. NOBE, Univ. of California, School of Engineering, *Los Angeles - U.C.L.A., California* 90024

This research program is for investigation of the inhibition of iron corrosion by organic compounds and for study of the mechanism of this inhibition in the absence and presence of chloride ions. Pertinent electrochemical parameters will be examined for pure and impure iron electrodes in both inhibited and uninhibited systems. The corrosion data obtained will be compared with the behavior predicted by recently developed theories. The investigation can be expected to result in a greater fundamental understanding of metallic corrosion and further insight into the mechanism of corrosion inhibition.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0066, GEL SEPARATION PROCESSES FOR SALINE SOLUTIONS

R.L. PECSOK, Univ. of California, Graduate School, *Los Angeles — U.C.L.A., California* 90024

In this study we will attempt to identify and define quantitatively the various mechanisms operating on the separation of simple ions and small molecules on existing gels. The approach to the elucidation of the mechanism will be a comparison of partition coefficients of various ions and compounds determined under special conditions. For example, variation of solute size and gel cross-linking will indicate the extent of the geometrical effect, while variations in flow rate will indicate the extent of restricted diffusion. Finally variation of ionic strength of the eluent, concentration of the solute, temperature, and degree and type of fixed charges in the network will indicate the degree of the various ionic mechanisms: ion exchange, ion retardation, and ion exclusion. Whatever the mechanism(s), new gels will then be synthesized which will enhance the exclusion of small ions. Hopefully then, sodium chloride will be excluded from the new gel material just as cobalt and nickel tris-ethylenediamine salts are excluded from Sephadex G-10.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0067, POTENTIAL APPLICATIONS OF NUCLEAR EXPLOSIVES IN WATER RESOURCE DEVELOPMENT

A.M. PIPER, U.S. Dept. of Interior, Water Resources Division, *Menlo Park, California*

At the request of the Atomic Energy Commission, the project seeks to delineate the hydrologic situations in which nuclear explosives might be used to advantage, and limitations on such use including potentially hazardous side effects. Three phases of study are contemplated: (1) Delineate physical, and hydrologic principles; (2) Identify type areas and sites, both within and beyond the United States, that match limiting specifications for an advantageous use of nuclear explosive. For certain of these, appraise potential hydrologic advantage and disadvantage in relation to legal, economic, and other non-hydrologic limitations; (3) Hopefully and ultimately to identify a site or sites suitable for demonstrating principles by a test detonation or detonations.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

3.0068, RESEARCH ON POROUS GLASS MEMBRANES FOR REVERSE OSMOSIS

G.A. GUTER, Mcdonnell Douglas Corporation, *Newport Beach, California*

The objectives of this research are to conduct exploratory studies entailing the characterization and assessment of the potential of various porous hollow glass filaments for use in the desalination and purification of brackish and other contaminated waters by the reverse osmosis process. Special hollow glass filaments will be prepared having a composition containing SiO_2-B_2O_3-K_2O and SiO_2-B_2O_3-Li_2O. Other materials such as calcium, strontium and barium will be added to modify the silica network. The fabrication of porous glass involving heat treatment, leaching, washing and partial firing will be modified to determine the optimum conditions for obtaining good reverse osmosis membranes. These membranes will be tested with sodium chloride solutions ranging in composition from 1000 ppm to 15,000 ppm. Pressures of 600 and 1500 psi will be used in the reverse osmosis experiments. Other studies using porous glass membranes will be conducted to test their use in the purification of space cabin waste water. Based upon these results, a demonstration unit capability of purifying the water for one man per day will be designed, fabricated and tested.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0069, 14-01-0001-1760 -- IN-SITU FORMATION OF REGENERATIVE CELLULOSE ACETATE MEMBRANES ON POROUS SUPPORTS

G.A. GUTER, Mcdonnell Douglas Corporation, *Newport Beach, California*

The objective of this program is to develop regenerative cast membranes with performance equivalent to films cast by other procedures. Membranes will be coated on ceramic and other porous tubes with varying casting solution compositions and procedures. Films will be made by alternately coating the tubes in casting solution, repeating this procedure until the desired film thickness is built-up, and finally the film will be cured in water by the standard procedure. Casting and testing apparently will be developed for evaluation of films produced on 9‘ long tubes. Commercially available ceramic tubes will be used for outside surface coating, and 1‘ diameter porous pipe will be used for inside surface coating. Films prepared in the above manner will be tested at 600 psi with 3000 ppm sodium chloride feed. Based on the data obtained from this study, a conceptual design for a 50,000 GPD regenerable membrane reverse osmosis unit will be developed.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0070, REVERSE OSMOSIS TUBULAR MODULE OPTIMIZATION

W. BAERG, Philco Ford Corporation, *Newport Beach, California*

a. Derive mathematical expressions relating the design and operating variables pertinent to reverse osmosis tubular module optimization. Using reasonable approximations, develop simplified solutions to find the most important variables and their ranges of greater interest. b. Carry out more exact machine computations of optimum design and operating conditions on a variety of cases of practical interest, i.e., for selected feed conditions, plant capacities, and membrane performance characteristics, agreed upon with the Government Project Monitor. c. Obtain experimental data on various tubular membranes (e.g., characterized by a range of heating temperatures and casting solution formulations) of salt rejection and product water flux for a range of values of the operating pressure and temperature, feed composition, and flow velocity. d. Integrate the results obtained in (c) with the computations of (b) to provide a set of practical design data for scaleup to an appropriate pilot plant scale in concurrence with the Government Project Monitor.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0071, DETERMINATION OF THE SURFACE AND COLLOIDAL CONDITIONS WHICH CAN LEAD TO HIGH SALT REJECTION REVERSE OSMOSIS POLYMER MEMBRANES

R.E. KESTING, Philco Ford Corporation, *Newport Beach, California*

The ultimate goal of the program is to improve the economics of the Reverse Osmosis Process by developing membranes which will exhibit a higher product flux for a given degree of permselectivity. A unified surface and colloidal chemical approach is being utilized to this end. In the surface chemistry portion of the program, the nature of the quasi liquid membranes which form spontaneously as a result of the surfactant capacities of certain feed additives and which act in series with Reverse Osmosis membranes to increase the latter's salt retention is being investigated. In the colloidal chemistry section, correlations are being sought between isotropy (as determined by light scattering measurements) in the polymer solutions from which membranes are made and the performance characteristics of the membranes themselves. The basic a priori postulate is that gel isotropy (in a plane parallel to the membrane surface) is attributable to and preceded by sol isotropy. Thus the ‘equivalent pore size‘ distribution may hopefully be lowered and salt retention increased by controlling sol isotropy.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0072, BRACKISH WATER FIELD TEST EVALUATION OF MEMBRANE PROCESSES

L.P. CARPENTER, Henry J. Kaiser Company, *Oakland, California* 94103

This contract was proposed to evaluate the desalting efficiency and economics of the membrane-based desalination processes and/or plant designs on a selected number of natural brackish waters under actual field service conditions. Results will be used to establish the economic potential of each candidate process and/or plant design being evaluated from scale-up to commercial application. Included in the study will be field evaluation testing of four membrane desalting pilot plants by using alternate pretreatment systems on a number of representative natural brackish waters at the Mobile Test Facility. The work will be accomplished in three phases which are: the design of the Mobile Test Facility; the preparation of this facility; and finally, field evaluation testing.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0073, PARAMETRIC ECONOMIC AND ENGINEERING STUDY OF THE REVERSE OSMOSIS PROCESS

V.S. IVINS, Westinghouse Electric Corp., *Orange, California*

The objective of this contract is to conduct a comparative engineering and economic evaluation of present technology reverse osmosis reference plant designs such as plate and frame, spiral, tubular and hollow fine fiber. Based on the results of this study, detailed capital and annual operating cost estimates for each reference plant design with capacities of 1, 10, and 50 mgd will be developed. Critical components, materials and design parameters for each design which contribute significantly to product water costs will be identified. Those areas associated with each critical parameter which have high probability for improvement with additional research and development will be specified. The second set of cost estimates for each design and plant size studied is to be based on projected technology membrane costs, membrane flux rates and life characteristics.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0074, THREE BASIC PROBLEMS IN FLUID MECHANICS EVAPORATIVE CONVECTION, ELECTRO-OSMOSIS, INTERNAL WAVES

A. ACRIVOS, Stanford University, School of Engineering, *Palo Alto - Stanford, California* 94305

Evaporative Convection: A central problem here is the determination of the detailed structure of the convective flow. We have already shown experimentally, using schlieren photography, that these flow patterns belong generally to one of four categories depending on the depth of the liquid layer, the evaporation rate, and on whether the convection is driven by buoyancy or surface tension. The experimental investigations, which are continuing, will be supplemented by a numerical analysis of the equation of change using a high speed computer, for the purpose of developing a theoretical model for this important phenomenon. Special attention will be focused on the role played by surface active agents and on whether their ability to dampen the overall convection is related in any way to their propensity to suppress evaporation.

Electro-osmosis: The purpose of this new research program is to study how the presence of an electro-osmotic motion near a solid interface will affect the rate of mass transfer to such a surface.

Internal Waves: Here we propose to investigate various classes of flows, such as internal waves, that owe their very existence to the presence of density gradients inside the fluid such as those existing for example in various parts of the oceans.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0075, TRANSPORT PHENOMENA IN FUSED ORGANIC SALTS

J.E. LIND, Stanford University, School of Engineering, *Palo Alto — Stanford, California* 94305 (14-01-0001-1683)

The basic question to be answered is how do the coulombic forces in a dense fluid affect the structure and the transport properties of the fluid. The answer to this question may be relevant to the understanding of interfaces of high concentration as in reverse osmosis. The viscosity and diffusion coefficients of salts with identical isoelectronic anions and cations are being compared with fluids of uncharged molecules which are isoelectronic to the salt ions. Their thermodynamic and transport properties are measured under pressure and the salt properties are compared with those of the nonelectrolyte at the same volume and temperature. These measurements permit comparison with statistical mechanical models and thus a structural interpretation is possible. The systems of interest are tetra-alkylammonium tetra- alkylboride salts and their hydrocarbon analogues.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0076, A STUDY OF THE HYDROLOGIC EFFECTS OF RAINFALL AUGMENTATION

R.K. LINSLEY, Stanford University, School of Engineering, *Palo Alto - Stanford, California* 94305

It is proposed to use a water-shed model, which effectively simulates the behavior of watersheds on a digital computer, as a basis for evaluating the probable hydrologic effects of rainfall augmentation for watersheds typical of several regions of the country. With this model it is planned to assess the available reservoir storage, flood peaks, soil moisture, actual evapotranspiration, and possibly suspended sediment production.

Specifically it is proposed that six watersheds be selected as representative of typical climatological and hydrologic regimes of the United States. Each watershed will be modeled; that is, necessary parameters for hydrologic model will be determined by a study of actual records. Actual rainfall over a period of thirty years will be fed into the computer as input, with appropriate instructions to increase the observed amounts to simulate rainfall augmentation by 5, 10, and 15 per cent. The outputs in the form of evapotranspiration, soil moisture, stream flow, flood peak frequency, sediment yield, and other factors will then be computed for the thirty year period and compared with the actual occurrences to determine the possible effect of rainfall increase. In addition to presenting the effects as calculated for each watershed, generalizations will be made so that the data may be used to estimate probable effects of seeding on other watersheds. In addition to answering many of the hydrologic questions regarding the effect of rainfall increase on streamflow, soil moisture, etc. the proposed analysis should provide information which could be of value to meteorologists and biologists in considering other side effects of rainfall augmentation.

SUPPORTED BY U.S. National Science Foundation

3.0077, OPTIMAL DESALINATION BY GEOMETRIC PROGRAMMING AND MATHEMATICAL DECOMPOSITION

D.J. WILDE, Stanford University, School of Engineering, *Palo Alto - Stanford, California* 94305

Certain novel optimization methods, which may be particularly suitable for desalination systems, will be investigated. One method is geometric programming, an elegant body of theory which not only can solve nonlinear optimization problems of the sort arising in desalination technology, but also can generate design rules for adapting desalination systems to changing economic and technological conditions. The other deals with decomposition principles for exploiting the structure of systems of weakly interacting components, not only to find the system optimum, but also to study the sensitivity of this optimum to uncertainty in cost estimates, design specifications, and performance of the components.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0078, MINIMUM WATER SANITARY SYSTEM

C. HOFFMAN, U.S. Navy, Civil Engineering Lab. , *Port Hueneme - Point Mugu, California*

Technical Objective: Investigate new concepts for the collection treatment and disposal of waste water in polar camps, and develop systems and components which are convenient to use, simple and inexpensive to operate, and which minimize pollution of the polar environment.

Approach: Develop and evaluate toilet units requiring little or no fresh water for flushing and investigate economic and sanitary methods and systems for the disposal of collected waste.

Progress: May 1966 through December 1966. A mechanical flush chemical toilet was developed. The unique feature of this unit is simplicity, other significant features include low cost, reliable sanitary operation, odor control and minimum water usage. Pollution control studies indicate that a control incinerator servicing all waste centers would provide an effective means of pollution control. Studies are continuing on the feasibility of using synthetic nonfreezing waste- carriage media. A literature review is being made to collect data on threat to health of polar camp personnel posed by viruses in human waste. N L Drobny, Mechanical-flush chemical toilet, tech rpt R-471, Aug 66.

SUPPORTED BY U.S. Dept. of Defense - Navy

3.0079, TEST OPERATION OF A 2,500 GPD TWO-STAGE SEA WATER REVERSE OSMOSIS PILOT PLANT

J.S. WILLIAMS, U.S. Navy, Civil Engineering Lab. , *Port Hueneme - Point Mugu, California*

The purpose of this program is to establish optimum operating conditions and economics of sea water desalination in a two-stage tubular reverse osmosis system. Through test operation on a natural sea water, the design integrity of the tubular design pilot plant and its components will be determined. The effective service life of the newly developed pyridine based cellulose acetate membrane for sea water desalination application will also be determined as well as the optimum pretreatment methods, operating conditions and desalting costs of sea water desalination in a two-stage tubular reverse osmosis system.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0080, A STUDY OF THE EFFECTS OF SURFACE POTENTIAL ON SCALE FORMATION

B.D. MARCUS, T R W Incorporated, *Redondo Beach, California*

This program is a continuation of one recently carried out under Contract No. 14-01-0001-646. In that effort it was shown that radioisotope techniques (in particular, autoradiography) were powerful tools in monitoring the early stages of scale formation on metal surfaces. Using such techniques, it was demonstrated that control of the electrical potential of the surface could substantially alter the rate of formation of calcium sulfate scale on platinum surfaces in supersaturated solutions. This was a significant finding in that it may be feasible to utilize this phenomenon to control the formation of scale in desalination equipment.

The purpose of the current program is to examine this phenomenon in detail as a function of system parameters such as temperature, concentration, pH, etc. In addition, efforts will be made to relate the observed behavior to the fundamental mechanisms of scale nucleation and growth. In particular, it is suspected that heterogeneous nucleation of scale involves an adsorption step which can be influenced by the surface potential.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0081, SEPHTON FLASH TUBE (VORTEX TUBE) PROCESS

H.H. SEPHTON, Univ. of California, School of Engineering, *Richmond, California* 94804

The objective of this project is to evaluate a novel method of fluid flow control as applied to a falling film of evaporating saline water and its vapor flowing through vertical distillation tubes with the purpose of enhancing heat flux through the wall of such tubes. This flow control is effected by imposing a continuous vortex upon the fluid in the tubes by a helical baffle inserted therein.

A vertical tube evaporator (VTE) test facility was constructed providing for the simultaneous comparative testing of pairs of vertical distillation tubes. Each pair is tested, one as a vortex tube with helical insert against the other as a reference tube without insert. Tube types and sizes are identical with those used in large plant operation and process conditions are controlled within limits determined by actual or proposed large VTE plant operation.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0082, MULTICOMPONENT FIXED-BED ION EXCHANGE IN THE TREATMENT OF SALINE WATER

T. VERMEULEN, Univ. of California, School of Engineering, *Richmond, California* 94804

In the continuing study of rate-limited column performance, the general expression for mass transfer within any rate-controlled phase (developed recently in this program) will be used to interpret experimental studies of H -Na -Ag and H -Ca -Mg systems with Duolite C-25 and Dowex 50W resins under separate conditions where pore diffusion, solid-diffusion, or external-mass-transfer control will be considered. Mathematical study of the column for ternary (and perhaps higher) systems will also be continued.

Numerous proposals to remove salt from saline waters by means of ion exchange accompanied by chemical reaction or phase change have been made in recent years. It is planned that specific systems of potential practical interest will be calculated by multicomponent equilibrium theory and an experimental verification of the results will be made.

Regenerant level, concentration, flow rates, number and arrangement of columns, and other variables usually controlling dynamic column performance affect the economic design of multicyclic fixed-bed operation. Pending objectives of the present study are the elaboration of a binary design method and its extention of multicomponent operation.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0083, PRINCIPLES AND PRACTICES FOR SALINITY CONTROL IN THE SOIL-WATER-PLANT SYSTEM

C.A. BOWER, U.S. Dept. of Agriculture, *Riverside, California*

Objectives: Develop principles, formulas, and practices (1) to ameliorate and prevent accumulations of salts and exchangeable sodium in soils, and (2) to minimize the adverse effects of accumulations on plants and soils.

Plan of Work: Use theory, instruments, lysimeters, models and field studies to determine drainage conditions and requirements and to develop improved drainage designs and materials in relation to soil and water properties, boundary conditions, irrigation methods and crops. Determine most efficient and economical means of leaching salts and replacing exchangeable sodium by applying waters and amendments in various ways and amounts to soil in laboratory columns, lysimeters and field plots. By field and laboratory studies develop tillage, and soil, water and crop management practices to improve soil permeability and tilth. In lysimeters and field plots determine leaching requirements for sustained high crop yields in relation to salinity of irrigation water, salt tolerance of crops, depth to water table and irrigation practices. Using field plots, devise special land-forming, planting and irrigation practices for minimizing adverse effects of salts and exchangeable sodium on plants.

SUPPORTED BY U.S. Dept. of Agriculture

3.0084, WATER QUALITY, AND THE CHEMISTRY, MINERALOGY AND BIOLOGY OF SALTAFFECTED SOILS

C.A. BOWER, U.S. Dept. of Agriculture, *Riverside, California*

Objective: Determine the relations between dissolved, adsorbed and precipitated soil salts, the effect of soil composition and water quality upon these relations, and the effect of salt distribution on the physical and chemical properties of soils.

Plan of Work: Determine equilibrium relations between dissolved, adsorbed and precipitated soil constituents. Monitor effluent composition from laboratory soil columns, and determine steady-state and transient concentrations within the columns. Determine the effects of solution composition and soil additives on soil physical and chemical properties, relating differences obtained to soil composition wherever possible. Extend laboratory results to the greenhouse and field, to test applicability in a dynamic system. Develop general principles for predicting the above phenomena, and integrate these principles into a satisfactory theory for predicting irrigation water suitability and effects under a wide range of conditions. Apply these principles to data obtained from irrigation projects, to assess their general applicability, the potential for reuse of water, and the extent to which satisfactory salt balance can be achieved.

SUPPORTED BY U.S. Dept. of Agriculture

3.0085, RELATION OF SALINITY TO STATE AND TRANSPORT OF WATER AND IONS IN SOIL AND PLANTS

C.A. BOWER, U.S. Dept. of Agriculture, *Riverside, California*

Objective: Develop a quantitative understanding of transport and energy status of water and ions in the soil-plant-atmosphere continuum as affected by the physical environment.

Plan of Work: Develop and improve techniques for in situ measurement of the components of the water potential in soil and plants. Determine the extent of the interdependence of the osmotic and matrix components of the water potential. Characterize the environment of plant roots with respect to ions and energy level of water. Relate uptake of ions and water by roots to their respective concentrations and energy levels at the root. Formulate, test, and improve mathematical and physical models for prediction of transport of water and ions through plants as influenced by root geometry, distribution of water and ions in the soil as functions of time and depth, magnitude and distribution among components of plant water potential, and vapor concentration gradient at the leaf surfaces.

SUPPORTED BY U.S. Dept. of Agriculture

3.0086, SOILS AND NUTRIENT CULTURE EXPERIMENTS TO DETERMINE THE EFFECTS OF VARIABLE SALINITY CONDITIONS ON CITRUS BEHAVIOR

F.T. BINGHAM, Univ. of California, Agricultural Experiment Sta., *Riverside, California* 92502

Study salinity tolerance of citrus under field conditions where variable salinity conditions are built up in soil from use of irrigation waters of different quality; measure behavior of citrus trees with respect to yield, size, and quality under varying patterns of salinity with respect to vertical distribution in profile and chemical characteristics; use same rootstock top combination and under same climatic conditions set up in solution cultures with graded salinity contents with salinity same through root zone but salinity varying from point to point in soil profile.

DESCRIPTION OF WORK - Field studies at Riverside are underway using Valencia trees budded on Troyer rootstock. Four treatments are to include: (1) water of excellent quality, (2) water of the ionic composition of Colorado River water, (3) water synthesized to approximate twice the ionic composition of Colorado River water, and (4) water synthesized to approximate 220 ppm Cl, low SO4, and give a 50-50 NA-Ca ratio. Trees are basined and each treatment includes 20 individual tree replicates. Solution culture studies designed to approximate soil solution concentrations in the field are planned.

3. WATER SUPPLY AUGMENTATION AND CONSERVATION

SUPPORTED BY U.S. Dept. of Agriculture
California State Government

3.0087, BORON CHARACTERISTICS AND RECLAMATION NEEDS OF SOILS IN WESTERN KERN COUNTY

F.T. BINGHAM, Univ. of California, Agricultural Experiment Sta. , *Riverside, California* 92502

Objectives are three-fold: 1. To characterize mineralogically and chemically, selected soils from Kern County representing significant acreages in need of reclamation. 2. To obtain detailed information of certain soil reactions that bear upon reclamation (boron desorption, cation exchange, salt movement, and water flow). 3. To test, under laboratory conditions, various reclamation techniques.

The project entails selection of representative samples from the field taken in conjunction with a semi-detailed soil survey and taking samples to the laboratory for detailed study.

SUPPORTED BY California State Government

3.0088, THE EFFECTS OF FLUORIDES IN AIR, WATER AND SOIL ON GROWTH, QUALITY AND YIELDS OF TREE, FIELD AND VEGETABLE CROPS

R.F. BREWER, Univ. of California, Agricultural Experiment Sta. , *Riverside, California* 92502

Objectives: 1. Determine effects of F accumulation on plant growth, crop yields and product quality. 2. Determine interrelationship between F and other plant constituents such as Ca, P, Zn, Mn, and Al. 3. Investigate the feasibility of protecting F-sensitive crops from F-polluted air by modification of cultural practices. 4. Study the physical and chemical effects of F-containing irrigation waters on western soils.

Description of Work Proposed: Test plants will be exposed to known concentrations of HF in the air or will be sprayed with dilute NaF or HF sprays to study effects on growth, yields, fruit quality and nutrient content. Calcium sprays will be applied to greenhouse and field plants exposed to F to determine feasibility of obtaining protection. Western soils irrigated with F-containg waters will be examined for physical and chemical changes.

SUPPORTED BY California State Government

3.0089, INCREASING CHAPARRAL WATERSHED YIELD THROUGH IMPROVED USE OF PHENOXY-TYPE HERBICIDES

J.R. GOODIN, Univ. of California, School of Agriculture, *Riverside, California* 92502

This project studies the influence of environment on the translocation of herbicides in resprouting chaparral species. Specifically, soil moisture, soil and ambient temperature, light, and humidity will be investigated in an attempt to find the correct combination of environmental factors which will lead to the greatest chance for success in causing a growth-regulating chemical to be translocated into the crown region. The following will be employed:

1. Labelled and unlabelled phenoxy-type herbicides will be used to study the rate and degree of absorption and translocation as influenced by soil moisture stress. 2. Other environmental factors such as air and soil temperature, relative humidity, and light will be investigated with respect to their influence on translocation of herbicides.

Laboratory data achieved under precisely controlled conditions will be correlated with field data obtained in this project and in WRC Project No. W121-5U-69.

SUPPORTED BY University of California

3.0090, COOPERATIVE RESEARCH ON SOIL AND WATER MANAGEMENT OF DRY-FARM GRAINLAND AND RELATED LANDS

R.E. LUEBS, Univ. of California, Agricultural Experiment Sta. , *Riverside, California* 92502

Objective: To develop effective soil and water management practices for conserving soil and water, and particularly to improve the efficiency of moisture use in a dry, mild winter climate.

Discription of work proposed: The following studies involving field, laboratory, and greenhouse experiments are proposed: (1) Measuring evaporative moisture losses from different soils during the rainless summer to evaluate fallow: (2) comparing several feasible tillage systems for their effect on moisture storage with fallow; (3) measuring moisture use efficiency for forage and grain crops under the prevailing low and erratic rainfall; and (4) determining optimum nitrogen availability for different levels of available moisture and for different methods of plant residue management.

SUPPORTED BY California State Government

3.0091, SURFACE AND SUBSURFACE IRRIGATION SYSTEMS FOR COASTAL CALIFORNIA

P. NIXON, Univ. of California, Agricultural Experiment Sta. , *Riverside, California* 92502

Objective: To develop methods and practices for irrigation of field and row crops and provide maximum efficiency of water used with a minimum buildup of saline elements.

Plan of Work: Continue collection of inflow-outflow of water, nutrient, and salt balance on 1000-acre citrus crop watershed. Continue replicated presalinized field plot, research on irrigation of potatoes to maintain high productivity and favorable salt balance. conduct field and laboratory tests of materials and devices for subirrigation of tree and row crops. Develop methods for installing and removing subirrigation systems. Conduct laboratory and field tests of saturated and unsaturated flow of moisture away from the subsurface irrigation system. Design optimum location of subirrigation device with respect to crop type and root zone.

SUPPORTED BY U.S. Dept. of Agriculture

3.0092, WATER USE UNDER DRYLAND CONDITIONS IN COASTAL VALLEYS OF CALIFORNIA

W.F. SPENCER, Univ. of California, Agricultural Experiment Sta. , *Riverside, California* 92502

Objective: To develop principles and practices for more efficient and effective use of precipitation on crop and rangelands in the coastal valleys of California.

Plan of Work: Field, laboratory, and greenhouse experiments will be conducted to determine proper cropping systems, sequences, cultural practices, fertilization, and combinations thereof necessary for maximum moisture utilization, optimum crop productivity, and maintenance of soil productivity. The work includes studies of climatic factors affecting water use, factors affecting infiltration, storage of water in soil, evaporation from the surface, the effect of concentrating rainfall, the interrelationships between timing of nitrogen fertilization and moisture availability in relation to stage of plant growth. In field trials different fertilizer rates will be applied to forage and grain crops, yields, quality of product, leaf area, root development, moisture use, and various climatic factors will be measured. The technique of adding soil moisture is used to secure better control of the moisture variable and lysimenters are used to more accurately estimate evapotranspiration.

SUPPORTED BY U.S. Dept. of Agriculture

3.0093, REGION 2 - WEED CONTROL

R.G. HOWARD, State Dept. of Water Resources, *Sacramento, California*

Cooperative study of Aquatic Weed Problems in irrigation and drainage systems to include the following: (1) Conduct life history studies of submersed and emersed Aquatic weed infesting large channels, lakes and reservoirs. (2) Field testing promising chemicals and mechanical devices for the control of submersed and emersed Aquatic weeds in large irrigation channels, lakes and reservoirs. (3) Study the environmental requirements of Aquatic weeds in irrigation canals and ponds with emphasis on intensity and quality of light, water quality, and mineral nutrient supply. Investigate potential ecological competition with weed pests. (4) Conduct adsorption isotherm studies on Aquatic soils with chemicals recommended for control of Aquatic weeds. (5) Determine effects upon different Aquatic weeds of various rates, formation and timing of application of selected herbicides in test canals. (6) Study effects of varying ecologic conditions and various chemical treatments upon Aquatic biota such as clams, sponges, bryzoa, etc.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

3.0094, WEED CONTROL IN IRRIGATION AND DRAINAGE SYSTEMS

R.R. YEO, State Dept. of Water Resources, *Sacramento, California*

Cooperative study of the Aquatic Weed Problems in irrigation and drainage systems to include the following: (1) Conduct life history studies of submersed and emersed Aquatic weed infesting large channels, lakes and reservoirs. (2) Field testing promising chemicals and mechanical devices for the control of submersed and emersed Aquatic weeds in large irrigation channels, lakes and reservoirs. (3) Study the environmental requirements of Aquatic weeds in irrigation channels and ponds with emphasis on intensity and quality of light, water quality, and mineral nutrient supply. Investigate potential ecological competition with weed pests. (4) Conduct adsorption isotherm studies on Aquatic soils with chemicals recommended for control of Aquatic weeds. (5) Determine effects upon different Aquatic weeds of various rates, formation and timing of application of selected herbicides in test canals. (6) Study effects of varying ecologic conditions and various chemical treatments upon Aquatic biota such as clams, sponges, bryozoa, etc.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

3.0095, DEVELOPMENT AND TESTING OF LARGE, SPIRAL-WOUND, MULTI-LEAF REVERSE OSMOSIS MODULES

T.J. LARSON, General Dynamics Corporation, *San Diego, California*

This contract is comprised of four main tasks. The first is to conduct a detailed evaluation of backing materials in order to arrive at an acceptable material selection for large modules. Each materials' cost and availability will be considered as well as its performance. In the second task, modifications to the internal module configuration will be evaluated in an effort to arrive at an acceptable design for large modules. Construction and the testing of experimental modules will be undertaken as required to assist in the evaluation of the various problem areas. Phase III includes conducting detailed evaluation of materials handling problems, configuration, support requirements; and the fabrication and testing of modules to establish an acceptable rolling technique for large modules. The last task is to carry out detailed tests on selected modules for the evaluation of various assembly methods.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0096, RESEARCH ON IMPROVED REVERSE OSMOSIS MEMBRANES

H.K. LONSDALE, General Dynamics Corporation, *San Diego, California*

This research is directed toward the characterization of modified (Loeb-Sourirajan type) cellulose acetate membranes and the development of ultrathin film-composite membranes for desalination by the reverse osmosis process. The properties of modified membranes to be examined are membrane compaction and useful life, and imperfections which lead to reduced semipermeability. Techniques are being sought for the preparation of ultrathin films (2000 Angstrom units thick) of cellulose acetates and a crosslinked polyvinylpyrrolidone system, and of suitable porous support membranes for these films, and of methods for incorporating thin films and porous supports into composite membranes with reverse osmosis properties superior to those of the modified membranes.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0097, STUDY OF REJECTION OF VARIOUS SOLUTES BY REVERSE OSMOSIS MEMBRANES

H.K. LONSDALE, General Dynamics Corporation, *San Diego, California*

The purpose of this research is to measure the selectivity of well-characterized cellulose acetate reverse osmosis membrane of the Loeb-Sourirajan type to a number of inorganic and organic solutes of importance to water quality. The intrinsic permeability of cellulose acetate to these solutes will be measured by means of a sorption experiment and the solute rejection will be measured in reverse osmosis tests under conditions that will allow the results to be extrapolated to other experimental conditions. Among the solutes of interest are ammonium, nitrate, bicarbonate, and phosphate salts, boric acid, a simple sugar, a chlorinated hydrocarbon, and urea. Methods for improving the rejection of some of these species will also be examined.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0098, TEST OPERATION OF A TUBULAR 4,300 GPD REVERSE OSMOSIS UNIT ON SEA WATER

J.C. CLIPP, Havens Industries, *San Diego, California* 90034

The objective of this contract is to advance the development of reverse osmosis processes for sea water desalination. Under this program, optimum operating conditions and preliminary economics of salt water desalination in a two-stage reverse osmosis system will be established. The Reverse Osmosis unit at the Clair Engle Test Facility in Chula Vista, California will be operated for a 90-day period during which specific observations will be evaluated and recorded. The membrane system will be modernized and various instruments will be employed in order that detailed and accurate recording and analysis of the pertinent data may be made.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0099, APPLICATION OF IRON-ALUMINUM BASE ALLOYS TO SALINE WATER CONVERSION

C.E. SMELTZER, Internat. Harvester Co. , *San Diego, California* (14-01-0001-1796)

In the flash-evaporator type of saline water converter, the cost of tubing becomes an important consideration. For reasons of low cost and ready availability, the ferrous alloys are being given serious conseideratin for these applications.

Alloys of iron and aluminum, made up of two of the most abundant elements in the earth's crust, should be of great interest from the viewpoint of economics. The Alfenol (Fe-A1) and Thermenol (Fe-A1-Mo) series exhibit stainless qualities and, in general, good corrosion resistance in various media. For example, the corrosion resistance of Thermenol is superior to both types 302 and 430 stainless steels in a 20 percent sodium chloride solution at 194 degrees F.

Purpose of this program is to systematically study the sea water corrosion properties of Alfenol and Thermenol type alloys, and to determine the effect of decreasing aluminum contents upon the overall corrosion resistance of these alloy systems. Hopefully, it will be possible to decrease substantially the aluminum content of these alloys, thereby greatly improving their ductility and still retain a sufficient degree of resistance to the corrosive sea water environment.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0100, BOUNDARY LAYER FLOW PROBLEMS IN DESALINATION BY REVERSE OSMOSIS

F.A. WILLIAMS, Univ. of California, School of Engineering, *San Diego - La Jolla, California* 92038

Theoretical and experimental research is being carried out on the reverse-osmosis method of water desalination. The discipline of the study is fluid dynamics. Velocity fields and salt concentration fields will be calculated theoretically and measured experimentally in a variety of flows which exhibit boundary-layer characteristics and which involve mass transfer through seimpermeable membrane walls. The membranes that will be employed will be those commonly used in reverse- osmosis devices for a water desalination. The geometries to be investigated first are steady laminar flow over a semiinfinite (semipermeable) flat plate and fully developed laminar flow in a two- dimensional channel with a semipermeable wall. The results of the research are expected to improve the accuracy of knowledge of osmotic properties of existing semipermeable barriers, to provide information concerning the onset of crystalization, and to clarify generally the process of salt buildup during reverse osmosis.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0101, PARAMETRIC ECONOMIC AND ENGINEERING EVALUATION STUDY OF THE ELECTRODIALYSIS PROCESS

A.J. ODONNELL, Bechtel Corporation, *San Francisco, California* 94119

This contract requires parametric engineering and economic evaluations of three basic electrodialysis designs of up to 50 mgd. The work is to be accomplished in five phases which include a state-of-the-art survey, an engineering and economic analysis, a component analysis, an economic analysis on the projected technology, and the preparation of a final report summarizing the study.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0102, THE ELECTROSORB PROCESS FOR DESALTING WATER

A.M. JOHNSON, Marquardt Corporation, *Van Nuys, California* 91409 (14-01-0001-1444)

Porous carbon electrode systems that display water desalting capability are under investigation. An understanding of the mechanism whereby such systems function is important for the attainment of the highest desalting performance that is consistent with long-term electrode durability. Mechanistic evidence that is presently available suggests the dominance of purely capacitive factors; but it is known that the responsiveness of a particular electrode to ions of one charge sign is dependent to an important extent upon the chemistry of the electrode's preparation. A theoretical model that appears to illuminate the behavior of known electrode-electrolyte systems is being developed with the aid of experimental tests.

The test program entails investigation of multivariable operating regimes, prepa ation and testing of novel electrode materials, and design construction and application of new test equipment. Feedwaters range from aqueous sodium chloride to simulated natural brackish waters.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0103, THE THERMOSORB PROCESS FOR DESALTING WATER

A.M. JOHNSON, Marquardt Corporation, *Van Nuys, California* 91409 (14-01-0001-1469)

A bed of suitably prepared porous carbons will sorb salt from low-temperature feedwater; introduction of hot feedwater then causes salt desorption. Practical sorbent beds in a works-scale unit are expected to operate between temperatures of about 20o and 80oC, permitting the use of low-cost heat. The functioning of a thermally modulated, carbon sorbent, desalting process is based upon the coupling of capacitive and ion-exchanging phenomena via the electron conductivity of the carbon sorbent matrix. Sorbent preparation and testing in progress is aimed toward the development of the most efficacious and durable salt sorbents that can be economically produced. As work progresses it is expected that system design will be initiated.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0104, THE ELECTROSORB PROCESS FOR DESALTING WATER

A.M. JOHNSON, Marquardt Corporation, *Van Nuys, California* 91409

Electrode systems based upon porous carbon are being investigated for desalting water. It is believed that the fundamental phenomena of desalting by these electrodes are those associated with capacitive charging of the extensive wetted surfaces supplied by the carbon. It is assumed that this behavior can be predicted from a knowledge of charge-versus-voltage function of a given surface for ionic species of interest, and that the nature of this function can be modified by suitable chemical pretreatment. Thus electrodes can be prepared especially for cation or for anion responsiveness. A theoretical model of these systems is being developed, analyzed, and compared with experimental results.

The test program includes preparation and testing of suitable electrode systems in terms of the theoretical model as well as in terms of performance level and of durability in the presence of various important ionic species. It also includes studies of variously pretreated carbons to determine their capacitive ion sorption characteristics. Design and performance optimization studies are planned to evaluate the potential of these systems for practical desalting applications.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0105, LIME MAGNESIUM CARBONATE PROCESS - SEA WATER SOFTENING PLANT

D.D. KAYS, Sterns Roger Corporation, *Denver, Colorado* 80204

Stearns-Roger has developed the system design and constructed a prototype facility competent to carry out research and development of the Lime-Magnesium Carbonate Process for pretreating sea water fed to evaporators. The plant has the capacity of treating approximately 3 MGD of sea water.

This pretreatment is a method of reducing the quantity of calcium present in the feed, thus reducing the solubility product and raising the temperature at which solid CaSO4 can form. In addition, bicarbonate can be removed, resulting in the precipitation of CaCO3. This has the potential of eliminating the present need for acidification. This modified sea water will then be suitable for evaporation at higher temperatures and, at the same time, less corrosion.

The prototype facility will provide process criteria for specifying and sizing of the clarifiers, reactors, and other equipment required for various size desalting plants.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0106, INVESTIGATIONS OF ALGAE INHIBITING MATERIALS

T.R. BARTLEY, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Attached aquatic organisms seriously reduce the carrying capacity of irrigation and water distribution structures. Laboratory and field studies show that by coating these structures with appropriate materials containing toxicants the organisms will not develop on the coated area. Coatings under study include antifouling paints, direct metal coatings to concentrate incorporation of toxicants in the concrete surface, and various other materials applied to the surface of the submerged concrete. The most promising results to date indicate that certain antifouling paints, a vinyl-resin system cuprous oxide or tributyl tin oxide, applied to submerged concrete will provide long-term inhibition of algae attachment. The present program has progressed sufficiently to provide recommendations for routine field use of specified materials on submerged concrete structures. These antifouling coatings are presently limited to small areas, such as concrete weirs and flumes, because of cost.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

3.0107, AROMATIC SOLVENT AQUATIC HERBICIDES AND EMULSIFYING AGENT TESTING

T.R. BARTLEY, U.S. Dept of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Certain aromatic hydrocarbon solvents are used extensively by the Bureau of Reclamation and cooperating irrigation districts for controlling submersed aquatic weeds. These materials are seldom available in quantity as formulated aquatic herbicides, but are often products of petroleum or coal-tar distillations that differ in makeup. Large-scale acquisition of these byproducts requires laboratory testing and evaluation for determining suitability as aquatic herbicides. Studies have shown that aromatic solvents must have specific physical and chemical properties, as well as proper dispersion in irrigation water by emulsifiers. Physical, chemical, and biological laboratory tests are conducted on samples of aromatic solvent materials and emulsifying compounds to determine whether they meet specifications and are effective as aquatic weed herbicides. These samples are submitted to the laboratory from Bureau field offices, manufacturers, and suppliers.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

3.0108, EFFECT OF COPPER SULFATE ON AQUATIC WEEDS

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Laboratory studies and experiments by other investigators have shown that copper has a pronounced effect on higher forms of aquatic vegetation. Copper has been used for many years as an effective algaecide. This study was undertaken to determine the effects of a semicontinuous feed of low concentrations of copper on the growth of aquatic weeds common to Western irrigation canals.

Small copper sulfate crystals are fed into the flowing water at a calculated rate based on water volume by means of an automatic feeding device equipped with a timer. The copper sulfate is fed into the water daily throughout most of the irrigation season. The aquatic weed growth will be observed frequently through the season to determine the effect of the treatment. Concentration of copper in the irrigation water will be monitored. Total alkalinity of water on copper concentrations is being investigated. Water temperature and other factors are investigated in this aquatic weed control study.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

3.0109, HERBICIDE RESIDUES

T.R. BARTLEY, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

It is important to know the level of herbicide that gets into irrigation water either through direct application to the water or through applications adjacent to the water. The amount of herbicide that accumulates in the aquatic plants and the aquatic and agricultural soils is also pertinent to a better understand and use of the weed control method being practiced.

Samples of water and sometimes aquatic plants, aquatic soils, and agricultural soils exposed to herbicide treatments are collected in and along irrigation canals for analysis of various herbicides commonly used for weed control on irrigation projects.

Herbicides such as 2,4-D, 2,4,5-T, xylene and acrolein copper, are being emphasized in this study. The level of herbicide present in samples will be measured through the use of gas chromatographic and atomic absorption spectrophotometric techniques.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

3.0110, SOLAR REFLECTANCE OF MONOLAYER-COVERED WATER SURFACES AS RELATED TO EVAPORATION SUPPRESSION

J.T. BEARD, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

A study is being made to determine the chemical substances which will substantially increase the solar reflectance of monolayer-covered water surfaces. The study includes determining the optical properties of these substances in the monolayer form. Known values for optical properties are limited to substances in the bulk form. Two basic categories of substances are under investigation: (1) Dyes, which by their general nature have a high coefficient of absorption in the visible energy wave lengths where most solar energy is found; and (2) polymers, wherein an increase in film thickness tends to increase the reflectance of films having certain optical properties.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

3.0111, WEED CONTROL AND REVEGETATION

C.L. DAVENPORT, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Work on the Rio Grande Project, Las Cruces Branch, New Mexico, consists of weed control demonstration on project right-of-way to ascertain most economical and effective means of controlling perennial grasses, woody plants and weeds to establish a permanent cover crop of adaptable grasses.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

3.0112, SURFACE FACILITIES FOR DISPOSAL OF DESALTING PLANT EFFLUENTS

L.M. ELLSPERMAN, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Objectives: To develop design criteria for surface facilities to be used in the disposal of desalting plant effluents.

Description of Work: a. Perform 'state of the art' bibliography, including literature and industry survey. b. Explore and evaluate soil samples from probable sites. c. Conduct a laboratory evaluation of the effectiveness of soil sealants and other lining materials with various brine effluents. d. Develop a monitoring system for continuous and routine measurements of seepage losses. f. Field test soil sealants and other lining materials and develop optimum methods of application. g. Prepare a manual on surface facilities for disposal of desalting plant effluents. h. Conduct an economic study of salt disposal.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0113, CONSUMPTIVE USE OF WATER BY SALT CEDARS

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Work being done on the Middle Rio Grande Project, near Bernardo, New Mexico, consists of three sets of lysimeters, each set consisting of three tanks, to be located in a representative area of salt cedars. One set, having a high water table, will be used as a control. The second set will be used to determine the effect of the rapid lowering of the water table. The third set will be located in a cleared area.

The purpose of the study is to (1) determine the change in consumptive use of salt cedars after the depth of groundwater has been rapidly increased; (2) determine the difference in consumptive use of water between cleared and uncleared areas; (3) to obtain data for comparison of consumptive use rates as determined for other areas and to appraise the validity of transferring such data to other areas.

During F. Y. 1965 routine operation and maintenance of the nine large and five small evapotranspirameters continued. Two vegetative density surveys were made of the salt cedar in the tanks and in the surrounding area. The tanks were flushed during November, but it was not necessary to add gypsum.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

3.0114, RADIO METHODS FOR DETERMINING WATER VAPOR CONTENT OF AIR

Q.L. FLOREY, U.S. Dept. of Interior, Evaporation Reduction Section, *Denver, Colorado* 80225

Study is a joint effort by the Environmental Science Services Administration and the Bureau of Reclamation in connection with the Lake Hefner field studies made during 1965,1966 and 1967. The Lake Hefner tests, which were designed to permit a comparison of several methods for determining evaporation losses and savings through the use of monomolecular films, also provides an ideal opportunity to measure the refraction of radio waves resulting from water vapor in the air and may result in a simple method for evaluating monomolecular films on large water surfaces.

The bulk aerodynamic and energy budget methods require extensive instrumentation and personnel and are indirect, empirical methods for estimating the evaporation in terms of other measurable parameters such as vapor pressure gradient, wind speed, and radiation balance. Results to date have been restricted to averages over periods of days to weeks. The study involves measurement of turbulent flux of water vapor both directly at a point and indirectly by the apparent variation of radio path length over distances of the order of several miles and comparing the indicated evaporation losses with those indicated by the various other methods to be utilized.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

3.0115, PROGRAM FOR FIELD EVALUATION OF REVERSE OSMOSIS PILOT PLANTS ON BRACKISH WATERS

D.H. FURUKAWA, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The objectives of this work are: to test operate reverse osmosis pilot plants on natural brackish waters at Roswell, New Mexico, and Dalpra Farm, Colorado, and to determine their operational characteristics; to obtain comparative data on the desalination performance characteristics of these units; to establish optimum operating conditions and pretreatment requirements for economic desalting of Roswell type brackish waters.

The scope of work will include: test operate pilot plants with blended brackish waters of 2,000 to 4,000 ppm at Roswell and 3,700 ppm at Dalpra Farm; establish optimum operating conditions, optimum feed water pretreatment requirements, and active service life of reverse osmosis membranes; conduct economic study and compare cost of desalting test brackish waters by different designs.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0116, PROGRAM FOR ELECTRODIALYSIS RESEARCH AND DEVELOPMENT

D.H. FURUKAWA, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The objectives of this work are: to establish long term effects on process characteristics and components for high temperature electrodialysis; to perform comparative evaluation tests on different neutral membranes using Dalpra Farm water supply as test water and commercial electrodialysis stacks as test vehicles.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0117, COMPARATIVE EVALUATION OF REVERSE OSMOSIS PILOT PLANTS OF DIFFERENT DESIGN CONFIGURATIONS

D.H. FURUKAWA, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The objective of this work is to obtain data on the design and performance characteristics of plate and frame, spiral, and tubular reverse osmosis systems through the test operation of 1,000 gpd pilot plant units on synthetic brackish waters under different test conditions. Based on test data, the design (or designs) will be identified that offers the most promise for immediate advancement to commercial application. Areas will be recommended where additional research and engineering efforts are needed to improve component reliability and performance capability of each design tested.

The general requirements of the work to be performed under the contract are as follows: 1. Operate pilot plants on synthetic waters under a preselected set of operating conditions and salinities. 2. Investigate the effect of changes in feed water salinity, feed water pH, and product to feed water ratio on the process efficiency and design integrity. 3. Investigate practical hydrodynamic methods of minimizing concentration polarization effects at the solution-membrane interface for each reverse osmosis unit design. 4. Develop standard test procedures to determine the performance characteristics of reverse osmosis membranes. 5. Identify potential areas where additional research and engineering efforts are likely to produce information helpful in lowering the cost of desalting brackish waters by reverse osmosis process. 6. Train the maintenance and operation contractor personnel to continue this test program in the OSW brackish water test center facility at Roswell, New Mexico. 7. Prepare a final report on results. With recommendations for further study.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0118, WEED CONTROL AND REVEGETATION

C. GUERRO, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Work on the Middle Rio Grande Project, New Mexico, consists of weed control demonstration on project right-of-way and river lands to ascertain the most economical and effective means of controlling woody plants. The funds for establishment of grasses for permanent vegetative cover have been applied to the control of woody plants.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

3.0119, WEED CONTROL AND REVEGETATION

A.L. HULBERT, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Work on the Rio Grande Project, Ysleta Branch, Texas, consists of weed control demonstration on project distribution and drain right- of-way to ascertain the most economical and effective means of controlling perennial grasses and weeds to establish a permanent cover crop of adaptable grasses.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

3.0120, HYDRAULIC MODEL STUDIES OF A PUMP INLET MANIFOLD

D.L. KING, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Because of the variable flow rates in the manifolds of flash distillation plants and the fact that the vapor pressure of the brine is near the flash point, there is a critical need for maintaining the design net positive suction head on the circulating pump and for eliminating vapor entraining vortices at the pump inlet.

A pump inlet system design has been verified by model tests to assure that design conditions for the pump suction will be met. The objective of the studies was to verify or, if necessary, to modify the design of the module inlet system so that it will be essentially free of vortex formation and excessive drawdown of the water surface.

Flow conditions in the evaporation channels immediately upstream from the manifold have also been investigated. The model is being retained to investigate any problems which might arise during operation of the prototype module.

Investigations to determine the head losses in the intermodule piping were completed.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0121, CONTROL OF WOODY PLANTS

W.D. LEIGON, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Work is being done on the Rio Grande Project, Caballo Reservoir, near Truth or Consequences, New Mexico. During the past years, a portion of this area has been aerial sprayed to determine the effectiveness of herbicides on woody plants when small volume applications are made. A new phase of program recently initiated with the State of New Mexico provides for removal of woody plants and control by various methods and root food reserve studies.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

3.0122, VALUE OF DESALTED WATER FOR IRRIGATION

J. MALETIC, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225 (14-01-0001-1241)

The technical objectives of this study are to make preliminary evaluation of the benefits that would accrue from using desalted water, at various quality levels, to augment and improve the water supply of three selected irrigated areas and to select a method for introducing desalted water into the existing irrigation systems of these areas. With the information noted above, the Office of Saline Water will be able to identify the design and operating criteria and the limiting economic constraints for desalting plants to be used for the application cited.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0123, SELECTION OF SITES FOR FIELD TESTING BRACKISH WATER CONVERSION UNITS

H.R. MCDONALD, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The objective of this work is to recommend sites for field testing brackish water conversion units, evaluate their suitability, and provide support services as requested. The Bureau of Reclamation will investigate, evaluate, and recommend sites suitable for conducting field operational tests of brackish water conversion units. Preference will be given to sites owned by or accessible to agencies of the Department of the Interior, in particular, the Federal Water Pollution Control Administration and the Bureau of Reclamation.

The test site should be available for a period of one or more years and should be of a size suitable for testing up to three brackish water conversion units simultaneously for purposes of comparison and to concentrate the need for support services to a few sites at a time. Reclamation has recommended a number of sites from which the required number will be selected by the Office of Saline Water as needed.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0124, BASIC INVESTIGATION OF HEAT AND MOISTURE TRANSFER ACROSS THE AIR-WATER INTERFACE

T.R. MEE, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

A laboratory study is being made of the heat and moisture transfer across the air-water interface. Particular attention is being given to the structure of the interface; the laminar layers above and below the surface; the modes of heat and mass transfer; and the nature of the physical and chemical parameters which govern the rate of mass transfer. An empirical model is being developed which will describe the physical process of water evaporation and the effects that air water temperature differences, wind and wave action, and laminar region thickness have on the process.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

3.0125, FIELD INVESTIGATION OF THE SUBMERSED AQUATIC ENVIRONMENT

N.E. OTTO, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Study of the ecological relationships of plants and animals in canal and reservoir environments are necessary to gain understanding of biological problems existing in these areas. Knowledge of environmental factors and interactions are essential to future improvement of aquatic weed and animal problems existing in irrigation distribution systems. Data have been collected from irrigation canals in three different geographical areas concerning the physical, chemical, and general biological aspects. Samples of soil, water, and biological materials are being collected for chemical and physical analyses in both weed-free and heavily infested canal sites. Observations are being made of all physical, chemical, and biological factors suspected as being important in the environment. Data obtained to date indicate that rooted submersed aquatic weeds are adapted to a wide range of environmental conditions, and no one specific set of factors nor interaction of factors has been demonstrated as being responsible for pondweed invasion and establishment in a canal system. Present emphasis on this phase of the aquatic pest investigations program is associated with more detailed study of the nutrient requirement of submersed aquatic weeds, including filamentous green algae.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

3.0126, FIELD EVALUATION OF SOIL-APPLIED HERBICIDE FOR TOTAL VEGETATION CONTROL

N.E. OTTO, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Twenty-two different soil-applied herbicide formulations are being evaluated for ability to provide complete control of vegetation. The initial herbicides under test were applied to replicated 1-square-rod plots at three different rates.

The study will be conducted for a minimum of 5 years on the original field test site. Data obtained will provide information useful to field operation personnel for improving non-selective herbicide applications and long-term vegetation control on areas where plant cover is undesirable. Evidence at the end of 4 years indicates that three of the newer formulations of herbicides are exhibiting more efficient vegetation control than most types presently under general use by the Bureau of Reclamation.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

3.0127, LABORATORY STUDY OF AQUATIC ENVIRONMENTAL FACTORS AND PLANT GROWTH STAGES ON AQUATIC WEED GROWTH AND HERBICIDAL RESPONSE

N.E. OTTO, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The effectiveness of aquatic herbicides often varies in the same canal system. The factors responsible for these variations in herbicidal response are seldom determined, but might be ascribed to variations in environment or plant material. Laboratory studies are being conducted to evaluate environmental factors, such as light, temperature, and plant growth stage on the development of aquatic weeds and response to herbicidal treatment. Laboratory studies are conducted in two controlled environmental growth chambers. Results show that controlled environmental variations of light and temperature exert considerable influence on the growth and development of two pondweed species studied. These studies also show that the morphological growth stage (relative age) attained by aquatic plants was a major determinant in the degree of injury obtained from treatment with two types of aquatic herbicides. Studies are conducted on a continuing basis as new aquatic herbicides and weed control techniques become available.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

3.0128, VALUE OF DESALTED WATER FOR IRRIGATION

H.L. PARKINSON, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Three irrigated study areas, located near Yuma, Arizona, Phoenix, Arizona, and Thermal, California, are being studied at reconnaissance level to determine the value of various water quality levels for irrigation. Improved water quality would be achieved by desalting brackish water in the 2000-5000 ppm range. Water quality levels of 400, 900, and 1500 ppm are being studied. Desalting costs are being developed for both Electrodialysis and Multistage Flash methods. Efforts are being made to maximize the possible benefits. Soil salinity is being held at optimal ranges for maximum production of selected crops by utilizing an adequate amount of deep percolation. Crops enterprise budgets are being used to evaluate potential direct benefits. Crop selection is carefully done to assure the best net income at each water quality level. Crops vary some between study areas.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

3.0129, A STUDY OF NATURAL EVAPORATION FROM FREE WATER SURFACES

R. PILIE, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

A laboratory and field investigation is being conducted to determine the quantitative relationship between wave characteristics, airflow characteristics, and evaporation rate. The microphysical processes that control the rate of mass transport across the water surface and how these processes change with wave activity particularly as influenced by monomolecular films, will also be studied. Field tests at Lake Hefner, Oklahoma will be conducted to develop methods of applying laboratory results to field situations.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

3.0130, EVAPORATION REDUCTION INVESTIGATIONS STUDY OF THE EFFECTS OF FATTY ALCOHOLS ON THE ECOLOGY OF LAKE HEFNER

J.K. SILVEY, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

A study is being made to determine the effects of fatty alcohols on the ecology, especially the bacteria and plankton population, of Lake Hefner.

Evaporation Reduction investigations utilizing various monolayer- forming fatty alcohol mixtures conducted at Lake Hefner during the summer and fall months of 1965, 1966, and 1967 provide an ideal opportunity to observe these effects, since records on bacteria and plankton populations under natural conditions are available for several years prior to the monolayer applications.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

3.0131, GREENHOUSE AND OUTDOOR NURSERY CULTURE OF SALTCEDAR PLANTS TO BE USED IN PHREATOPHYTE CONTROL PROGRAM

P.M. TURNER, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Plants for herbicide testing purposes are cultured in a greenhouse. Stem cuttings are used as propagating material. Saltcedars are also grown in a nursery and are used for field-type studies of phreatophyte control methods.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

3.0132, HERBICIDE EVALUATION FOR PHREATOPHYTE CONTROL

P.M. TURNER, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Phreatophytes cover 16 million acres along water courses in the 17 Western States and may consume 20 to 25 acre-feet of water annually. Economical methods of control, primarily chemical, have been the object of investigations. Systemic herbicides are applied by foliar spraying to salt cedar plants at different rates. Effects of replicated

Herbicide treatment results will be correlated between indoor grown plants. The effects of adjuvants such as thickeners, surface active and emulsifying agents are evaluated for enhancement of herbicidal activity. Environmental factors of precipitation, relative humidity, air temperature, water table depth and soil composition are recorded and their effects on herbicide applications determined. The ecological aspects of saltcedar invasion of grassland following scouring and silt deposition resulting from flooding are being studied. The annual cycle of carbohydrate reserves have been determined by chemical analysis of root samples which have been collected in the field. This has been correlated with the response of plants to herbicides and other control methods. Combined methods of control such as mechanical mowing followed by herbicide treatments have been tested. The quality of water used for the herbicide spray diluent and its effects on treatments is being investigated Soil application of herbicides has been evaluated.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

3.0133, MICROBIOLOGICAL INVESTIGATIONS

P.M. TURNER, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Microorganisms occurring in water supply, storage and conveyance systems cause problems such as corrosion, deposition, plugging and fouling. Investigations are made to identify the organisms, determine their mode of action and response to their environment, and to find effective measures of control.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

3.0134, HYDROLOGIC STUDIES LEADING TO SITE UTILIZATION

S. WEST, U.S. Dept. of Interior, Water Resources Division, *Denver, Colorado*

Study the hydrologic regimen around nuclear test areas and supply the knowledge gained to safety and engineering management practices. Provide data for utilization of water resources around nuclear test sites.

Specific major areas of study include: (a) Natural hydrochemical and hydrogeologic conditions near sites of planned atomic detonations, (b) distribution of radionuclides in earth materials and associated groundwater, (c) field transport characteristics of radionuclides.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

3.0135, CONSTANT TOTAL PRESSURE EVAPORATION WITH HEART REUSE BY A BUILT-IN ENGINE

C. CHENG, Univ. of Denver, School of Engineering, *Denver, Colorado* 80210

In the process, an auxiliary system consisting of two organic substances which are partially miscible in a certain temperature range and have a critical solution temperature is used to serve as a built- in engine in an evaporating system to help separating fresh water from a brine. One substance is called a boiling point depressor and is added to the boiling mass to lower its boiling temperature, and the other is called an absorbent and is added to the condensing side to raise the temperature of the condensing mass. By the raising and lowering of the condensing and boiling temperatures respectively, heat of condensation can be effectively utilized in the evaporating of the boiling mass under a constant total pressure condition. The auxiliary system is regenerated by cooling below the critical solution temperature. A system consisting of a fluorocarbon as a depressor and a higher boiling parrafin hydrocarbon as an absorbent would be an ideal system owing to non-toxicity and low solutbility in water.

The study will be directed primarily toward the screening of working mediums and determination of the necessary physical property data. Laboratory scale equipment will be constructed so that the feasibility of the process can be determined and the effects of heat and mass transfer can be evaluated.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0136, THE EFFECTS OF VELOCITY ON THE PASSIVATION OF ALLOYS IN BRACKISH WATER

D.T. KLODT, Univ. of Denver, Denver Research Institute, *Denver, Colorado* 80210

The primary objective of the proposed research program is to develop a basic understanding of the effects of velocity on passivity and corrosion resistance of alloys used in desalination plants. Another objective of the program is to provide engineering data on the corrosion resistance of eight commercially available alloys exposed to velocity conditions in brackish water. Environmental factors such as temperature, degree of aeration, concentration of the electrolyte, and the velocity of the electrolyte relative to the test metal surfaces will be similar to those that would be encountered in a typical process for desalting brackish water.

Analysis of the passivity will be conducted by electrochemical and electron microscopy techniques. The electrochemical, that is, potentiostatic measurements will be used to determine the overall or average passivity of the alloys. Electron microscopy studies of the structural and topographical characteristics of localized passivity breakdown will be correlated with the potentiostatic measurements. Thus, these analyses of passivity will be used to evaluate the basic behavior of the various alloys under velocity conditions. Also, the experimental techniques will be evaluated in terms of their potential usefulness in the development of new or modified corrosion resistant alloys in velocity exposure service.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0137, A STUDY OF THE STRESS-CORROSION SUSCEPTIBILITY OF CUPRO-NICKEL AND TITANIUM UNDER DESALINATION CONDITIONS

R.N. ORAVA, Univ. of Denver, Denver Research Institute, *Denver, Colorado* 80210

The objective of this research project is to establish the stress- corrosion susceptibility of titanium and cupro-nickel under conditions peculiar to desalination operations. The investigation is designed to provide the information necessary for the prediction of long-term stability from the standpoint of stress-corrosion behavior. Sheet and tube specimens of A-70 and A-40 grade commercial titanium, and 90Cu- 10Ni, 70Cu-3Ni-0.5Fe copper-nickel alloys will be tested by continuous immersion in saline solutions. The specimen variables will be grain size and hardness temper, and the testing variables will be the applied stress on the specimen, and the composition, velocity, and temperature of the environment. The variation of stress will serve to establish a stress-failure time relationship. The solutions will be brackish water, and natural sea water with three different salt contents up to about 11 percent. Three velocities (0,4,8 Fps.) and four temperatures will be examined (ambient, 150, 200, and about 250 degrees F).

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0138, EVAPORATION OF WATER AS RELATED TO WIND BARRIERS

J.E. CERMAK, Colorado State University, School of Engineering, *Fort Collins, Colorado* 80521

The evaporation of water from soil and water surfaces and from plants is intimately associated with the local wind characteristics such as turbulence, mean velocity, temperature and water vapor content. Properly designed and located wind barriers and soil surface corrugations show considerable promise for controlling the local habitat with respect to turbulence and mean velocity or in other words the local transfer coefficients.

By means of experimental measurements over simulated corrugated surfaces with and without wind barriers placed in a special wind tunnel, an attempt will be made to attain the following objectives: 1. Determine the local heat and mass transfer coefficients over the surface of corrugated areas. The variation of these coefficients for a wide range of corrugation configuration, spacing, depth, and orientation relative to the mean wind direction is to be obtained. In addition to direct measurement of the transfer coefficients, the local mean wind distribution and turbulence characteristics are to be determined. 2. Determine the local heat and mass transfer coefficients over surfaces which are bordered by obstacles such as tree rows, hedge rows, stubble strips, and solid or semi-solid barriers. The variations of these coefficients for a variety of barrier structures, row spacing and height is to be obtained. Local mean wind distributions and turbulence characteristics are to be measured in addition to the local transfer coefficients. 3. Develop analytical methods, using the experimental data acquired, which will assist in the design of wind barriers for planning water conservation measures.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Colorado State University

3.0139, HYDRAULIC OPERATING CHARACTERISTICS OF LOW GRADIENT BORDER SYSTEMS PHASE II

N.A. EVANS, Colorado State University, School of Engineering, *Fort Collins, Colorado* 80521

Data from 104 experimental irrigations over a two-year period will be analyzed to form rules for optimum combinations of site and crop factors (discharge, border gradient, irrigation time, hydraulic resistance of soil and crop surface, infiltration characteristics, etc.) in order to achieve maximum efficiency in distribution of water. A method for using the border in obtaining 'effective' constants for a commonly used empirical intake function will be verified and a comparison will be made with the same constants obtained by ring infiltrometers.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Colorado State University

3.0140, ROCKY MOUNTAIN OROGRAPHIC CLOUD PRECIPITATION AND MODIFICATION

L.O. GRANT, Colorado State University, School of Engineering, *Fort Collins, Colorado* 80521

This grant is for support of the continuation of the studies of orographic clouds and precipitation studies over the Colorado Rockies formerly supported under GA-847. It provides for a systematic investigation of orographic cloud and precipitation processes and their modification, and embodies a step-by-step exploration of the various factors relevant to the system. Consideration will continue to be given to the nucleating characteristics of seeding materials, the diffusion and transport of seeding materials, the thermodynamic, dynamic and microphysical processes in orographic clouds, and the quantity and distribution of precipitation resulting from orographic cloud systems under both seeded and unseeded conditions.

SUPPORTED BY U.S. National Science Foundation

3.0141, FACILITIES, METHODS AND DESIGN CRITERIA TO PUMP, CONVEY, CONTROL AND MEASURE WATER FOR AGRICULTURAL PURPOSES IN THE NORTHERN PLAINS

H.R. HAISE, Colorado State University, School of Engineering, *Fort Collins, Colorado* 80521

Object: To develop and evaluate improved methods and facilities to increase efficiency and reduce labor requirements for pumping, conveying, controlling and measuring irrigation water; and to develop systems to handle runoff in areas of limited rainfall for more efficient crop production and storage of livestock and domestic water supplies.

Plan of Work: Investigations will be conducted in the laboratory and field. Particular attention will be given to automatic devices for distribution of irrigation water to border strips and furrows with the prime consideration being the more efficient use of water with reduced labor requirements. Structures that combine water control and water measurement adapted to on-farm conditions will be developed and evaluated to permit irrigation farmers to easily and accurately measure water at strategic points in their farm irrigation distribution system. New methods and materials for conveying water, such as flexible tubing and canal liners made of plastic and rubber, will be evaluated for adequacy, stability and adaptability. Field installations of water harvesting systems will be developed on non-irrigated lands to allow long-term evaluation of climatic vagrancies, cropping patterns, and economic feasibility. Another approach to be investigated involves concentration of runoff from small watersheds, usually marginal lands, and diverting such runoff into spreading systems or pans for more intensive crop production, or into storage reservoirs for livestock or domestic water supplies.

SUPPORTED BY U.S. Dept. of Agriculture

3.0142, IRRIGATION PRACTICES, REQUIREMENTS AND DESIGN CRITERIA FOR EFFICIENT USE OF WATER AND SUSTAINED CROP PRODUCTION IN THE NORTHERN PLAINS

H.R. HAISE, Colorado State University, School of Engineering, *Fort Collins, Colorado* 80521

Object: To determine proper timing of irrigation based upon stage of plant development and/or plant distress symptoms in relation to moisture availability, fertility status, plant density, etc., as affected by evapotranspiration processes; to develop and evaluate practical devices and procedures to estimate evapotranspiration and to develop and evaluate facilities, methods and design criteria for improved water application and distribution efficiency including hydraulics of flow in relation to stream size, and other factors for production of high quality crops.

Plan of Work: Studies will be made in the field, laboratory and greenhouse of (1) plant response to irrigation and related factors; (2) soil moisture availability on uptake and use of plant nutrients and related problems; (3) proper timing of irrigation;

(4) correlation of measured evapotranspiration for principal crops grown under various soil and climatic conditions; (5) developing more reliable methods of estimating evapotranspiration; (6) magnitude of influence of various climatic conditions on the evapotranspiration process and results considered when developing predictive equations; and (7) the fundamental relationships of stream size, slope, soil roughness, crop retardance, etc., affecting flow in surface irrigation systems. The combined crop and soil effects will be evaluated. Design procedures will be formulated.

SUPPORTED BY U.S. Dept. of Agriculture

3.0143, WATER YIELD IMPROVEMENT IN THE SNOWPACK TIMBER ZONE, RUNOFF FROM RANGELANDS

M.D. HOOVER, Colorado State University, Agricultural Experiment Sta., *Fort Collins, Colorado* 80521

Plan of Work: The project staff will continue its investigation on (1) forest and snow relationships, specifically: different timber- cutting patterns on snow accumulation and melt and water yield, net radiation, soil moisture, and water vapor transport; (2) mountain range hydrology, specifically: the relation of grazing to water yield and sediment movement; and (3) reduction of erosion and damaging storm runoff. The latter phase is concerned with designing and testing gully control structures and the use of plants for erosion control.

SUPPORTED BY U.S. Dept. of Agriculture

3.0144, FLOW MEASUREMENT OF IRRIGATION WATER

H.J. KOLOSEUS, Colorado State University, Agricultural Experiment Sta., *Fort Collins, Colorado* 80521

Irrigation Flow Meters & Canal Structures - A. The general objective is to develop a new and improved device and techniques for the measurement of irrigation water. Specific problems include the following: Design and evaluation of trapezoidal measuring flumes. Determine the effect of convergence on the calibration of the Parshall Measuring Flume. Evaluate the vane-type flow meter.

DESCRIPTION OF WORK: The various measuring devices are tested in the hydraulics laboratory. The technique varies with each measuring device.

SUPPORTED BY Colorado State Government

3.0145, WATER YIELD AS RELATED TO CLIMATIC WATERSHED CHARACTERISTICS IN THE NORTHERN PLAINS

D.A. WOOLHISER, Colorado State University, School of Engineering, *Fort Collins, Colorado* 80521

Object: To identify the climatic and watershed factors influencing water yield from agricultural watersheds; to evaluate and integrate these factors quantitatively; to develop simple field procedures and 'working tools' by which the seasonal, annual and longer period yield of water from ungaged watersheds may be reliably estimated, and to develop methods by which ground water recharge and the yield of water from ground water may be estimated.

Plan of Work: The work is currently in progress on agricultural watersheds in the vicinity of Hastings, Nebraska; Newell and Cottonwood, South Dakota; and Ft. Collins, Colorado. Some of the factors required for the analyses and which are measured or otherwise documented for the study are: rates and duration of streamflow; precipitation patterns; antecedent moisture; season; soils; land use; conservation and watershed management practices; ground water evaluations; riparian vegetation; geology; gradients and hydraulic roughness of stream channels; and the size, shape and other geomorphic attributes of the watersheds.

SUPPORTED BY U.S. Dept. of Agriculture

3.0146, WATER YIELD IMPROVEMENT, AND SNOW AND AVALANCHE PREDICTION AND PREVENTION, IN THE ALPINE REGIONS OF THE CENTRAL ROCKY MOUNTAINS

M. MARTINELLI, U.S. Dept. of Agriculture, Rocky Mtn. For. & Rg. Ex. Sta., *Fort Collins, Colorado*

Object: To determine methods to increase snow storage in alpine snowfields; to control evaporation and melting; and to reduce snow avalanche danger by working out improved forecasting of hazard and methods of stabilizing snowpacks on mountain slopes.

Plan of work: In Snowfield research, the staff will continue to collect climatic data from alpine areas, and is testing varieties of snow fences. They are studying (1) snow accumulation and melt, (2) snow transport by wind, (3) the aerodynamics of mountain terrain, and (4) the use of chemicals to accelerate or retard snowmelt. Watersheds are being calibrated to test promising methods of alpine snowpack management. In Avalanche research, the staff is investigating European control methods for application to Rocky Mountain conditions. They are also determining the relationships between meteorological, terrain, and snowpack conditions and avalanche formation and movement.

SUPPORTED BY U.S. Dept. of Agriculture

3.0147, DEVELOPMENT OF WATER PURIFICATION SYSTEMS BASED ON REVERSE OSMOSIS

B. GITLOW, United Aircraft Corporation, *Hartford - E. & W. Hartford, Connecticut*

The performance of cellulose acetate reinforced membranes cast directly on nylon reinforcing cloth will be evaluated to determine rate at which water is purified in terms of gallons of water purified per square foot of active membrane area and the percent of salt rejection when the feed water concentration is 10,000 ppm and the flow conditions are turbulent. Some of the best performing membranes will be tested for extended periods of time to determine their potential for long life operation. Composite membranes applied to suitable support materials will also be fabricated and evaluated.

A small compact, disposable cartridge using composite membranes will be fabricated to demonstrate the feasibility and performance of such a cartridge.

Studies will be conducted to evalute the design configurations which are feasible utilizing a reinforced membrane.

The performance of advanced reverse osmosis membranes will be evaluated; those membranes which demonstrate high levels of performance will be tested for extended periods of time.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0148, THE DESIGN, CONSTRUCTION AND TESTING OF A 10,000 GPD TRANSPORT DEPLETION DESALINATION PILOT PLANT

F. HARTER, United Aircraft Corporation, *Hartford - E. & W. Hartford, Connecticut*

A 10,000 gpd capacity transport depletion desalting pilot plant will be designed, constructed and receive laboratory evaluation. This will be accomplished by reviewing the available transport depletion data, identifying a series of design concepts, and constructing that concept which appears to offer the greatest potential. A brief laboratory evaluation of the pilot plant will be performed using synthetic brackish solutions.

Small experimental programs to define the properties of neutral and cation selective membranes, to more fully characterize the electrical performance of the transport depletion process using bench scale units, and to evaluate the hydrodynamic properties of transport depletion channels which incorporate various support screens will be performed.

Design specifications including cost estimates will be prepared for a 100,000 gpd capacity transport depletion test bed plant. A parametric cost analysis for commerical transport depletion plants of 1, 5 and 10 mgd capacity will also be performed.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0149, STUDY OF METHODS TO RETARD COMPACTION OF CELLULOSE ACETATE MEMBRANES IN REVERSE OSMOSIS DESALINATION

R.D. DEANIN, Debell & Richardson Inc. , *Hazardville, Connecticut* 06036

Compaction of cellulose acetate membranes in desalination of water by reverse osmosis, appears similar to cold flow of plasticized cellulose acetate plastics. Of the techniques which reduce cold flow in plasticized cellulose acetate, those which appear compatible with use in reverse osmosis membranes have been selected for experimental study: increasing molecular weight, cross-linking, and reinforcement with fibers and pigments. These techniques will be applied first to solid films, then to asymmetric membranes used in reverse osmosis of saline water, to see whether they reduce cold flow, and whether they reduce compaction.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0150, DEVELOPMENT OF A 50,000 GALLON PER DAY NELLEN STACK ELECTRODIALYSIS MODULE

W.R. WILLIAMSON, Cuno Engineering Corporation, *Meriden, Connecticut* 06453

This contract is for the purpose of evaluating the technical and economic feasibility of the Nellen (flexible membrane) electrodialysis stack design in a 50,000 gallon per day module pilot plant. One module, 20-inches wide by 30-feet long, containing 75 membrane cell pairs will be designed, built and tested. Tests will be run on brackish water of 3,000 ppm total dissolved solids at internal liquid flow velocities from 2 to 10 centimeters per second. The cost of water from the Nellen type electrodialysis plants with capacities of 50,000 gpd, 200,000 and 400,000 gpd will be estimated.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0151, CONSERVING SOIL MOISTURE BENEATH RED PINE BY MEANS OF A FOLIAR SPRAY OF A STOMATA - CLOSING CHEMICAL

P.E. WAGGONER, Conn. Agric. Expt. Station, *New Haven, Connecticut* 06504

Objective: To ascertain whether a thorough foliar spray of phenylmecuric acetate conserves soil moisture beneath a stand of large red pine.

Procedure: Soil on 5 pairs of 50-foot plots will be covered with plastic. Thirty-foot red pine grow on plots. One lot of trees in each pair will be sprayed thoroughly with phenylmercuric acetate in 0.1% wetting agent. Seasonal change in soil moisture to a depth of 10 feet will be determined by neutron meter. A one-tenth saving in transpiration should create a significant 1 inch savings in the seasonal change.

SUPPORTED BY U.S. Dept. of Agriculture

3.0152, INTERFACIAL STRUCTURE AND TRANSPORT IN WATER

J.B. FENN, Yale University, School of Engineering, *New Haven, Connecticut* 06520

In a recent study we investigated the effect of monolayers on evaporative heat and mass transfer at water surfaces. We found that compressed films of cetyl alcohol, in addition to their evaporation suppression ability, also decreased natural convection in the water. This decrease might have resulted either from a change in the rheologic nature of the surface due to the presence of the film or from changes in the water properties over a distance of many molecules caused by the films. It could, of course, have been a result of both. The present study is an extension of this earlier work. We intend to take a closer look at surface structure and transport in water.

The use of oriented compressed monolayers as 'orientation promoters' on surfaces of pure water and various aqueous solutions seems to be a promising method for studies of structure and properties of water surfaces. If combined, for example, with Brownian Motion studies it may be of great value in determining quantities such as surface viscosity, thermal gradients and the depth of the surface region. If combined with further evaporation studies and flow measurements, it can provide information on velocity or (in the case of solutions) concentration gradients near the surface.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0153, A STUDY OF THE BENEFITS OF PLASTIC MATERIALS IN DESALINATION PLANTS

D.R. GOODRICH, Amer. Cyanamid Company, *Stamford, Connecticut*

The goal of this investigation is to determine those areas where desalination costs can be minimized by replacing the current materials of construction with plastic or plastic-lined materials. The proposed method involves process analysis of existing desalination plants, collection of plastics data, computerized searching of candidate materials to meet materials requirements, and cost analysis. The four processes under consideration are: Electrodialysis, Reverse Osmosis, Distillation (M.S.F. and L.T.V.), Freezing (V.F.V.C.).

Materials requirements can be categorized into two areas: functional and environmental. The functional criteria of the equipment include heat transfer, mass transfer and storage, whereas the environmental criteria include process conditions such as temperature, pressure, flow rates and composition. Process and cost data will be obtained from construction, operating and maintenance records of pilot and demonstration plants.

A literature survey will be made to collect comprehensive physical property and cost data on commercially available plastics. A computer search program will be developed to perform materials replacement studies. Plastics cost data, such as fabrication costs, when not available, will be estimated. Based on comparative cost analyses, areas where plastics usage may be beneficial will be recommended.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0154, CONSTRUCTION AND DEVELOPMENT OF SPIRAL DESIGN ELECTRODIALYSIS MODULE

M. MINTZ, Amer. Machine & Foundry Co. , *Stamford, Connecticut* 06907

This study is for the purpose of developing a low-cost spiral design electrodyalysis stack module and new, improved anion exchange membranes. The work proposed will include the construction and delivery of a 10,000 gpd electrodialysis unit of circular configuration, the development of a spiral design electrodialysis stack cartridge, and membrane development. Based on the final field test results, the most promising anion membrane will be selected for further field evaluation on natural brackish waters and a final report summarizing the work accomplished will be submitted.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0155, DEVELOPMENT OF A THIN-LIQUID FILM MEMBRANE DEVICE FOR EFFICIENT DESALINATION BY REVERSE OSMOSIS

D.S. DAVIES, Dorr Oliver Incorporated, *Stamford, Connecticut* 06904

The main objective of this contract is to establish the technical feasibility and the economic potential of the thin-channel concept in large-size reverse osmosis plants. Within the scope of work to be accomplished, the two broad task outlines are to conduct test runs with 25 and 100 gpd thin-channel design reverse osmosis units; and to prepare a conceptual design and economic analysis of the thin-channel concept. This contract could conceivably be considered an extension of Contract No. 14-01-0001-542 which was terminated on December 31, 1967.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0156, THE DEVELOPMENT OF AN ANALYTICAL MODEL OF A FLASH STAGE

D.A. FISHER, Univ. of Connecticut, School of Engineering, *Storrs, Connecticut* 06268

Work is continuing on the model development described below using several sets of recently obtained AMF-Cuno Millstone Point Laboratory Test data: a) the entrance jet region - wherein a submerged wall jet from the entrance orifice, spreads vertically with recirculation above the jet. A high degree of turbulence causes large values of thermal conductivity in the vertical heat flow which evaporates the liquid at the free surface; b) the central portion - wherein the velocity profile adjusts from a maximum at bottom to a maximum near the top; c) the exit region - wherein the fluid is accelerated for entrance into the following stage. The major vertical heat transfer occurs in region b). A typical boundary layer occurs at the channel bottom. Jet induced turbulence predominates. In region b) at the liquid surface vapor is generated at the greatest rate. Turbulent thermal conductivity approximates 300,000 Btu/hr ft degrees F. Tentative relations for turbulent thermal conductivity are proposed. Fluctuations due to the turbulence is suggested as cause of large values of thermal conductivity measured.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0157, DOCTORAL DISSERTATION RESEARCH IN POLITICAL SCIENCE

L.L. GERSON, Univ. of Connecticut, Graduate School, *Storrs, Connecticut* 06268

MARTIN H. GREENBERG, a doctoral candidate, will test various hypotheses concerning government in Mexico by undertaking a case study of irrigation projects and water supply. Water is of central importance to the economic life of the country and by studying the decision making process concerning it it is hoped to provide information on such fundamental questions as the location of power and the nature of federalism in Mexico.

SUPPORTED BY U.S. National Science Foundation

3.0158, PRODUCTION OF 90-10 COPPER NICKEL TUBING FOR DESALTING

J.R. BONNAR, Anaconda Company, *Waterbury, Connecticut* 06702

This OSW contract was awarded to produce, inspect and ship approximately 300,000 lbs. of 3/4' OD x 0.035' wall 90-10 copper nickel (CDA alloy designation 0706) tubing in 68-foot, 61-foot and 17-foot lengths for use by the OSW in their San Diego desalting test module. Satisfactory tubing was produced using conventional brass mill equipment and was shipped as specified by subject contract.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0159, INVESTIGATION OF MULTI-EFFECT MULTI-STAGE (MEMS) EVAPORATOR DESIGN PARAMETERS

F.W. GILBERT, Amer. Machine & Foundry Co. , *Waterford, Connecticut*

A. Furnish all utilities, materials and labor to carry out investigations of MEMS flash phenomena on the 10-stage module and on the flash test chamber. B. Investigations will include, but not be limited to, determination of design parameters involving stage efficiency, heat transfer, mass transfer of liquids and vapors and effects of gas and organic contamination.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0160, PLANT-WATER-USE EFFICIENCY WITH GROWTH REGULATORS AND TRANSPIRATION SUPPRESSANTS

D.J. FIELDHOUSE, Univ. of Delaware, School of Agriculture, *Newark, Delaware* 19711

This project involves laboratory and field investigations for reducing the need for irrigation for certain major vegetable crops. This involves the use of plant growth regulants and transpiration suppressants. The basic approach in this investigation is the bringing together of isolated biological findings to form a systematic and usable program for increasing the efficiency of plant water use.

The three areas of concentration for increasing plant-water-use efficiency are as follows: 1. To stimulate faster germination and early plant growth in order to establish plants before dry soil conditions exist. 2. To reduce water loss during critical periods of plant growth through the use of transpiration suppressants. 3. To use plant growth regulators for altering plant growth, fruit set, and fruit maturation.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Delaware

3.0161, PRESSURE AND TEMPERATURE DEPENDENCE OF VOLUME VISCOSITY AND MICROSOPIC STRUCTURE IN WATER AND SALINE SOLUTIONS

C.M. DAVIS, Amer. University, Graduate School, *Washington, District of Columbia* 20016

The volume visocosity, eta sub v, of water and saline solutions will be determined as a function of temperature and pressure by means of ultrasonic absorption. The measurements will extend over pressure and temperature ranges of 1 to 1000 atmospheres and 0 degree C to 100 degrees C respectively. In particular the anomalous pressure dependence of eta sub v in water will be investigated in order to determine the effect of temperature and salinity on the reported maximum in eta sub v Finally the relation between eta sub v and structural models of liquids will be used as a means of evaluating various proposed structural models of water in terms of the measured values of eta sub v.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0162, THE PREPARATION OF ULTRA-THIN REVERSE OSMOSIS MEMBRANES BY ELECTROSTATIC DEPOSITION

P.F. WATERS, Amer. University, Graduate School, *Washington, District of Columbia* 20016

Experimental and theoretical studies will be done on the influence of selected variables on the efficiency and durability of ultra-thin reverse osmosis membranes deposited on porous substrates by electrostatic spraying. Various solvent systems for cellulose acetate will be examined in order to determine the effects of polymer-solvent thermodynamic interactions, dielectric constant, surface tension and applied potential on reverse-osmosis membrane performance. In addition, the influence of field configuration, field gradient and porous substrate material will also be investigated.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0163, AN EVAPORATIVE FREEZING PROCESS FOR DESALTING WATER

H.M. CURRAN, Catholic University of America, School of Engineering, *Washington, District of Columbia* 20017

The objective of the contract is to develop, on a pilot plant level, a batch-type evaporative freezing process for desalting water. The vapor produced is removed and then condensed on the washed ice. Freezing, washing and melting are carried out in a single vessel. A series of vessels operated in a cyclic manner produce fresh water from saline water. The system obviates the necessity of moving ice-brine slurries.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0164, PARAMETRIC ECONOMIC AND ENGINEERING EVALUATION STUDY OF THE REVERSE OSMOSIS PROCESS

J.R. WILSON, Kaiser Industries Corporation, *Washington, District of Columbia* 20008

The objective of this study is to conduct a comparative engineering and economic evaluation of reverse osmosis plants utilizing present and projected technology and considering the following module design concepts: (1) plate and frame, (2) spiral, (3) tubular, and (4) hollow fine fiber. The evaluation will include: detailed capital and annual operating cost estimates for plant capacities of 1, 10 and 50 million gpd in plants using each of the four module design concepts; identification of the critical components, materials, and design parameters that contribute significantly to product water costs; and a second set of detailed capital and annual operating cost estimates based on projected estimates of technology, membrane flux rates and life characteristics.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0165, DEVELOPMENT OF HOLLOW FILAMENT TECHNOLOGY FOR REVERSE OSMOSIS DESALINATION SYSTEMS

T.A. OROFINO, Monsanto Research Corporation, *Washington, District of Columbia* 20036

The research and development studies under this contract are directed to meet the following objectives: (1) To characterize reverse osmosis membranes which provide high and low water flux and salt rejection with respect to their morphology and structure; (2) To develop new and improved polymer systems which will provide low-cost, long life, hollow fine fiber reverse osmosis membranes with high water flux and salt rejection properties; (3) To develop techniques for the economical production of hollow fine fiber reverse osmosis membranes; (4) To develop a low capital-cost hollow fine fiber reverse osmosis cell design having the potential for scale-up to mgd brackish water desalting plants, and to construct of 1000 gpd pilot plant from this design; (5) To test operate the pilot plant on synthetic brackish waters in order to confirm its design integrity and performance characteristics.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0166, A METHOD FOR SYSTEM EVALUATION AND COST-EFFECTIVENESS OF LARGE MULTISTAGE FLASH DESALTING PLANTS

N. ARAD, Planning Research Corporation, *Washington, District of Columbia*

A methodology, embodying both a probabilistic approach to system performance and a deterministic thermodynamic process analysis, was applied for the evaluation of the system effectiveness and the cost- effectiveness analysis of variations in the design and maintenance concepts of large, multistage flash-type, desalting plants. The analysis of subsystem effectiveness resulted in the development of the Effectiveness Model, which embodies equipment performance and process thermodynamics, for the determination of the desalting plant average annual system effectiveness. The stochastic failure and repair duration processes, which govern equipment performance, were studied and limited available data correlated in order to determine the underlying probability distribution functions. A computer program, to assist in the computations involved in the determination of the life-span values of the average annual effectiveness of the individual subsystems and for the desalting plant as a whole, was developed. The methodology was exercised on a 50 million gallons per day multistage flash plant. An analysis for determining the cost-effectiveness of variations in design and maintenance procedure concepts were analyzed. Twelve variations in design and maintenance procedure concepts were analyzed. Eight of these were found to be cost-effective, demonstrating the validity and usefulness of the methodology developed.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0167, CORROSION RESEARCH

J. KRUGER, U.S. Dept. of Commerce, Inst. For Materials Res. , *Washington, District of Columbia* 20234 (14-01-0001-1091)

The program emphasizes scientific research directed toward providing a basis for the most economical selection and utilization of materials for desalination plants. For this purpose, research is aimed at understanding under practical conditions, how corrosion occurs and how it may be predicted and controlled. The program stresses research on materials of both current and potential interest in desalination systems. Thus materials that are currently used in distillation plants, copper-nickel alloys and certain aluminum alloys, will be investigated via electron microscopy to determine the extent of initial corrosion and the nature of the protective films which prevent corrosion. There will also be a study of copper-nickel alloys to investigate the question of why adding small amounts of iron in critical concentrations reduces the corrosion rate of material in hot sea-water. Such work may reveal general principles that may be applied to corrosion prevention. Iron and iron alloys are potentially useful materials in desalination systems because of their low cost. However such materials so far have been susceptible to corrosion under distillation conditions. There will be several studies on iron and iron alloys: on the growth kinetics, the electronic properties and the structures of the protective surface film on iron, and on how the film is broken down by chloride ions. The techniques that will be used in these studies, optical ellipsometry, and low-angle electron diffraction, are among the most powerful of modern tools to examine the properties of surfaces. These studies, aimed at understanding how iron corrodes, may point to ways of preventing such corrosion - by alloying, for example, or by altering slightly environmental conditions. The technique of cathodic protection may apply here and there will be work investigating the feasibility of using this method to make iron utilizable. As a further objective, the program makes available to OSW consultative and advisory services directed toward more immediate and short term corrosion problems.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0168, THE CONNECTICUT RIVER STUDY

R.B. HANDLEY, U.S. Dept. of Interior, Bureau of Outdoor Recreation, *Washington, District of Columbia* 20240

Objective - To determine the feasibility and desirability of establishing all or parts of the Connecticut River Valley as a national recreation area.

The present and future recreational needs, supplies, and demands will be analyzed along the Connecticut River itself. This study will be broad in scope giving consideration to such things as open spaces and cultural areas as well as picnic areas, etc.

Procedure - A BOR study group will: (1) Evaluate the recreational, fish and wildlife, forest, and water and power resources of the Connecticut River Valley; (2) Evaluate the Connecticut River and its component parts under the National Recreation Area Criteria, and (3) Prepare a report containing recommendations.

The above can be accomplished in the two years allotted and the study by working closely with and by drawing heavily upon the data being collected by other study groups such as the group preparing the Connecticut River Basin Comprehensive Plan.

SUPPORTED BY U.S. Dept. of Interior - Bu. Outdoor Rec.

3.0169, RESEARCH ON LIFE SUPPORT POROUS MEMBRANES FOR REVERSE OSMOSIS

L. KINDLEY, U.S. Dept. of Interior, Office of Saline Water, *Washington, District of Columbia*

Objective: a. Problem: To recover potable water from urine and wash water in spacecraft life support systems. b. Application: Wash water and urine water recovery systems. This work will determine the feasibility of closing the water loop by reverse osmosis via porous membranes.

Approach: Porous glass membranes will be developed and utilized in studying the feasibility of reverse osmosis process of or water recovery.

Progress: No significant progress to report to date. Reporting dates from 29-03-68 to 22-05-68.

SUPPORTED BY U.S. Natl. Aero. & Space Adm.

3.0170, SCENIC RIVERS STUDY

A.H. UNDERHILL, U.S. Dept. of Interior, Bureau of Outdoor Recreation, *Washington, District of Columbia* 20240

A nationwide study was coordinated by the Bureau of Outdoor Recreation in 1963-64 to inventory and evaluate wild or scenic river needs and possibilities. The study was supervised by a

5-member study team composed of representatives of the Departments of the Interior and Agriculture.

Based on the results of the study, a report 'Wild Rivers' was published, and legislation was recommended by the Administration for the establishment of a Nationwide System of Scenic Rivers. Nine rivers are proposed for initial 'national scenic river' designation. Thirty- five other rivers are earmarked for further evaluation within 10 years after enactment of a Scenic Rivers Bill. other 'candidate' rivers will be studied by the Secretary of the Interior and Secretary of Agriculture. The proposed legislation also provides for the inclusion of 'State and local scenic rivers' in the Nationwide System.

SUPPORTED BY U.S. Dept. of Interior - Bu. Outdoor Rec.

3.0171, ISLAND STUDY

A.H. UNDERHILL, U.S. Dept. of Interior, Bureau of Outdoor Recreation, *Washington, District of Columbia* 20240

This survey and planning study has three major objectives: (1) Inventory all 10-acre or larger islands in the U.S., Puerto Rico, and the Virgin Islands by size, ownership, and development status. (2) Identify and evaluate those islands which have significant wilderness, historical, or other recreational values. (3) Develop a program for island conservation.

The Island Study was started during fiscal year 1967. The inventory phase and the detailed studies of those islands with significant recreational values have been completed. The final report, outlining a program for island conservation, should be released during fiscal year 1969.

SUPPORTED BY U.S. Dept. of Interior - Bu. Outdoor Rec.

3.0172, FLOOD FREQUENCY SYNTHESIS FOR SMALL STREAMS IN ALABAMA

UNKNOWN, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242

Objective: To gage small watersheds and develop a method for estimating peak rates of runoff.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Alabama State Government

3.0173, ST. JOHNS RIVER FISHERY PROJECT

H.L. MOODY, State Game & Frsh. Wtr. Fish, *Eustis, Florida* 32726

The purpose of this study is to monitor fish populations of the entire St. Johns River for fishery conservation purposes.

The rapid rate of human population growth in this section of Florida has produced and is continuing to cause limological and terrestrial changes, through public works and other activities, which has adverse effects on the fishery of the river. The aim of this study is to define these changes more precisely in order that deteriorations of the fishery may be arrested or prevented.

Fish population samples are taken with various standard fishing gear and by different methods, including chemicals, to determine successive changes in the populations and their species composition which may be related to natural environmental factors, water pollution, or to artificial changes in the habitat. Studies of sportfisherman success, harvest rates and fishing pressure are also made.

SUPPORTED BY Florida State Government

3.0174, SYNTHESIS AND EVALUATION OF NEW POLYMER MEMBRANE CANDIDATES FOR APPLICATION IN REVERSE OSMOSIS

T.W. BROOKS, Peninsular Chem. Research Inc. , *Gainesville, Florida* 32603

Proposed work under this contract involves the synthesis and evaluation of certain block or graft copolymers as potential membrane materials applicable in the reverse osmosis process for desalinating brackish water or sea water. Such hydrophilic polymers as poly (ethylene oxide), poly (vinyl alcohol), and poly (diallyldimethyl ammonium chloride) are to be incorporated into block or graft copolymer systems with such hydrophobic partners as styrene, acrylonitrile, and methyl methacrylate. The hydrophobic segments play a dual role in that they serve to render the hydrophilic segments water-insoluble and to provide adequate compressive modulus to the derived membranes. Each block or graft copolymer system is to be prepared in several compositions in order to ascertain the effect of composition on such membrane properties as water permeability, salt permeability, compression resistance, and other variables which are fundamentally significant in the reverse osmosis process. Where possible, such structural features as stereoregularity and crystallinity of hydrophilic segments will be studied to ascertain the significance of morphology in relation to water transport properties of subject membranes.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0175, WATER CONTROL FOR FOREST PRODUCTION

C.M. KAUFMAN, Univ. of Florida, Agricultural Experiment Sta. , *Gainesville, Florida* 32601

Objectives: 1. To determine effects of saw palmetto on availability of soil moisture for tree growth. 2. To evaluate methods for reducing water loss by controlling non-tree vegetation. 3. To determine effective means for controlling water table levels by drainage and by irrigation as measured by tree response.

Procedures: 1. On sites of varied palmetto density; in open and forest, remove palmetto from one plot, leaving paired control undisturbed. Measure density of vegetation and soil moisture for relationships. 2. Control vegetation for planting of select-bred slash and longleaf pine: Already established after 9 treatments of burn, cut, chop, disc, and plow; later to be cultivated. 3. Ditch drain in flatwoods with organic hardpan soils, and test-plant to select-bred slash pine.

SUPPORTED BY U.S. Dept. of Agriculture

3.0176, CULTURAL MANAGEMENT PRACTICES OF FORAGE CROPS FOR PASTURES HAY OR SILAGE

D.E. MCCLOUD, Univ. of Florida, Agricultural Experiment Sta., *Gainesville, Florida* 32601

Object: To develop improved cultural management practices designed (1) to enhance establishment and persistence, and (2) to increase yield and quality of newly developed varieties of forage crops used for pasture, green feed, hay and silage.

Plan of work: Greenhouse, small plots, or minature pasture paddocks (where animal performance is not measured), will be used to screen forage varieties and mixtures and to study establishment, maintenance, and utilization practices. Establishment studies will include evaluation of plant population or stand density, seedling development, persistence, and botanical composition as influenced by seeding time and rate. Maintenance management will involve time, frequency, and intensity of defoliation by clipping or grazing as related to factors such as LAI (leaf area index). Appraisal of species will include persistence, recovery after defoliation, seasonal pattern of growth, heat, drought and cold tolerance, and competiveness. Response of new forage crop varieties and mixtures to different kinds, rates, and times of application of fertilizer as well as to supplemental irrigations will be determined. For each experiment appropriate replicated experimental designs will be used.

SUPPORTED BY U.S. Dept. of Agriculture

3.0177, IRRIGATION EFFICIENCY

J.M. MYERS, Univ. of Florida, School of Agriculture, *Gainesville, Florida* 32601

It is likely that all citrus and many other crops in Florida, in excess of 1,000,000 acres, will be irrigated with lower application rates within the next few years. This will lead to smaller and more frequent applications which may increase the total evaporation losses. Inherent in these low rates of application are many changes which influence evaporation losses. These include smaller droplets, wider sprinkler spacing, extended irrigation time, up to as much as 30 hours on a given area, and higher elevation of sprinkler heads.

The problem of controlling evaporation losses could become particularly serious in the citrus belt of Florida where industrial, domestic and agricultural water consumption is increasing at a rapid rate thus making more efficient application essential.

The evaluation of evaporation losses during irrigation needs to be investigated so that steps can be taken to reduce the losses. As competition for water increases the information to be derived from this research will be essential to sound economic analysis, pertaining to the allocation of water.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Florida

3.0178, TEMPORARY LININGS FOR WATERWAYS AND EMBANKMENTS

J.M. MYERS, Univ. of Florida, Agricultural Experiment Sta. , *Gainesville, Florida* 32601

Objectives: To determine design criteria for newly constructed waterways and embankments covered with erosion retarding material and to determine hydraulic characteristics of lining materials.

Work proposed: The experimental procedure will involve four types of tests. The first will consist of basic studies to determine some of the more important functional specifications for a cover material. The second and third tests will be combined and will involve the determination of the hydraulic characteristics of existing temporary cover materials in combination with several representative types of Florida soils, and the effect of these cover materials on establishment of a permanent vegetative cover. The last group of tests will consist of field experiments to evaluate laboratory findings and to evaluate methods for installing the materials.

SUPPORTED BY U.S. Dept. of Agriculture
Florida State Government

3.0179, IRRIGATION EFFICIENCY

J.M. MYERS, Univ. of Florida, Agricultural Experiment Sta. , *Gainesville, Florida* 32601

Objective - To evaluate factor influencing irrigation water losses for the various types of systems used in Florida Agriculture.

Description of Work Proposed - An evaluation will be made of factors affecting evaporation losses from sprinkler irrigation. Water droplet size, wind velocity, air quality (temperature and vapor pressure), soil and vegetation are among the factors that will be studied. A wind tunnel type environmental control facility will serve as the primary apparatus for obtaining measurements of water losses due to evaporation. Laboratory findings will be correlated with field results.

SUPPORTED BY Florida State Government

3.0180, THE INFLUENCE OF INADEQUATE WATER SUPPLY ON METABOLISM IN BIOLOGICAL SYSTEMS WITH EMPHASIS ON PROTEIN SYNTHESIS AND NUCLEIC ACID METABOLISM

S.H. WEST, Univ. of Florida, School of Agriculture, *Gainesville, Florida* 32601

Limited water supplies and low water-holding capacities of soils contribute to an environment in which plants are constantly subjected to stress. Water stressed plants provide an excellent tool to study the effect of limited water supply on sub-cellular processes applicable to all biological organisms. Plants provided varying levels of water stress by adding mannitol to their nutrient solutions will be compared with controls. The synthesis of protein essential to life as enzymes and structural units, will receive emphasis. The effect of water stress on amino acid incorporation into proteins and synthesis of specific proteins will be observed. Nucleic acid metabolism will be studied since it plays such an intimate role in protein synthesis by providing the mechanism and genetic information for specific protein formation. Nucleic acids from stressed and control plants will be isolated and compared quantitatively and qualitatively by differential centrifugation, methylated albumin chromatography, radioisotope incorporation and thin layer chromatography. Functionality of each fraction in protein synthesis will also be measured. This information will be used to determine if tolerance to water stress can be induced by chemicals or management practices and if plants can be altered by critical breeding programs to provide adaptation to insufficient water supplies.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Florida

3.0181, THE ELECTROCHEMICAL BEHAVIOR OF METALS AND ALLOYS IN SEA WATER AND THE EFFECT OF BIOLOGICAL SLIMES ON THEIR RATES OF CORROSION

K.G. COMPTON, Univ. of Miami, Graduate School, *Miami - Coral Gables, Florida* 33124

The effects of microbiological slimes on the corrosion rates of metals in natural sea water will be compared to those in sea water from which these micro-organisms have been removed. The purpose of this study is to establish or disprove the need for including the biological factors in any study of materials for use in sea water and, if essential, to determine the extent of the effect. The well established effect of anaerobic organisms will not be included. In the second phase of the study, a galvanic series of metals and alloys in sea water at elevated temperatures will be determined over a range of water salinity. The temperature range in this work will be from 212 degrees to 400 degrees F. The resulting data will establish design criteria to minimize galvanic corrosion effects in plants. The corrosion rates will be determined by the polarization resistance method and will include a small range in velocities. The potentials will be reported as differences between metals and between the metals and reference electrodes.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0182, TEMPERATURE EFFECTS ON BIOLOGICALLY INTERESTING MEMBRANE SYSTEMS

W. DROSTHANSEN, Univ. of Miami, Graduate School, *Miami - Coral Gables, Florida* 33124 (14-01-0001-1649)

It is intended to study the effects of temperature on the properties of two types of membranes which are biologically interesting. The first membrane system to be studied is a non-aqueous ('oil') membrane supported by a solid porous (reactive or non-reactive) matrix (such as a Millipore filter). The second type of membrane to be studied is the bimolecular leaflet membrane. It is intended to measure parameters such as membrane potentials, biionic potentials, electric resistivity and hydraulic permeability (where applicable) of these membranes at closely spaced temperature intervals over a relatively extended temperature range. The purpose of this study is to investigate the effect of temperature on membrane properties in general and, if possible, specifically to relate such observations to structural changes in the water and adjacent to membranes.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0183, FREEZING POTENTIAL STUDY

W. DROSTHANSEN, Univ. of Miami, Graduate School, *Miami - Coral Gables, Florida* 33124

It is proposed to study certain aspects of the freezing potential phenomena (the development of a potential between an advancing ice front and the unfrozen supernatant liquid, often referred to as the Workman-Reynolds effect). We propose to seek evidence for the existence of transient, polar structures in freshly formed ice and to study the subsequent relaxation of such structures to conform to the overall non-polar structure of bulk ice. The study will include (a) a search for freezing potentials associated with the freezing of dilute solutions of electrolytes in heavy water, (b) the study of the effects of added non-electrolytes (such as alcohol, ketones, etc.) on the freezing potentials obtained with a number of electrolytes in water and (c) a study of the effects of pressure on freezing potentials.

3. WATER SUPPLY AUGMENTATION AND CONSERVATION

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0184, TOLERANCE OF CITRUS TO LOW TEMPERATURES

W.C. COOPER, U.S. Dept. of Agriculture, *Orlando, Florida*

Object: To provide a better understanding of the chemical and physiological nature of cold hardiness and dormancy in citrus.

Plan of work: Chemical and physical measurements will be conducted on various tissues after being exposed to various controlled or natural environmental conditions. Citrus types grown under controlled temperature and light conditions will be evaluated for dormancy and cold hardiness characteristics. Various rootstock-scion combinations grown in the field and/or greenhouse will be evaluated for dormancy and cold-hardiness characteristics. After natural freezes in Texas, Florida and California, test plantings and commercial plantings will be surveyed to determine the influence of climate, tree age, rootstock, scion, fertilizer and irrigation practices, and other operations on the degree of cold damage. Promising leads will become the focus of new research.

SUPPORTED BY U.S. Dept. of Agriculture

3.0185, RELATION OF NITROGEN LEVEL, HIGH WATER TABLE AND SOIL SALINITY TO GROWTH, YIELD AND FRUIT QUALITY OF DATES

W.C. COOPER, U.S. Dept. of Agriculture, *Orlando, Florida*

Object: To determine the rate of nitrogen fertilization necessary to maintain economical production and high fruit quality of dates; and to study the responses of the date palm to high water table and to soil salinity, especially as regards salt absorption and accumulation in leaves and roots.

Plan of work: A nitrogen-rate trial is being conducted on replicated plots with palms in full bearing on a loam; and a block of young palms on sand will be used in a similar nitrogen-rate trial as soon as they reach bearing age. Pinna samples will be taken for analysis at appropriate intervals to establish, if possible, the respective levels of nitrogen considered to be deficient, adequate, or excessive. The growth and salt absorption of date offshoots and seedlings grown in sand culture and salinized soil plots will be studied. Periodically samples of soil and date pinnae will be taken from date gardens affected by high water table and soil salinity to determine the general level of soil salinity and the accumulation of chlorides in pinnae.

Cooperation: USDA Salinity Lab., Riverside, Calif., and growers.

SUPPORTED BY U.S. Dept. of Agriculture

3.0186, TOLERANCE OF CITRUS TO SALINITY AND BORON IN THE SOIL AND IRRIGATION WATER

W.C. COOPER, U.S. Dept. of Agriculture, *Orlando, Florida*

Object: To study the mechanism of salt-tolerance by citrus trees.

Plan of Work: At the Weslaco station scion-rootstock combinations will be screened for salt and boron tolerance by growing them in field plots which can be flooded with irrigation water carrying graduated amounts of various salts separately and in combination. The trees will then be frozen at the conclusion of the experiment, to study possible interactions of salt tolerance and cold-hardiness. Chemical analysis of plant parts and soil will be made so that growth and cold-hardiness behavior can be related to tissue and soil composition. At Weslaco various rootstock-scion combinations will be tested for salt tolerance when grown under various controlled environmental conditions. Chemical analysis of plant parts will be made to relate plant behavior with tissue composition. At Weslaco and Indio hybrid seedlings will be screened for salt tolerance in field plots which can be flooded with irrigation water carrying graduated amounts of various salts separately and in combinations. Chemical analysis of plant parts will be made to study inheritance of salt tolerance.

Cooperation: Texas Agr. Expt. Sta. Texas.

SUPPORTED BY U.S. Dept. of Agriculture

3.0187, RELATIONSHIP OF TUBE-AND REEF BUILDING MARINE ANNELIDS TO COASTAL ENGINEERING AND CONSERVATION PROBLEMS IN FLORIDA

D.W. KIRTLEY, Florida State University, Graduate School, *Tallahassee, Florida* 32306

Detail the distribution of sabellariidae reefs on the nearshore floor and in inlets and harbors, particularly on the lower east Florida coast. Examine growth rates of worms and worm colonies, developmental history of worm reefs. Determine environmental variables which control size, shape and orientation of reefs. Attempt to isolate parameters which might be controllable in future conservation practices, beach erosion and coastal engineering problems.

SUPPORTED BY Florida State Government

3.0188, EFFECT OF PH AND IONIC STRENGTH ON THE CRYSTALLIZATION AND MORPHOLOGY OF POLYMER MEMBRANES AND FIBERS

L. MANDELKERN, Florida State University, Graduate School, *Tallahassee, Florida* 32306

Two major research areas related to the properties of polymeric systems will be investigated. One set of problems is concerned with the effect of pH and ionic strength on the crystal-liquid phase transition of polymer membranes and fibers. The other type of problem to be investigated involves the interaction, swelling and permeation of pure liquids and salt solutions at temperatures well below the melting temperature where the morphology has been pre-defined by controlled crystallization. In the first set of problems we plan to study the behavior of such crystalline polyelectrolytes as polymethacrylic and polyacrylic acid in order to obtain quantitative physical chemical information in regard to the role of pH and ionic strength in influencing the melting temperature and in describing reversible mechano-chemical processes. The other area of investigation will be concerned with the properties of cellulose acetate membranes which have been prepared in a prescribed and predetermined manner. Initial interest will be centered on the molecular origin of the multiple transitions that have been reported for this class of polymers, their effects on physical properties and permeability and the influence of thermal and solvent treatment on the location of the transition.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0189, MODEL STUDIES FOR DEVELOPMENT AND CALIBRATION OF STREAMFLOW CONTROL DEVICES IN THE SOUTHERN BRANCH

P. MAYER, U.S. Dept. of Agriculture, *Athens, Georgia*

Object: To study models of streamflow control structures, such as Tainter gates, adapted for use on low-gradient channels, and calibrate these devices for measuring discharge rates. To develop similitude relations so that standardized patterns can be designed for flow measurement, and to make exploratory tests for improvements. To develop sensing devices for periodically recording gate positions and water levels. To develop discharge calibrations under various flow conditions with different gate openings. To develop ADP programs to translate data obtained into discharge rates using high-speed computers.

Plan of Work: The plan of work includes the study of scale models, the development of sensing devices, and the development of computer programs. Specifically, scale models of operating Tainter gates are constructed in the hydraulic laboratory and calibrated under different combinations of underflow and overflow, with outlets submerged and unsubmerged, and for installations with one, two, and three gates operating as parallel units. Exploratory studies to improve the structural design are made, and similitude relations developed in an effort to standardize gates. Sensing devices to readout prototype gate positions are adapted for use with water stage recorders so that discharge rates can be determined from degree of gate opening. Using all this in-

formation, an ADP program is developed to translate field data into discharge rates utilizing the calibration coefficients and equations obtained from flow tests. These investigations are made under a research contract with the Georgia Institute of Technology.

SUPPORTED BY U.S. Dept. of Agriculture

3.0190, ECONOMIC AND AGRONOMIC EVALUATION OF FERTILIZER RESPONSE OF FORAGE CROPS

*E.R.*BEATY*, Univ. of Georgia, Agricultural Experiment Sta. , *Athens, Georgia* 30602

Objectives are (1) to describe the yield of Coastal Bermudagrass and bahiagrass as a function of nutrients and water (2) to determine the influence of continued forage yield stresses on soil physical properties and nutrient content, (3) to establish the economics of forage fertilization.

The two grasses shall be subjected to 9N, 9P and 9K treatments each at two moisture levels. The design shall be cube lattice and the experiment shall be continued until a response has been obtained to the applied nutrients. The forage will be clipped each 4 to 5 weeks throughout the season. At that time an economic analysis of the response of forage production to fertilizer and H2O will be made. Soil samples will be collected so as to follow soil nutrient changes.

SUPPORTED BY Georgia State Government

3.0191, IRRIGATION REQUIREMENTS, PRACTICES AND METHODS OF APPLICATION FOR EFFICIENT PRODUCTION OF CROPS IN THE SOUTHEAST

J.R. CARREKER, Univ. of Georgia, U.S.D.A. Se. Watersh. Res. Ct. , *Athens, Georgia* 30601

Object: To evaluate water intake, retention, and transmission of soils; determine the effect of the soil moisture regime on crop production as related to stage of physiological development and to management practices; to develop information for predicting need for irrigation; and to develop and evaluate procedures for water application in crop production for different crops and for various site conditions.

Plan of Work: Various types of equipment and techniques for measuring infiltration rates under variable conditions will be compared and evaluated. Soil moisture intake will be related to soil profile. Methods to identify, measure, and evaluate moisture retention and transmission will be studied. Water management practices for crop production will be evaluated under different soil moisture regimes. Determination will be made of (1) water requirements of plants as a function of the physiological state of development, (2) interactions between water management regimes and fertility levels, crop strains, tillage, etc., (3) moisture penetration patterns, plant rooting patterns, and evapotranspiration, (4) interrelations of irrigation with other management practices, (5) field irrigation by surface and subsurface methods in contrast to sprinkler methods, and (6) relationships of water application to soil, slope, row length and grade, furrow patterns, etc.

SUPPORTED BY U.S. Dept. of Agriculture

3.0192, THE EFFECT OF BRACKISH WATER ON PLANTS AND SOIL IN THE SOUTH

J.R. CARREKER, Univ. of Georgia, U.S.D.A. Se. Watersh. Res. Ct. , *Athens, Georgia* 30601

Object: To determine the effect of methods, frequencies, and amounts of irrigation water of varying salt concentrations on plant growth and soil physical properties, and the degree of salinity of potential brackish irrigation water resources.

Plan of Work: Field plot and laboratory studies are used to determine the response of crops to treatments with irrigation water of different salt concentrations. The effect of brackish water on soil properties, and the effects of rainfall in removing salt from the root zone will be determined.

SUPPORTED BY U.S. Dept. of Agriculture

3.0193, THE INTERRELATIONSHIP BETWEEN WATERSHED FACTORS THAT AFFECT RUNOFF RATES AND VOLUME YIELDS IN THE SOUTHERN COASTAL PLAINS

T.H. ROGERS, Univ. of Georgia, U.S.D.A. Se. Watersh. Res. Ct. , *Athens, Georgia* 30601

Object: To identify the watershed factors that influence runoff rates and water yields; and to determine the interrelationships between these factors to develop methods for estimating the magnitude and frequency of storm runoff, and the monthly, seasonal, and annual net water yields for ungaged agricultural watersheds.

Plan of Work: The plan of work includes definining in detail the watershed characteristics of a small agricultural watershed (approximately 20 square miles) near Ashburn, Georgia; expressing these characteristics in numerical form for analysis by digital computers; determining the interrelationships between the watershed factors that logically affect the hydrology of a watershed; and testing the relations determined on a larger parent watershed. Characteristics of a small adjacent watershed (approximately 2.5 square miles) undergoing urban development will also be sampled and compared with those of the predominately agricultural area. The study is under research contract with the University of Georgia.

SUPPORTED BY U.S. Dept. of Agriculture

3.0194, SHALLOW WELLS AND IRRIGATION PITS FOR IRRIGATION AND OTHER FARM WATER SUPPLY IN THE COASTAL PLAINS

A.W. THOMAS, Georgia Coastal Pl. Expt. Sta. , *Tifton, Georgia* 31794

Objectives and Work Proposed: These will be studies of shallow aquifer water supply available to farms. Investigations will be made under a variety of conditions as to quality of the aquifer and environmental topography. They are planned to include the supply efficiency and adequacy of impoundage in irrigation pits and pumping adequacy of shallow wells of various types. The following objectives are specified: (1) To determine topographic and soil conditions which favor or affect condition of water supply in near-surface aquifers. (2) To ascertain for sites selected for study the dependability of water supply through periods of favorable and unfavorable rainfall. (3) To correlate results of tests at different locations under different soil and topographic conditions to establish supply probabilities under intermediate conditions. (4) To develop criteria by which engineers and soil scientists can classify sites for irrigation pits and shallow wells on the basis of topography and soils.

SUPPORTED BY Georgia State Government

3.0195, INVESTIGATION OF SOIL AND WATER LOSSES THROUGH CROPPING SYSTEMS AND SOIL MANAGEMENT PRACTICES

A.W. THOMAS, Univ. of Georgia, Agricultural Experiment Sta. , *Tifton, Georgia*

Objectives: (1) To evaluate certain cropping and land cover on the basis of yield as equated against resulting soil and water losses. (2) To develop principles for the conservation of soil and water based on the evaluation of physical and chemical characteristics of coastal plain soils which influence their susceptibility to deterioration.

Description of Work: Eighteen (18) plots, each 1/20 acre in size, are divided into 2 replicates of 9 plots each. They are on a 3% slope of Tifton loamy sand. Each plot is a separate drainage unit with provisions for measuring volume of 'water lost' by runoff, for the handling of soil loss in the form of settled sludge, and for the determination of soil loss by weight of dry soil. Plot treatments involve (1) a plot which is plowed annually and is kept in a condition of cultivated fallow; (2) a plot on which corn is grown annually with crop residues as winter mulch; (3) a 3-year rotation of annual crops; and (4) a 4-year sod-based rotation which includes 2 years of perennial grass and Crimson clover, corn and peanuts. In the rotations each year of the rotations is included on the plots each year.

SUPPORTED BY Georgia State Government

3.0196, SURFACE WATER STORAGE AND SUPPLY ON FARMS IN THE COASTAL PLAINS

A.W. THOMAS, Univ. of Georgia, Agricultural Experiment Sta., *Tifton, Georgia*

On existing farm ponds and/or on ponds especially constructed for the purpose, studies will be initiated to accomplish the following objectives under a range of conditions from high watershed water yield and probable high storage efficiency to low water yield and doubtful storage efficiency: (1) To determine optimum storage volume in relation to conditions of the contributing watershed and to determine reliability of supply. (2) To determine losses in potential storage due to excessive flow and the losses in impounded volume by seepage and surface evaporation; to isolate causes of the losses; and to develop methods of reducing losses. (3) To determine the efficiency of a pond as a source of water supply by equating the depth-area ratio to input minus losses for various conditions of coastal plain soils and topography.

SUPPORTED BY Georgia State Government

3.0197, DRAINAGE REQUIREMENTS OF CROPS IN THE SOUTH

R.R. BRUCE, U.S. Dept. of Agriculture, *Watkinsville, Georgia*

Object: To determine (1) the drainage requirements of specific crops at different stages of development, and (2) the degree of drainage permissible for efficient crop production with minimum of subsidence in organic soils. Plan of Work: Drainage requirements of various crops will be evaluated under conditions of controlled temperature, humidity, and light in North Carolina. Plants will be grown in soil tanks equipped to provide controlled water table movement. It is anticipated that accurate drainage coefficients should be forthcoming for use in drainage system design. Data will be obtained on the relation between water level and rate of moisture use by plants, available water in the soil profile, and crop growth response.

SUPPORTED BY U.S. Dept. of Agriculture

3.0198, EVAPOTRANSPIRATION BY SUGAR CANE

P.C. EKERN, Univ. of Hawaii, Water Resources Research Ctr., *Honolulu, Hawaii* 96822

Field data from the installation of a large semi-contained hydraulic lysimeter within a major irrigated sugar cane region at the Kunia substation of the Hawaiian Sugar Planters' Association will be given laboratory analysis for correlation of the measured rate of consumptive use with pan evaporation and other soil and meteorological parameters suitable for prediction of irrigation interval scheduling.

Other activities: Calibration of this instrument as a primary standard for the measurement of evaporation from water, Latosol, and successive growth stages of sprinkler irrigated sugar cane; assessment of the patterns of moisture movement within the lysimeter and measurement of the heat budget within the soil; calibration of the neutron probe for tropical soils; and collection of seepage waters for detection of the rate of movement of nitrates and other constituents through the profile into the ground water.

Methods used: A 6 m square, 2 m deep container with walls of fiber glass reinforced resin, supported on an hydraulic scale of nylon reinforced irrigation hose will comprise the lysimeter. Batteries of resistance blocks, tensiometers, and access tubes for neutron probe will be arrayed for in situ record of soil moisture status. A similar array of thermistor units will record temperature gradients within the lysimeter soil. Porous ceramic tubes will be used to maintain soil water suction equivalent to 100 cm of water at the bottom of the soil column. Percolate waters withdrawn through this system will be preserved for qualitative analysis. Correlative studies will be made of the long period (24 hour) water use rates with pan evaporation and other predictive parameters. Short period (hourly rates) will be assessed as reflected in cane growth, particularly in the presence of temporary mid-day wilt.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Hawaii

3.0199, THE EFFECTS OF SALINE IRRIGATION WATER ON SODIUM ACTIVITIES AND PHYSICAL PROPERTIES OF LATOSOLIC SOILS

G. UEHARA, Univ. of Hawaii, Hawaii Inst. of Geophysics, *Honolulu, Hawaii* 96822

The latosolic soils of tropical regions contain large amounts of iron, aluminum and oxides. Because of the high oxide content, they have excellent physical properties and stand up well to agricultural practices which would quickly cause loss and permanent deterioration in other soils. Many of these soils occur in sub-humid and semi-arid regions and crop production is limited by the lack of water.

It has already been shown in preliminary experiments on Molokai, Hawaii, that saline water can be used successfully for irrigation purposes on these soils.

The objectives of this proposal are: 1. To determine for latosolic soils in Hawaii the amount of salt that can be tolerated in irrigation water without physical deterioration of the soils. 2. To determine the amount of salt absorbed by these soils when different concentrations of salt are used in the irrigation water, and different methods of applying the water are used. 3. To determine the distribution of sodium ions between soil and soil solution and relate this to actual changes in physical properties, to the availability of nutrients to crops, to the fundamental absorptive properties of the soils, and to theoretical explanations of the effects of cations on soil physical properties.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0200, SALINITY TOLERANCES OF CERTAIN TROPICAL SOILS AND RELATIONSHIPS BETWEEN SODIUM ION ACTIVITIES AND SOIL PHYSICAL PROPERTIES

G. USHARA, Univ. of Hawaii, Agricultural Experiment Sta., *Honolulu, Hawaii* 96822

1. To measure salinity tolerances, that is, the ability of the soil to resist physical deterioration by saline waters in two groups of semi-arid tropical soils. 2. To measure the salinity effect by conventional means and also by a new technique which involves the direct measurement of sodium ion activities. 3. To develop the direct determination of sodium ion activity into a new and more fundamental tool in soil salinity work.

Highly structured tropical soils will be subjected to saline and sodic conditions, and the effects of salts and sodium ions on the physics of these soils will be evaluated. If these soils can withstand saline and sodic conditions, it is hoped that large areas of arid and semi- arid tropical areas with similar soils may be brought to their full agronomic potential by irrigation with saline waters.

SUPPORTED BY Hawaii State Government

3.0201, AQUIFER-STREAMFLOW INTERRELATIONSHIPS IN UPSTREAM AGRICULTURAL WATERSHEDS OF THE PACIFIC NORTHWEST

W.R. HAMON, U.S. Dept. of Agriculture, *Boise, Idaho*

Object: To determine characteristics of subsurface water movement and losses or gains in stream channels as related to geologic formations and their properties; to evaluate source and disposition of water in complex watersheds and segments thereof as related to geologic and other characteristics; and to assess effects of irrigation water diversions and cultural practices on streamflow and subsurface recharge.

Plan of Work: The work is currently concentrated on the Reynolds Creek Experimental Watershed southwest of Boise, Idaho. Among other factors, the investigations include: geologic mapping, ground water observations; soil moisture determinations; transmission capacities of soils and aquifers; and the consideration of influent and effluent streamflow.

SUPPORTED BY U.S. Dept. of Agriculture

3.0202, WATER ACCUMULATION, FLOOD-WAVE MOVEMENT AND WATER YIELD FROM COMPLEX WATERSHEDS OF THE PACIFIC NORTHWEST

W.R. HAMON, U.S. Dept. of Agriculture, *Boise, Idaho*

Object: To study movement of water from unit sources areas or accumulation areas through complex watershed channel systems and how these flows produce hydrographs; to evaluate effects of climatic and watershed characteristics and snow-water accumulation on peak flows and water yield and to develop methods for estimating dependable water yield from sagebrush-range type watersheds.

Plan of Work: The work is concentrated in the Reynolds Creek Experimental Watershed southwest of Boise, Idaho, and in Moscow, Idaho. The general plan is to: sample the range of conditions of precipitation and climate, watershed size, soils, land use, culture, geology, water storage structures, and other watershed factors; develop relationships between precipitation and runoff as modified by watershed factors; and generalize these relationships so the findings may be extended to ungaged watersheds.

SUPPORTED BY U.S. Dept. of Agriculture

3.0203, IRRIGATION REQUIREMENTS, PRINCIPLES AND PRACTICES FOR EFFICIENT USE OF WATER IN THE PACIFIC NORTHWEST

M.E. JENSEN, U.S. Dept. of Agriculture, *Kimberly, Idaho*

Object: To develop criteria and practices for efficient irrigation water management on major crops and soil types in the Pacific Northwest.

Plan of Work: Field studies will be made of evapotranspiration and climatic data on various crops at locations within major irrigated aeras; also the proper balance between crop density, frequency of irrigation and soil fertility. Laboratory studies will be conducted to develop improved techniques that may be used in field studies. The effects of various management factors on water use and water use efficiency, intake rates and soil properties will be determined in field plots, laboratory, greenhouse and growth chambers. Information will be obtained on water use and related climatic factors. Extensive laboratory and field plot work will be conducted on soil structure and moisture retention and transmission of both stratified and non stratified soils. Field studies will be made to modify problem soils to improve intake, storage, and transmission of water and effect of salt removal by organic or inorganic amendments or mechanical means.

Cooperation: Washington, Oregon, and Idaho Agricultural Experiment Stations; SCS; U. S. Bureau of Reclamation; soil conservation districts.

SUPPORTED BY U.S. Dept. of Agriculture

3.0204, SURFACE AND SPRINKLER IRRIGATION SYSTEM DESIGN AND OPERATION FOR EFFICIENT WATER USE IN THE PACIFIC NORTHWEST

M.E. JENSEN, U.S. Dept. of Agriculture, *Kimberly, Idaho*

Object: To develop improved design and operating criteria and facilities for surface and sprinkler irrigation systems.

Plan of Work: Laboratory, field and model studies will be made with mathematical analyses to develop working relationships and to develop principles of surface irrigation hydraulics. This general procedure will apply to all phases of the work in this line project. Evapotranspiration data will be analyzed and incorporated into working charts and graphs for design engineers. New techniques and devices for applying and controlling irrigation water, including automation, will be developed theoretically, then tested in the laboratory and in the field under normal operating conditions. Laboratory studies will be made to determine the normal operating conditions. Laboratory studies will be made to determine the hydraulics of various gravity and sprinkler irrigation devices and the effects of wear and corrosion on these properties. Detailed studies of the uniformity of irrigation will be made to evaluate the efficiency and effectiveness of current and newly developed systems. Studies of stream size-slope-length of run will be done in plots and field installations to develop usable design and operating criteria. Technical publications and reports, operating procedures and popular type publications will be made available.

Cooperation: Washington, Oregon and Idaho Agricultural Experiment Stations; SCS; U. S. Bureau of Reclamation; soil conservation districts; and others.

SUPPORTED BY U.S. Dept. of Agriculture

3.0205, SOIL AND WATER MANAGEMENT PRACTICES FOR THE CONTROL OR ALLEVIATION OF SALINE AND SODIC SOIL PROBLEMS IN THE PACIFIC NORTHWEST

M.E. JENSEN, U.S. Dept. of Agriculture, *Kimberly, Idaho*

Object: To study the distribution and quantity of salts and exchangeable cations in salt-affected soils as affected by leaching, water quality, amendments and crop and soil management practices; and to evaluate the effectiveness of practices for removal of soluble salts and exchangeable sodium.

Plan of work: Controlled field experiments are conducted involving variables of culture, tillage, irrigation, drainage or amendment practices to replace sodium or remove salt from the soil with leaching water and to follow by chemical analysis changes in salt content and exchangeable cations. Special emphasis is placed on modification of water transmission properties of soils by mechanical or other means and on design of irrigation systems and management practices to improve the salt and sodium status of affected soils.

SUPPORTED BY U.S. Dept. of Agriculture

3.0206, GEOTHERMAL RESOURCES OF IDAHO

S.H. ROSS, State Bur. of Mines & Geol. , *Moscow, Idaho*

First & Second year: General survey to divide hot spring and hot well areas into ones of potential geothermal energy and ones that are unimportant. Location, ownership, discharge, temperature, and chemical quality of each spring will be determined.

Second & Third year: Detailed studies of areas of geothermal potential.

SUPPORTED BY Idaho State Government

3.0207, INVESTIGATION OF SEEPAGE REDUCTION BY NATURAL PROCESSES IN IRRIGATION CANALS

C.E. BROCKWAY, Univ. of Idaho, Water Resources Research Inst. , *Moscow, Idaho* 83843

The objective of this research would be to develop instrumentation for the measurement of soil properties and flow phenomenon under existing canals and natural channels and to investigate the causes and magnitude of natural sealing processes which occur throughout the season. Field work would be conducted using selected canal sections in the canals near Twin Falls, Idaho in which piezometers, tensiometers and soil moisture measuring tubes would be installed and monitored. The natural biological activities in the silt layers at the bottom of canals would be studied.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Idaho

3.0208, IRRIGATION OF WINTER WHEAT IN SOUTHERN IDAHO

G. MCMASTER, Univ. of Idaho, Agricultural Experiment Sta. , *Moscow, Idaho* 83843

OBJECTIVES: (1) Investigate methods of moisture control and effects on winter wheat at planting. (2) Determine the effect of soil-moisture level in the root zone from planting to heading and from heading to maturity on yield, maturity, protein content and milling qualities of winter wheat. (3) Determine the effect of soil moisture and nitrogen interaction on yield and quality of spring wheat.

Wheat will be planted in seed beds containing different amounts of moisture. Irrigation frequency will be used to maintain different soil-moisture levels from planting to heading and from heading to maturity. The soil moisture will vary from field capacity following irrigation to a predetermined point within the available soil moisture range. Soil-moisture effects will be a determined on evapotranspiration, yield, height, test weight, maturity, protein content and milling qualities.

SUPPORTED BY Idaho State Government

3.0209, EVALUATION OF INORGANIC MEMBRANES FOR ELECTRODIALYSIS OF BRACKISH WATERS

D.B. BOIES, I I T Research Institute, *Chicago, Illinois*

The performance of an electrodialysis stack using inorganic ion- exchange membranes will be evaluated. The cation-permeable membrane will be based on zirconium acid phosphate and the anion -permeable membrane is based on hydrous thorium oxide. The cell will be operated in the range of 500-1000 gallons per day. Variables to be investigated include feed concentration in the range of 1500 to 5000 ppm dissolved solids, velocity, temperature (ambient to 180 degrees F), and the effect of contaminants including both bicarbonate and sulfate hardness, iron, and anionic surfactants. At least one run will be conducted for a period in excess of 500 hours to obtain information on the stability and life of these membranes.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0210, CONCEPTUAL DESIGN STUDY FOR ELECTRODIALYSIS

D.B. BOIES, I I T Research Institute, *Chicago, Illinois*

The objective for this program is to investigate new concepts in electrodialysis for the desalination of water. The present work involves an investigation of electrodialysis using membranes with embossed flow channels. Such a design will lend itself to more economical and simpler cell construction by elimination of the conventional spacer, and possibly to improved cell performance.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0211, THE PREPARATION OF REVERSE OSMOSIS MEMBRANES BY THE SURFACE MODIFICATION OF CELLULOSE AND RELATED MATERIALS

J.J. HILLMAN, I I T Research Institute, *Chicago, Illinois* (14-01-0001-1445)

The purpose of this investigation is to obtain a material system of reverse osmosis membrane preparation which would be characterized by an inherent ability to form exceedingly thin active layers under conditions susceptible to very careful control and regulation. The end goal is the preparation of reverse osmosis membranes of substantially higher water flux values than the Loeb-type membranes without diminution of their salt-discriminating function.

This is to be achieved by the superimposition of an exceedingly thin slat-rejecting membrane or layer upon the surface of a polymeric film whose thinness, chemical nature, and morphology endow it with ample water flux but with insufficient salt-rejecting ability. This arrangement will be approached in a number of different ways. Each should be capable of producing the active salt-rejecting layer in degrees of thinness approximating monomolecular dimensions. Chief among these is the vapor and liquid phase acetylation of cellulose films.

The proposed undertaking will define in the laboratory the reactions, reaction conditions, and post-reaction treatments necessary to achieve high water flux and salt-discrimination qualities by surface modification. It will also concern itself with the investigation and elucidation of the water diffusion and salt-rejection mechanisms that will characterize the subject membranes.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0212, PREPARATION OF REVERSE OSMOSIS MEMBRANES BY SURFACE MODIFICATION OF CELLULOSE AND RELATED MATERIALS

J.J. HILLMAN, I I T Research Institute, *Chicago, Illinois*

The goal of the current program is the development of reverse osmosis polymer membranes superior to those currently in use. This objective is presently being pursued by direct chemical alteration of the surface of a polymeric film whose thinness, chemical nature, and morphology endow it with ample water flux but insufficient salt rejecting ability. Because of the present utility of cellulose acetate as a reverse-osmosis membrane, efforts involve the surface acetylation of cellulosics. Proper environmental control during acetylation with acetyl chloride has resulted in the achievement of a membrane that exhibits a salt rejection of 92% and greater durability than the Loeb membrane after extended use.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0213, IMPROVEMENT OF THE CORROSION RESISTANCE OF ALUMINUM BRASS FOR USE IN SEA WATER CONVERSION PLANTS

M.A. HOWES, Illinois Institute of Technol. , Iit Research Institute, *Chicago, Illinois* 60616

Standard aluminum brass has a good inherent corrosion resistance in sea water and also forms a 'self-healing' protective surface. The protective quality is related to the aluminum oxide component in the surface film. This work is directed towards improving the corrosion resistance of aluminum brass by promoting the formation of bohmite, a compact hydrated form of aluminum oxide (Al2O3.H2O). This will be carried out in an oxidizing atmosphere based on carbon monoxide, carbon dioxide, and water vapor at temperatures around 1000 degrees Fahrenheit. The kinetics of the reaction will be studied and the optimum conditions will be corrosion tested in 3 1/2% brine solution, first under static conditions and then in a loup system.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0214, FIELD EVALUATION OF THE SUL-BISUL ION EXCHANGE PROCESS FOR DESALTING BRACKISH WATERS

K.A. SCHMIDT, Elgin Softener Incorporated, *Elgin, Illinois* 60120

To evaluate the operational performance of the Sul-biSul ion exchange process using brackish waters of different composition and salinities by employing a speciality designed mobile unit. Data on resin performance and criteria on equipment design useful in extrapolating to large size plants will be obtained.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0215, CONCEPTUAL DESIGN STUDY ON REVERSE OSMOSIS MEMBRANE ASSEMBLY MODULAR UNIT

J.D. ZEFF, General American Trans Corp. , *Niles, Illinois*

Under this program, conceptual design studies will be conducted on several reverse osmosis membrane assembly modular unit designs suitable for use in large-scale desalination plants. Investigations on the technical and economic feasibility of employing shell-and-tube reverse osmosis membrane assembly modules with shell-side feed will be made. The membrane will be located around the outer periphery of thin tubes made of a suitable support material. Turbulence will be provided by either staggered baffles or the tubes themselves. Four different tube and baffle arrangements will be examined in sufficient depth so as to determine the feasibility of each for use in the construction of commercial reverse osmosis plants.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0216, CONTROLLED FREEZING DESALINATION

B.T. CHAO, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

The main objective is to study the heat and mass transfer processes associated with the separation of dissolved salt from brine by controlled freezing at the exterior surface of chilled pellets which traverse in the brine, initially downward and then upward. The reversal in pellet motion is brought forth automatically by the reduction in its apparent density as the ice layer formed over its external surface grows. Sealed in the pellet is a substance which is initially frozen solid and gradually transforms to the liquid state as heat is transferred into it. The pellets serve both as artificial nucleation sites and as carriers of ice.

Analytical studies are being made to develop suitable mathematical models for the description of the multi-region heat flow problem involving phase change and mass transfer. Experiments would be conducted to examine any shortcomings of the theory and then to seek improvements.

SUPPORTED BY University of Illinois

3.0217, LABORATORY STUDIES OF CONSERVATION AND DRAINAGE STRUCTURES

R.N. FENZL, Univ. of Illinois, Agricultural Experiment Sta. , *Urbana, Illinois*

The first phase of a laboratory investigation of factors contributing to bed scour below a cantilevered pipe outlet was completed. Depth and volume of scour were measured in relation to height of the outlet above the bed, jet velocity, and depth of tailwater over the bed. Mean fall velocity of the cohesionless bed material was estimated through empirical relationships. It was concluded that scour was related primarily to the outlet jet velocity.

SUPPORTED BY U.S. Dept. of Agriculture
University of Illinois

3.0218, TRANSFER OF SALT AND WATER ACROSS MEMBRANES OF PLANT MITOCHONDRIA

J.B. HANSON, Univ. of Illinois, School of Agriculture, *Urbana, Illinois*

Proposes a study of active sale and water transport in corn mitochondria in three phases.

1. To determine conditions essential for obtaining active transport of monovalent ions into the mitochondria, and the relationship of this transport to the nature of the accompanying anion. The part played by various cations and anions in spontaneous swelling will also be examined to see if the hypothesis is sound that swelling is caused by cation reaction with the non-phosphorylated intermediate of oxidative phosphorylation. 2. The effect of water and water structure on the stability and rate of energy-linked function in the membrane will be studied. An examination will be made for temperature anomalies in the energy-linked functions which would suggest that water structure is implicated. The results with various cations (phase 1) will be studied with respect to the properties of the hydrated ions in regulating stability of high-energy intermediates.

3. The role of phospholipids in energy-linked functions will be investigated. The amounts and kinds of phospholipids in active and senscent mitochondria will be determined. Experiments will be performed with auxins, which tend to increase the phospholipid content of mitochondria.

Statistical-mechanical methods are to be applied to these problems. 1. The calculation of the thermodynamic properties of the 'primitive model' of single and mixed electrolyte solutions with reasonable numerical accuracy at concentrations as high as 1 molar. 2. Calculation of the terms in the equivalent conductance of order c ln and c, where c is the concentration, for unsymmetrical electrolytes and for mixtures, on the basis of the simplest (Debye-Huckel) model. 3. Calculation of nuclear-magnetic relaxation times in ionic solutions and their relation to transport coefficients, on the basis of the simplest model. 4. Study of the effects on all of the above of using more realistic models.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0219, RAINFALL EVALUATION STUDIES

F.A. HUFF, Univ. of Illinois, State Water Survey Division, *Urbana, Illinois*

The evaluation of field experiments in weather modification is extremely difficult since natural variations in weather often exceed the changes which the experiment is attempting to induce. This grant will provide for a study of natural weather variability over a densely instrumented rain gage network now in existence near the University of Illinois. The effort will include:

1. An investigation to establish the effects of natural rainfall variability. 2. distribution patterns. 3. An investigation of the time distribution of rainfall. 4. Establishment of space and time sampling requirements to determine reliability of an arial basis.

Evaluation of various statistical tests and techniques for application in rainfall modification experiments in the Midwest.

SUPPORTED BY U.S. National Science Foundation

3.0220, RUNOFF FROM SMALL AGRICULTURAL AREAS IN ILLINOIS

B.A. JONES, Univ. of Illinois, School of Agriculture, *Urbana, Illinois*

A computer program was developed which combines individual raingage records into a watershed Thiessen weighted rainfall record. The 18 years of rainfall records have been combined to provide rainfall records for each of the four watersheds. Because of the wide variability of the rainfall intensities of record, a thesis study has been initiated to study the effect of micro-relief surface depression storage on a storm hydrograph.

SUPPORTED BY U.S. Dept. of Agriculture
University of Illinois

3.0221, INFLUENCES OF SALINE WATER ON CONCRETE

W.L. DOLCH, Purdue University, School of Engineering, *Lafayette - West Lafayette, Indiana* 47907

This investigation will involve the study of the effects of saline waters, of the composition and at the temperatures of interest in the problem of sea-water conversion, on cement paste and concrete.

The effects on the chemical composition of the hardened cement paste will be studied. New phases produced will be identified. It is hoped to gain information on their rate of formation and the effects of temperature.

The effects on the dimensional stability of pastes, mortars, or concretes will also be studied. The properties to be investigated are volume change, strength, and elastic modulus.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0222, THE EFFECT OF SUBSOIL TREATMENT ON SOIL CONDITIONS, CROP GROWTH, AND RUNOFF

H. KOHNKE, Purdue University, Agricultural Experiment Sta. , *Lafayette - West Lafayette, Indiana* 47907

The objectives are to determine to what degree subsoiling, subsoil fertilization and vertical mulching affect soil conditions, growth of crops and surface runoff. It consists essentially of two parts: watershed runoff studies and plot studies.

Description of work: The watershed studies have shown only minor effects of subsoiling on runoff. For this reason this work has been simplified by using on three subsoil treatments (untreated, subsoiling with subsoil fertilization, vertical mulching) and by merely determining peak runoff rates instead of total amounts of runoff.

The plot experiments are being continued on the same plots that were used for this purpose for a number of years, in order to determine whether repeated subsoiling will bring about essential changes in soil conditions and crop yield increases.

SUPPORTED BY Indiana State Government

3.0223, MOLECULAR BEAM INVESTIGATION OF THE WATER MOLECULE

C.R. MUELLER, Purdue University, Graduate School, *Lafayette — West Lafayette, Indiana* 47907

The primary objective of the research is the detailed study of interactions of the water molecule--monomer with monomer and monomer with dimer, etc. The first measurements will be made of the differential collision cross-section with thermal beams. Subsequent measurements will be made with seeded sonic beams to obtain velocity selection and inhomogeneous electric fields to incorporate rotational state selection. This will provide information on the asymmetry of the intermolecular potential of the water molecule.

The experiments will be done with the modulated molecular beam technique with sharply tuned preamplifiers and long time averaging by use of the Enhancetron signal averager.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0224, PREDICTING RUNOFF AND GROSS EROSION FROM FARMLAND AND DISTURBED AREAS

W.H. WISCHMEIER, Purdue University, Agricultural Experiment Sta., *Lafayette - West Lafayette, Indiana* 47907

Objectives: (1) Improve precision of field soil-loss estimation to guide farm planning for soil and water conservation, (2) develop an empirical soil-loss equation universally applicable wherever the factors can be locally evaluated, and (3) develop equations, tables and graphs to serve as ready-reference source for locality values of the factors.

This is a State companion project for the Agricultural Research Service national runoff and soil-loss data laboratory. Basic data assembled from 47 locations in 24 states will be statistically analyzed by machine methods.

SUPPORTED BY Indiana State Government

3.0225, DEVELOPMENT OF SUPPORTING RUNOFF AND EROSION CONTROL PRACTICES AND SYSTEMS IN THE CORN BELT

W.H. WISCHMEIER, Purdue University, U.S.D.A Soil & Wat Cons. Lab., *Lafayette - West Lafayette, Indiana* 47907

Object: To develop and test improved terraces, diversions, contour, contour stripcrop systems and other supporting conservation practices for control of runoff and erosion and waterways.

Plan of Work: Work under this line project will be located in areas where a particular phase of the study is a critical problem. Terrace studies will be conducted on field-size units. Runoff and soil losses will be measured by weirs, flumes, silt samplers and surface elevation readings. Rates of runoff and channel depth probabilities will be determined throughout the terrace of diversion length. Stripcropping studies will involve row grade and strip width on field plots representative of on-the-farm strip crop installations. Wind erosion control practices are under study to prevent filling of drainage ditches.

SUPPORTED BY U.S. Dept. of Agriculture

3.0226, INVESTIGATIONS OF EROSION CONTROL AND WATER CONSERVATION

C.E. BEER, Iowa State University, Agricultural Experiment Sta., *Ames, Iowa* 50010

This project is designed to study and quantitatively evaluate the factors associated with soil erosion. Included in the study is the determination of components of the hydrologic cycle (precipitation, runoff) and how they relate to the process of sheet and gully erosion.

Analyses to date have provided information for use in the design of more efficient methods of soil and water management. This has been accomplished through development of factors used in the Universal Soil Loss Equation and a quantitative expression for prediction of gully development.

The procedures used in the research include data collection from instrumented watersheds and small plots. The watersheds vary in size from 7 to 14 mi2 and are instrumented for precipitation measurement, amount and rate of runoff and sediment production and detailed changes in land cover and erosion development. The small plots are instrumented in a similar manner.

The location of the experimental areas is in Western Iowa and situated in the land resource area characterized by a deep-loess soil.

This project was initiated in 1949, however the problems receiving the research emphasis have changed during its tenure. The completion date is set for June 30, 1969.

SUPPORTED BY Iowa State Government

3.0227, INFLUENCE OF STRONGLY BOUND COUNTER-IONS ON PERMSELECTIVE MEMBRANES

F. DEKOROSY, Negev Inst. For Arid Zone Res., *Beersheva, Israel*

Counter-ions are attracted to the active sites of permselective membranes by forces which differ according to the size, charge and van der Waals forces relative to them. Strongly bound counter-ions decrease the permselectivity of the membrane, they also cause de-swelling and thus may affect the conductivity of the membranes by orders of magnitude. Strongly bound counter-ions with charges higher than that of the site may change the net charge and thus the sign of permselectivity of the membrane.

In this project we are going to vary the capacity, pK, cross linking and thickness of the membranes and charge and size and van der Waals attraction of the counter-ions. We are going to investigate the influence of these parameters on the electrochemical properties of the membranes. Extremely thin membranes will be investigated in the same manner. We are going to investigate the kinetics of 'poisoning' and 'depoisoning' of membranes.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0228, CONCEPTUAL DESIGN STUDY ON ELECTRODIALYSIS MEMBRANE ASSEMBLY MODULAR UNIT DESIGN

C. FORGACS, Negev Inst. For Arid Zone Res., *Beersheva, Israel*

This contract was undertaken to develop new and improved conceptual designs for electrodialysis desalination membrane assembly modular units which are economical and practical for use in brackish water desalting plants of 1, 5, 10 and 50 millions gallons per day (mgd) capacity. In order to accomplish this, information must be provided in sufficient detail on the proposed membrane assembly modular unit design to show that the design is practical as assessed against present state-of-the-art, and has the potential to be economically superior to present day technology electrodialysis plant designs. It must also be shown that plants based on these designs will be capable of producing potable water in the quantities and of the quality stipulated at an economically attractive cost. Critical design parameters and components associated with the proposed conceptual design will be identified. They should be explored through pilot plant studies to verify their economics and integrity.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0229, PHYSIOLOGICAL ADAPTATION OF PLANTS TO MOISTURE AND OSMOTIC STRESSES WITH RESPECT TO SALT ACCUMULATION

Y. VAADIA, Negev Inst. For Arid Zone Res., *Beersheva, Israel*

Object: (1) To study nutrient and salt fluxes and accumulation in intact plants and excised tissues at high concentration and/or tissue saturation; (2) to evaluate the effects of salinity and moisture deficits on energy metabolism; (3) and to assess hypothesis explaining growth reduction due to salt and water stresses.

Plan of Work: The research will involve a wide range of plants including sunflower, barley, beans, peas, tobacco and others. Experiments under objective (1) will involve kinetic study of salt fluxes in excised and intact plant roots at salt saturation and high external concentration. Anions such as chloride will be used primarily. Under objectives (2) and (3) measurements will be made of oxidative activity on intact cells in excised tissue and cell free organelles. Particular attention will be given to phosphorylation/ Under objective (3) we have already shown that variation in the supply and translocation of kinetin-like root hormones may regulate the modification in shoot metabolism under stress. Experiments will be designed to test in a preliminary manner the effect of root hormones, endogenous as well as synthetic analogs on energy metabolism.

SUPPORTED BY U.S. Dept. of Agriculture

3.0230, PERFORMANCE AND SCIENTIFIC DESIGN OF SPRINKLERS USED FOR IRRIGATION

H.J. FINKEL, Technion, *Haifa, Israel*

Object: To investigate the hydrodynamic properties and performance of different types of sprinklers, and develop principles for improvement in their design.

Plan of Work: The hydrodynamic properties of currently used sprinklers will be studied using high-speed motion picture techniques, and equipment for drop counting, sizing, trajectory plotting, and impact measurement. The process of stream breakup and drop formation and size in relation to orifice shape and pressure will be studied for the development of design principles. These principles will be used in the design of improved sprinklers for the efficient application of water at desired intensities, high uniformity of distribution, a minimum of evaporation loss, and low impact forces. Sprinklers will be built according to the new design and tested both in the laboratory and field.

SUPPORTED BY U.S. Dept. of Agriculture

3.0231, BIOLOGY AND CONSUMPTIVE WATER USE OF PERENNIAL RANGE PLANTS UNDER DESERT CONDITIONS

M. EVENARI, Hebrew University, *Jerusalem, Israel*

Object: To obtain basic data on soil-water-plant climate relationships and to study the biology, phenology, growth, yields, and persistence of perennial grasses and other range plants, with different water regimes under natural desert conditions.

Plan of Work: Four to five species of the following group will be studied: Hordeum bulbosum, Phalaris tuberosa, Oryzopsis miliacea, Avena sterilis, Lolium rigidum, Cynodon dactylon, and Medicago sativa. Effects of density on yields and persistence will be investigated. Six flood treatments are planned for the first three years: one flood (early); one flood (late); two floods (early); two floods (late); three floods; and five floods. A 'flood' means wetting to field capacity the root zone (5-6 ft. depth). In the fourth and fifth years, a no flood treatment and variations in flooding depth (2-7 ft) will be introduced. Net assimilation rate, relation of phenology to water regime, growth rate, dormancy, yield and persistence of plants will be correlated with the seasonal march of soil moisture. Soil moisture along the whole wetting profile will be measured every two weeks during the growing season and every four to six weeks during other seasons of the year.

SUPPORTED BY U.S. Dept. of Agriculture

3.0232, ION TRANSPORT IN SOME HALOPHILIC ORGANISMS

B.Z. GINZBURG, Hebrew University, *Jerusalem, Israel*

This work concerns ion metabolism in some halophilic bacteria and algae. These organisms are adapted to life in solution containing 30% salt. It has been shown that such organisms have more powerful mechanisms for the regulation of their ions than do organisms from more usual habitats. It is proposed to relate a biophysical study of ion concentrations and fluxes with the biochemical means whereby chemical energy is liberated and transferred to the transport systems of those ions transported actively across the cell membranes. The results will be used to test the theory of transport processes derived from the thermodynamics of irreversible processes by A. Katchalsky and his coworkers.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0233, CROP, SOIL AND WATER USE EFFECTS OF LOW INTENSITY SPRINKLER IRRIGATION

S.D. GOLDBERG, Hebrew University, *Jerusalem, Israel*

Object: To determine the effects of greatly reducing the rate of sprinkler irrigation application on water use requirements of crops, irrigation erosion, soil aeration and aggregation, microbiological activity, and crop yield and quality.

Plan of Work: Use will be made of a range of soil textural classes with particular attention to the medium to fine sizes. Five representative crops, (probably peanuts, cotton, alfalfa, citrus and vegetables) will be included. The intensity of irrigation water application will range from the maximum infiltration rate to only a relatively small fraction of the established rate. Data will be secured on crop yield and quality; water use, including water delivery, runoff and soil loss if any, water distribution, and soil moisture to below root zone; and climatic factors, including rainfall, humidity, radiation, temperature and wind as needed for interpretation of water use data. Evaporation losses during water application; deep percolation losses; and soil aeration, aggregation and microbiological effects of water application will be evaluated. Periodic records will be secured of plant disease developments. Records will be kept of water application equipment so hydrodynamic characteristics may be determined from A10-SWC-11 is desirable.

SUPPORTED BY U.S. Dept. of Agriculture

3.0234, ION DISCRIMINATION BY HYDROPHOBIC MEMBRANES

A. ILANI, Hebrew University, *Jerusalem, Israel*

Filters containing fixed negative charges of low concentration will be produced by various methods. Such filters will be saturated with hydrophobic solvents and interposed between aqueous solutions. The ability of such membranes to discriminate between various cations will be studied by measuring:

1. Equilibrium distribution ratio between water and membrane of various cations. 2. The dependence of the resistance of membrane on the counterion present in the aqueous medium. 3. Bi-ionic potential across such membranes. 4. The diffusion coefficient of ions in such membranes.

It is essential to have a low concentration of fixed charge sites in order to maintain hydrophobicity of the filter. If the charge sites' concentration is too high the hydrophobic solvent will be displaced from the filter's pores by water as soon as it is exposed to the aqueous solution. On the other hand, with no fixed charged sites in the membranes the situation reduces to that of diffusion through homogeneous hydrophobic solvent layer. The effect of a change in fixed charge sites density on ion diffusibility within the membrane will be studied.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0235, DIFFERENCE IN EFFECTS OF FOREST AND OTHER VEGETATIVE COVERS ON WATER YIELD

A.Y. SHACHORI, Ministry of Agriculture, *Nathanya, Israel*

Object: To determine the characteristic effects of pine forest, oak-chaparral, grass cover, and bare ground on moisture loss and disposition of precipitation in the Karst formation of the Cenomanian- Turonian complex in Israel.

Plan of Work: Two blocks of four plots each, representing pine grass and bare areas have been selected for study near Mt. Carmel, in Israel. Three techniques of investigation will be applied to these plots: (1) Direct measurement of water loss from soil and rock: Each plot is equipped with five aluminum access tubes installed to depths of 10-12 meters. (2) Direct evapotranspiration measurements from oak- chaparral and grass cover will be made with a 10-square-meter transpiration tent. (3) Energy balance determination: Bimonthly measurements of incident and reflected short wave radiation, and net radiation, will be made throughout the year from a helicopter hovering 10 meters above the vegetation canopy. (7.5 pmy)

SUPPORTED BY U.S. Dept. of Agriculture

3.0236, THE EFFECT OF BOLL MOISTURE STRESS ON DEVELOPMENT AND LINT QUALITY OF COTTON

A. MARANI, Hebrew University, *Rehovot, Israel*

Object: To define the effects of low and high levels of moisture stress applied under varying climatic conditions and at different stages of growth to two varieties of cotton selected for their differences in response to climate.

Plan of work: Each year experiments will be conducted at three locations--(a) the coastal plain with mild summer temperatures and high relative humidity, (b) the Negev region with higher temperatures and low relative humidity, and (c) the Boisan valley with a very hot dry climate. In each location the eight following treatments will be compared: No irrigations after planting; moisture stress from beginning of flowering for six weeks; from beginning of flowering for three weeks; from beginning of boll development to end of season, from beginning of boll development for three weeks; from mid-bolling to the end of the season; two moisture stress periods as in 3 and 6; and complete irrigation. Soil moisture at different depths of all plots will be recorded daily, and flower and boll counts made throughout the season. Lint percent, boll size, upper half mean staple length and lint quality will be determined at several harvesting periods. Vegetative development will be assessed. Stomatal aperture will be evaluated and leaf sap examined, and these data related to the soil and climatic conditions at sampling time. (2.25 pmy per yr.)

SUPPORTED BY U.S. Dept. of Agriculture

3.0237, AGRICULTURAL UTILIZATION OF SOILS AFFECTED BY SALINITY

S. RAVIKOVITCH, Hebrew University, *Rehovot, Israel*

Object: To determine the yield response of plants growing in saline substrates to the application of specific combinations of plant nutrients; to study ion movement in soils and resulting exchange reactions; and to select salt-tolerant plants that will produce economic yields when irrigated with moderately saline waters.

Plan of Work: Plants of economic value in agriculture will be grown on slightly to moderately saline soils of different properties. Cereals, legumes and vegetables will be selected according to their growth and production for special plant nutrient supply studies. The effects of different rates and combinations of macro and micro plant nutrients on the growth and production of the various selected plant species will be evaluated. The movement of plant nutrient ions in the saline soils will be followed and the influence of these ions on exchange reactions determined. Initial phases of the product will be conducted under greenhouse conditions, and crops and fertilizer treatments exhibiting favorable results studied under field conditions.

SUPPORTED BY U.S. Dept. of Agriculture

3.0238, RUNOFF INDUCEMENT IN ARID LANDS

D. HILLEL, Volcani Inst. of Agric Res. , *Rehovot, Israel*

Object: To apply recent developments in the theory of rain infiltration in layered soils to the practical problem of controlling infiltration and runoff; (2) to study the feasibility of using various treatments to seal the soil surface against infiltration and stabilize it against erosion; (3) to develop practical methods for inducing and utilizing runoff in crop and pasture production and in reservoir supply.

Plan of Work: (1) Lab trials: a series of experiments to test various surface treatments designed to form a stable impermeable crust with combined chemical and mechanical treatments. This stage will necessitate the construction of devices for measuring infiltration, runoff and erosion under sprinkling and flooding. Prototypes of such devices have already been developed at Rehovot and have proved their usefulness. (2) Field trials: Results of preliminary laboratory trials will be tested under field conditions. Runoff plots will be constructed to permit measurement of runoff yields and erosion under natural and artificial rainstorms. (3) Large-scale applications: Results of laboratory and field trials will be applied in full-scale systems of runoff utilization. Methods of runoff inducement will also be applied to pilot engineering projects such as stockwater reservoirs, cisterns, retention dams and water-spreading systems.

SUPPORTED BY U.S. Dept. of Agriculture

3.0239, WATER TRANSPORT THROUGH HYPERFILTRATION MEMBRANES

O. KEDEM, Weizmann Institute of Science, *Rehovoth, Israel*

Osmotic water flow and water self-diffusion through solvent-swollen gels and through hyperfiltration membranes were recently investigated. The results indicate that the mechanism of water flow in cellulose acetate membranes is close to molecular diffusion in liquids. We thus hope that the measurement of water diffusion in organic liquids may lead to a rational choice of alternative polymers. We plan to estimate the mobility of water relative to the solvent by simultaneous tagging of water and the organic solvent.

Polymer membranes will be tested. We have shown that salt rejection as a function of flow rate can be predicted from the salt permeability and the reflection coefficient ('apparent osmotic pressure') of the membrane, both measured in the absence of volume flow. In particular, the maximal salt rejection, which can be reached in practice only very thin selective films, is given by the reflection coefficient which is easily measured. This test procedure will be checked and, if necessary, modified for concentration-dependent transport coefficients.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0240, DESALINATION BY THE INVERSION ON THE ORDER OF MELTING BY APPLIED PRESSURE

R.G. AKINS, Kansas State University, School of Engineering, *Manhattan, Kansas* 66504

The ultimate objectives of the proposed work is to make technical and economic feasibility study of a freezing process which takes advantage of the abnormal melting point curve of water in upgrading heat energy. In this process, a suitably selected working medium is used to remove heat in the ice making operation by melting the medium at a low pressure and to supply heat in the ice melting operation by solidifying the working medium at a sufficiently high pressure.

The proposed work can be broken into two parts: the first part would be that of continuing the gathering of thermodynamic data on the organic working mediums. The second (and major) part would be to construct and operate a 1,000 gallons per day (fresh water) semi-pilot plant. In this study, the effects of the operating variables on the rate of heat transfer both in the ice making and ice melting operations and the quality of ice crystals produced will be studied. In the operation of this proposed semi-pilot plant, information for planning a full size pilot plant can be obtained and control problems and other basic physico chemical processes associated with the process can be studied.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0241, OPTIMAL DESALINATION SYSTEMS

L.T. FAN, Kansas State University, School of Engineering, *Manhattan, Kansas* 66504 (14001-001-1283)

It is proposed that a number of problems of prime interest to the Office of Saline Water be approached adopting freely any method or combination of methods of optimization which suit the problems and situations. Problems to be considered include (1) additional optimization studies of the reverse osmosis and multieffect, multistage flash evaporation systems; (2) optimization studies of other desalination processes such as electrodialysis systems; (3) the development of additional optimization techniques and computational techniques that are needed for the optimization of desalination systems; (4) optimization of desalination systems during unsteady state operation; and (5) optimization studies related to the reliability and management of desalination systems.

While the major concern of this proposed work is not the development of system equations or models characterizing systems and their components, the broad interests and capabilities of the present investigators will make possible the development of performance equations to provide representative optimal solutions for specific systems or components. The major emphasis, however, will be in optimizing already formulated system models satisfying the objective functions and constraints of the systems.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0242, PRODUCTION OF HIGHLY PALATABLE WATER FROM AIR FOR HOUSEHOLD, LIVESTOCK, AND INDUSTRIAL USE

R.C. HALL, Kansas State University, Agricultural Experiment Sta. , *Manhattan, Kansas* 66504

The shortage of water is a recurrent problem in agriculture and industry. It is believed that there are good possibilities of producing potable water by absorbing water vapor from the air with a liquid such as ethylene glycol, followed by separation of the water and glycol in a solar still. The design of solar stills is well along; therefore the objectives of this project are: 1. Design and test equipment for absorbing water from the air. 2. Make estimates of the economics of the proposed process. Triethylene glycol will be used as the first absorbent. Various contacting devices, such as towers, will be designed and their operating characteristics determined. After the most efficient design is found, a large scale absorber will be built from which costs data may be obtained.

SUPPORTED BY Kansas State Government

3.0243, ECONOMICS OF SOIL CONSERVATION PRACTICES WITHIN WATERSHEDS

R.D. MCKINNEY, Kansas State University, Agricultural Experiment Sta., *Manhattan, Kansas* 66504

Objectives: To make economic analyses of applied conservation practices and associated cultural practices using the 10 years of data that has been gathered in three Kansas watersheds since 1953. To analyze the economics of applied conservation practices by watershed, by farm and by soil types.

Description of Work Proposed: The ten years of collected data will be processed so that land use cultural practices and applied conservation practices can be associated with all lots of land and soil types. Detailed analyses will be made of the effect on yield of contour farming, terracing by crops, soil types and by farm organizations. Weather data is available in one watershed. This data will be used in correlation studies on yields and cultural practices. The data gathered for this economic study will also be used in a cooperative study with A.R.S. which has collected sediment and run off data on the Sabetha Watershed over a ten year period.

SUPPORTED BY Kansas State Government

3.0244, EVAPOTRANSPIRATION AND ITS CHEMICAL REDUCTION

W.L. POWERS, Kansas State University, School of Agriculture, *Manhattan, Kansas* 66504

Precision lysimeters will be used to measure evapotranspiration (loss of water by evaporation from soil and plant surfaces) from agricultural land. Relationships between plant and environment (wind velocity, air temperature, humidity soil temperature, soil water, and radiation) and evapotranspiration will be formulated for short (less than one hour) periods of time. Using the knowledge gained, transpiration reducing chemicals will be applied to plants and their effectiveness measured by lysimeters.

The precision lysimeter along with the collected plant environment data will be used as a standard for comparison with the present indirect, but more mobile Bowen Ratio method for estimating evapotranspiration from chemically treated plots throughout Kansas.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Kansas State University

3.0245, SOIL WATER MOVEMENT

W.L. POWERS, Kansas State University, Agricultural Experiment Sta., *Manhattan, Kansas* 66504

The objective of this research is to measure water movement in soil and use the information obtained from these measurements to evaluate water management and conservation practices.

Water movement in soil profiles will be followed by mercury-in- glass tensiometers supplemented with Bouyoucos gypsum blocks or gravemetric measurements. Hydraulic gradients determined with the tensiometers and Bouyoucos blocks will be used to determine capillary conductivity values of the water in the soil.

Water management and conservation practices will be evaluated on the basis of the information found from this water movement research.

SUPPORTED BY U.S. Dept. of Agriculture
Kansas State Government

3.0246, INTER-DISCIPLINARY RESEARCH IN THE AREA OF THE KANO PLAINS, WESTERN KENYA

S. OMINDE, Univ. College, *Nairobi, Kenya*

I. Ecological surveys, settlement and land use - Work is already in progress at University College on settlement and land use in the area of the Kano Plains; it is proposed to extend this to include geomorphological, hydrological and ecological data collection to provide the most up-to-date scientific information for regional planning.

II. Biological studies (proposed as Kenya's contribution to the IBP) preliminary data will be collected on three aspects of the ecology: a) productivity of fish in the lake shore region and the streams of the Kano Plains affected by migrations; this will be extended to include the fisheries potential productivity in the pilot irrigation scheme. b) the ecology of snails in the area. c) the ecology of mosquitoes, biting flies and other aquatic insects under water-logged and irrigation conditions - this survey to be correlated with current public health aspects already being studied.

III. Socio-economic problems - Experience in a pilot project has underlined the need for urgent investigation on both the immediate problems of attitude and impact of the far-reaching changes in the way of life of the people in the area outside the pilot scheme. The problem of population density and the impact of the change on existing traditional economy will be studied, including an inquiry into attitudes toward family planning.

SUPPORTED BY Rockefeller Foundation

3.0247, CORROSION AND MASS TRANSFER FROM CYLINDERS OF METALS ROTATING IN SEAWATER AT HIGH TEMPERATURES AND PRESSURES

J. MARANGOZIS, Univ. of Southwestern La. , School of Engineering, *Lafayette, Louisiana* 70506

The purpose of the project is to measure and correlate the rates of corrosion of cylinders of such metals, as ferrous alloys, aluminum and aluminum-base alloys in seawater at temperatures up to 400 degrees F. and pressures up to 250 psia. It is proposed to use a high-pressure autoclave inside which cylindrical specimens of the metals are to be rotated under well-defined conditions of the most important independent variables, including fluid velocity, temperature, pH of solution, oxygen or carbon dioxide concentration, seawater composition, etc. It is expected that the experimental data, in conjunction with a mathematical analysis of rotational flow around cylinders in light of the boundary layer theory and the principles of ionic phenomena can lead into establishing quantitative relationships between the rates of corrosion and the pertinent variables.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0248, STUDY OF ORIENTED CELLULOSE MEMBRANES FOR REVERSE OSMOSIS AND THE RELATIONSHIP BETWEEN MORPHOLOGY AND SALT REJECTION

E. KLEIN, Gulf South Research Institute, *New Orleans, Louisiana* 70126

Cellulosic membranes having varying degrees of orientation and lateral order will be prepared on a continuous extrusion apparatus. The morphology of the membranes will be determined by deuterium oxide exchange measurements. The diffusion coefficient for water and NaCl will be measured in the membranes, as well as the solvent and solute partition coefficients between the membrane and aqueous salt solutions. Attempts will be made to correlate the morphology of the structures with the permeability of solvent and solute. Those membranes considered promising will be evaluated for reverse osmosis applications in desalination.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0249, THE USE OF NUCLEAR METHODS FOR DETERMINING FOREST SOIL SITE INDEX

J. KUPRIONIS, Louisiana Polytechnic Inst. , School of Agriculture, *Ruston, Louisiana* 71270

Objectives: (1) To determine the values of nuclear methods to locate the depth, the surface, thickness and density of the least permeable layer of two forest soil profiles. (2) To determine the relationship of the data in (1) to water intake, runoff and water storage capacity of the soils. (3) To correlate data of (1) and (2) to an evaluation of site index.

Abstract of Procedure: A depth density gauge using cesium-137 as a source of gamma rays will be used to determine the depth to, thickness of, and density of the least permeable layer of two forest soil profiles. Rainfall, runoff, and infiltration data from natural rainfall will be collected. These data will be analyzed, by computer programs to determine site index.

SUPPORTED BY U.S. Dept. of Agriculture

3.0250, LIGHTWEIGHT WATER PURIFICATION UNIT

C.S. BARNHART, U.S. Army, Limited War Laboratory, *Aberdeen Proving Ground, Maryland* 21005

Tech Objective: To fabricate a lightweight, all-plastic still weighing less than six pounds when empty; which produces 1 to 2 quarts per hour of high quality distilled water from turbid, brackish or saline sources. The still will utilize locally available fuel.

Tech Approach: The boiler is a 6-inch diameter, 4-foot tube of fiber glass fabric impregnated with silicone rubber. When filled with water, the boiler can be heated directly in a wood fire. The water level in the boiler can be maintained by addition of raw water during operation through a specially designed filling valve. Distillate is condensed by air cooling, in plastic tubing. Filled lengths of condenser tubing can be tied and cut off for convenient transport of distillate.

Progress: The results of the Army evaluations were that even though the device did meet the technical objectives, tactical requirements in remote areas did not warrant use of this device. The task was then terminated.

SUPPORTED BY U.S. Dept. of Defense - Army

3.0251, REVERSE OSMOSIS WATER PURIFICATION

C.S. BARNHART, U.S. Army, Limited War Laboratory, *Aberdeen Proving Ground, Maryland* 21005

Tech Objective: To obtain potable drinking water in the Delta region of RVN.

Tech Approach: To fabricate a lightweight unit using current state-of-the-art reverse osmosis techniques. In this process, water is forced under pressure through cellulose acetate membranes backed up with porous supports. The membranes are not filters or ultra-filters but function as osmosis in reverse. The water molecules pass through leaving behind salts and other particulate materials.

Progress: Two items were shipped to RVN for utilization by U. S. Forces in the Delta in April 1968. To date, no report has been received. The general characteristics of these units are: weight of unit- approximately 60 lbs; capacity - 100 gallon per day fresh water from highly saline sources. Water output: fuel ratio - 34 lb water per 1 lb fuel.

SUPPORTED BY U.S. Dept. of Defense - Army

3.0252, INDIVIDUAL WATER FILTRATION DEVICE

H. ROSEN, U.S. Army, Limited War Laboratory, *Aberdeen Proving Ground, Maryland* 21005

Tech Objectives: To develop a water filtration device for individual use that will remove particles larger than 10 microns in diameter.

Tech Approach: The unit includes a piston-type pump by means of which water is drawn into a filter and forced through it. The filtered water is then collected directly in a standard one or two quart canteen to which the unit is attached. The filter does not remove bacteria.

Progress: An evaluation of this unit was accomplished in South East Asia during 1966. The results of this evaluation indicated that standardization for quantity procurement of this assembly was not desired and future requirements would only be of a special use nature. The task effort has been terminated.

SUPPORTED BY U.S. Dept. of Defense - Army

3.0253, DEVELOP A COMPUTERIZED METHODOLOGY FOR EVALUATION OF MUNICIPAL WATER CONSERVATION RESEARCH PROGRAMS

N. GREENBERG, Hittman Associates Inc., *Baltimore, Maryland*

The proposed research will develop digital computer programs that will allow the computation of benefit-cost ratios for an array of proposed conservation alternatives for any given municipal area in the United States. The program will compute the overall benefit to the municipality in gallons of water saved by the adoption of conservation policies, attitudes, techniques, devices, or systems. The foundation for the proposed research will be the model now under development for OWRR which analyzes and defines the municipal water requirements as a 'consumption system' on a microscopic basis. That model will be extended and converted to allow the reflection of the impact of many conservation approaches simultaneously.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

3.0254, THE ROLE OF BRITTLE SURFACE FILMS IN STRESS-CORROSION CRACKING

J.A. GREEN, Martin Marietta Corporation, *Baltimore - Middle River, Maryland*

The basic aim of this project is to examine the proposal that stress-corrosion cracking proceeds by the repeated formation and rupture of brittle surface films. A major prediction of this 'brittle-film' model is that the rate of cracking is controlled by the rate of growth of the brittle film, and thus, to determine the validity of the model, studies are being undertaken to correlate these rates. ellipsometric technique has been employed to study rates of film growth on alphabrasses exposed to aqueous-ammonia solutions. The results provide strong support for the brittle-film model, both the rates of growth of the film (cuprous oxide) and the rates of cracking increasing markedly with increasing zinc content of the brass, increasing temperature, and anodic polarization. These studies are being extended to failures of a magnesium alloy, an austenitic stainless steel, and an alpha-titanium alloy in aqueous-chloride environments.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0255, THE ROLE OF BRITTLE SURFACE FILMS IN STRESS-CORROSION CRACKING

E.N. PUGH, Martin Marietta Corporation, *Baltimore - Middle River, Maryland*

Objective: This research program is aimed at evaluating the role of brittle surface films in stress-corrosion failures occurring in aqueous chloride environments.

Scope of work: (a) Systems; (1) Austenitic Fe-20% Ni-20% Cr alloy exposed to aqueous 42% MgCl2 at about 150 degrees C, (2) Single phase Mg-6% Al alloy exposed to aqueous solution of 40 g/l NaCl and 40 g/l K2CrO4 at room temperature.

(b) Stress-Corrosion Studies: Specimens taken from alloy will be axially loaded in tension while immersed in test solution, using conventional stress-corrosion equipment. Rates of cracking will be determined from these experiments.

(c) Electron-Microscope Studies: Replicas taken from the stress- corrosion fracture surfaces will be studied to determine whether discontinuous cracking has occurred. If the presence of this type of cracking is confirmed, measurements of the striations will be made to determine the thickness through which the crack propagated during each step. Electron-diffraction studies will be made in the microscope to determine the nature of the surface films. In addition, the nature of the films in the fracture surfaces will be investigated in situ by reflection electron diffraction.

(d) Ellipsometric Studies: Polished, unstressed specimens of the alloys will be exposed to the test solutions in the cell of an ellipsometer. Film growth will be allowed to proceed under conditions duplicating those of the stress-corrosion exjperiments, and the film thickness will be determined continuously. The film growth rates will be used with data from the electron-microscope studies to calculate rates of cracking for comparison with experimentally determined cracking rates.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0256, IMPROVED CULTURAL PRACTICES FOR PRODUCING SAFFLOWER UNDER IRRIGATED AND NON-IRRIGATED CONDITIONS

J.O. CULBERTSON, U.S. Dept. of Agriculture, *Beltsville, Maryland*

Object: To develop improved practices for producing safflower through research on crop sequence and rotation practices; fertilizer treatments; methods of tillage; date, rate, and method of planting; weed control; and other cultural practices.

Plan of work: Appropriate field plot techniques will be used in investigating and developing improved tillage and management practices under irrigated and non-irrigated conditions. Research will involve various combinations of fertilizer treatments, rates and dates of planting, irrigation practices, crop sequences, rotation practices, and methods of planting. Pre-emergence and, particularly, post emergence chemical weed control will receive attention in cooperation with State and Federal specialists. Studies will be made to evaluate selected chemicals in field plots and study effective dates and rates of application. The effects of various crop sequences, irrigation practices and methods of planting upon incidence and severity of disease and weed populations will be investigated. Various combinations of the above procedures will occupy one to several acres at Logan, Utah; Mitchell and Alliance, Nebraska; and Mesa, Arizona.

SUPPORTED BY U.S. Dept. of Agriculture

3.0257, IRRIGATION PRACTICES AND FACTORS AFFECTING THE WATER REQUIREMENT OF CROPS IN DIFFERENT LAND RESOURCE AREAS OF THE NORTHEAST

J. LUNIN, U.S. Dept. of Agriculture, *Beltsville, Maryland*

Object: To determine the consumptive use, water requirement and moisture extraction patterns of specific crop plants at various growth stages, to evaluate environmental factors affecting soil-water-plant relationships, and to integrate the information into efficient irrigation practices for various land resource areas.

Plan of Work: Laboratory, greenhouse and field work will be combined into an integrated program to develop new concepts of soil- water -plant interrelationships. Information is being obtained on factors affecting consumptive use of water at various plant growth stages, moisture extraction patterns of various crops, and effect of soil-water suction on water utilized by plants. Study will be made of (1) effect of climatic components on evapotranspirational losses so that existing climatic data can be used to estimate evapotranspiration and predict the need for irrigation, (2) criteria for development of efficient irrigation practices for specific crops, crop rotations and other management systems, and (3) efficiency of irrigation practices in terms of product quality and yield. Moisture retention and transmission characteristics of major benchmark soil types will be made.

SUPPORTED BY U.S. Dept. of Agriculture

3.0258, EFFECTS OF USING SALINE AND INDUSTRIAL WASTE WATERS ON YIELD AND QUALITY OF PLANTS

J. LUNIN, U.S. Dept. of Agriculture, *Beltsville, Maryland*

Object: To investigate the quality of brackish (saline) and industrial waste waters from various sources for supplemental irrigation application methods and frequencies and their effect on plant growth and soil physical-chemical properties.

Plan of Work: Field surveys will be made to characterize the quality of brackish and industrial waste waters, and their chemical composition determined. Field investigations where brackish water is used to irrigate vegetable and forage crops under field conditions will be studied to determine (1) the best methods and frequencies of irrigation, (2) salt accumulation as affected by irrigation and leaching by rainfall, and (3) salt tolerance of various crops. Greenhouse investigations will be carried out to determine soil-plant-water interrelationships as affected by salinity. This includes soil and solution culture studies to evaluate interactive effects between salinity and fertility, and levels of base saturation and growth state at time of salinization. Laboratory investigations will be made of cation exchange reactions in various soils at different levels of base saturation as affected by leaching with saline solutions followed by leaching with distilled water. The effect of these reactions on physical properties of the soil (permeability, modulus of rupture, bulk density, etc.) will be determined. Similar studies will be carried out using processing plant effluents.

Cooperation: Virginia Agricultural Experiment Station; SCS; U. S. Salinity Laboratory; Virginia Truck Experiment Stations.

SUPPORTED BY U.S. Dept. of Agriculture

3.0259, EFFECTS OF FERTILIZER AND SOIL MANAGEMENT PRACTICES, IRRIGATION, PLANT SPACING, AND OTHER CULTURAL TREATMENTS ON BERRY PRODUCTION

D.H. SCOTT, U.S. Dept. of Agriculture, *Beltsville, Maryland*

Object: To determine the effects of fertilizers and soil management practices, irrigation, plant spacing, and other cultural treatments on yield and quality of berries produced, particularly for newer varieties.

Plan of work: Work plans vary from year to year depending upon th kind of problem to be solved. Plants are usually grown in replicated plots and data obtained on characters such as fruit size, yield, time of ripening, disease ratings, and fruit quality in relation to variousjs treatments. Nutrition, irrigation, mulching, chemicals for weed control, methods of propagation, and physiological responses of plants to temperature and photoperiod are investigated both in green houses and field plots.

SUPPORTED BY U.S. Dept. of Agriculture

3.0260, EFFECTS OF NUTRITION, CULTURAL PRACTICES AND WEATHER ON THE GROWTH, DEVELOPMENT, YIELD AND QUALITY OF CORN

G.F. SPRAGUE, U.S. Dept. of Agriculture, *Beltsville, Maryland*

Object: To study the absorption and use of different mineral elements by the plant and the distribution of these elements in different plant parts; the relation of environment and heredity to composition and quality; and the responses of corn plants and seeds to various environmental factors; and to determine the adaptability of new and improved corn strains to different cultural practices.

Plan of work: Inbred lines and hybrids in field plots and sub-irrigated gravel cultures will be compared to learn the differences in rate or total amount of absorption of various chemical elements and the distribution of these elements in the various plant parts. The physiological basis for differences in absorption or distribution observed will be established through laboratory studies. Corn seedlings and plants in the field, greenhouse and laboratory will be subjected to variations in light, temperature, moisture, nutrition and other agents and a determination made of the differences in strain reaction. The physiological basis for observed differences will be explored, and the possibility of increasing strain differences by selection determined. Different corn strains under different cultural and production practices will be compared to those on soils of different fertility and growth yield and quality of corn produced by the different methods measured.

SUPPORTED BY U.S. Dept. of Agriculture

3.0261, IMPROVEMENT IN CIGAR TOBACCOS BY DEVELOPMENT OF MORE ADEQUATE CROPPING SYSTEMS, FERTILIZATION, CULTURAL AND CURING PRACTICES

G.L. STEFFENS, U.S. Dept. of Agriculture, *Beltsville, Maryland*

Object: To improve the quality and yield of filler, binder and wrapper types of cigar tobaccos and to maintain economical production through adequate cropping systems, fertilization, cultural and curing practices.

Plan of work: Using accepted experimental design and field plot techniques research will be conducted to study cropping systems, crop handling practices including curing, additions to the soil of mineral, manure, and organic supplements as they are related to yield and quality of cigar filler and binder and wrapper types of leaf. Laboratory studies will be made upon leaf of known history from experimental plots with a view to arriving at a more adequate basis for quality evaluation and relating the findings to improvement of the crop. In an effort to lower cost of production, it is necessary to adapt improved cultural practices suitable for automation, and also the application of growth regulators which do not result in undesirable effects. Treatments involving cropping sequence, fertilizers, cultural practices, and curing methods will be evaluated statistically so as to analyze the interaction among these variables. Other factors such as time and method of topping, suckering, irrigation, spacing, trans-varietal differences will also be studied.

SUPPORTED BY U.S. Dept. of Agriculture

3.0262, VARIETAL EVALUATIONS AND IMPROVED AGRONOMIC PRACTICES FOR SUGARBEETS

D. STEWART, U.S. Dept. of Agriculture, *Beltsville, Maryland*

Object: To evaluate hybrids and varieties of sugarbeets for regional adaptation, and develop agronomic practices for more efficient production.

Plan of work: Promising varieties and new developments in sugarbeet breeding research will be evaluated in regional programs of field trials that will be planned to sample soil types and weather conditions and appraise varietal tolerance to prevalent diseases. Hybrids, breeder seed, and other varietal developments in breeding will be screened and will involve disease tolerance, bolting resistance, sucrose percentage, size of root, etc. The most promising entries will be further evaluated in intensive tests to determine more precisely their regional adaptation. The interrelation of adapted varieties to regimes of spacing, fertilization, and plant populations will be studied in relation to quality and productivity. Crop sequence, plant residues, soil amendments, tillage, and irrigation will be studied in relation to the pathogenic flora and fauna as well as to quality and productivity. The influence of plant spacing along the row and distance between rows will be studied in relation to productivity weed control, and other field practices. The cultural studies will be aimed at developing field practices that will bring about a reduction in labor requirements with monogerm seed.

SUPPORTED BY U.S. Dept. of Agriculture

3.0263, PROTECTIVE FILMS FORMED BY PLASMA ANODIZATION

L.P. SKOLNICK, Univ. of Maryland, School of Engineering, *College Park, Maryland*

Surface coatings on aluminum and iron will be prepared by anodic oxidation by using oxygen ions formed in a glow discharge. Coatings formed in this way will be evaluated for their protection of aluminum and iron from corrosion in saline environments. In addition, the structure of oxides formed by plasma anodization will be compared to those formed by anodic reaction in an aqueous electrolyte.

The growth rate of the oxide film will be monitored in situ by optical means utilizing an ellipsometer. Impurities incorporated into oxides formed by aqueous anodization can be eliminated in plasma anodization since the composition of the electrolyte is a controlled variable in the latter case.

Aluminum oxide is thought to be non-protective in chloride environments because of pitting which occurs as the chloride ion replaces hydroxyl groups included in the film during formation in aqueous elecrrolytes. Due in part to its variable valence, formation of protective oxide coatings on iron introduces additional questions. However, if chemically pure films produced under the highly controlled conditions of plasma anodization behave differently from films formed in an aqueous environment, a better understanding of the passivation and anodic protection of both iron and aluminum will be achieved.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0264, DEVELOPMENT OF IMPROVED CELLULOSE ACETATE MEMBRANES FOR REVERSE OSMOSIS

B.M. RIGGLEMAN, Hercules Incorporated, *Cumberland, Maryland*

The objective of this program is to continue the development of composite hollow-fiber membranes for desalination by reverse osmosis and to demonstrate membrane performance in a laboratory hollow-fiber desalination module. Maximum performance in these composite membranes will be achieved by optimizing separately the membrane substrate and the selective layer.

The materials proposed for composite hollow-fiber membranes include crosslinked cellulose and cellulose triacetate. Substrates made of crosslinked cellulose are strong, compaction-resistant and solvent inert. Such substrates have been demonstrated in flat sheet membranes. For the selective layer, a thin film of cellulose triacetate (CTA) will be coated directly from dilute solution on to the substrate. The salt rejection of CTA is excellent; and, the resulting composite membrane should be acceptable for treating either brackish water or sea water.

Hollow-fiber membranes of cellulose-CTA will be prepared on the laboratory scale and evaluated in a laboratory module. The performance of the hollow-fiber membranes and module will be compared with state- of-the-art systems.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0265, THE MECHANISM FOR FORMATION OF A SKINNED TYPE MEMBRANE

R. BLOCH, Hydronautics Incorporated, *Laurel, Maryland*

It is proposed to study the mechanism of film formation in 'skinned' type cellulose acetate and other membranes by the following methods: (a) A quantitative analytical study of the rate processes occuring during skin formation such as, evaporation rate, diffusion rates of solvent into water and water into casting solution. (b) A study of phase separation in multi-component systems by the application of Flory's theory of phase separation for binary mixtures, to ternary and quaternary systems. (c) The measurements of polymer-solvent interaction parameters of various polymer-solvent systems by osmotic or light scattering methods. Primarily these will be determined for cellulose acetate in acetic acid, dimethyl formamide and triethyl phosphate. (d) An experimental study of rate processes under controlled conditions, e.g., evaporation rates will be varied by allowing evaporation into a chamber of controlled vapor pressure of the solvent. (e) A correlation between degree of skinning and the polymer-solvent interaction parameter for a number of solvents.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0266, RESEARCH ON HIGH-EFFICIENCY COMBINED EVAPORATIVE AND CONDENSATIVE HEAT TRANSFER SYSTEM

C.E. BROWN, Hydronautics Incorporated, *Laurel, Maryland*

The purpose of the research project is to provide understanding and design information on heat transfer systems in which surface tension phenomena are exploited to provide high overall heat transfer coefficients. Most systems studied have shown good results with pure water or condensing steam, but there is usually an inherent tendency for the evaporator using sea water to polarize sharply, thus offsetting the desired high efficiency for heat transfer. Furthermore, since cost per pound of water evaporated is a paramount factor, the attainment of high heat transfer efficiency should go hand-in-hand with surfaces and surface preparations which can be produced at low cost. The work in progress at HYDRONAUTICS, Incorporated has as one of its goals the attainment of high heat transfer coefficients by making use of the surface tension and surface tension gradients which occur on three dimensional evaporating films of sea water. The goal is constrained to metals and configurations which offer promise of being inexpensive in both initial cost and maintenance. Present efforts are primarily being expended on extremely thin, flat Titanium foils on which a pattern of Teflon of other nonwetting material is used to produce controlled rivulet flow.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0267, STUDY OF THE HYDRODYNAMIC ASPECTS OF DESALINATION BY REVERSE OSMOSIS

M.P. TULIN, Hydronautics Incorporated, *Laurel, Maryland*

The general aim of the proposed research program is to accelerate the enginerring development of reverse osmosis techniques for the desalination of water. Specifically it is planned to devise and develop methods for the determination of intrinsic membrane characteristics to suggest and investigate different geometrical configurations and hydrodynamic conditions which may enhance depolarization and to analyze different reverse osmosis systems from an economical point of view.

Analytical and experimental studies will be undertaken to further these aims. Suitable apparatus will be developed for membrane characterization. Experimental investigations will be carried out in specially designed equipment, to study practical and desirable ways and means of depolarization and decantation of the polarization layer.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0268, HYDROFORMING REVERSE OSMOSIS MEMBRANES AND A DESALTING MODULE BASED ON THE HYDROFORMING PROCESS

M.P. TULIN, Hydronautics Incorporated, *Laurel, Maryland*

It is proposed to produce reversed osmosis tube assemblies by a process of hydroforming, in which a cellulose acetate membrane is formed directly within a suitable porous support tube. This is accomplished by forcing a cellulose acetate solution in acetone plug through the support tube by means of a gas column followed by a cold water column. Under proper conditions, a membrane is deposited on the support tube wall with a controllable thickness over a great length.

The optimum conditions of hydroformation will be determined and the operating characteristics of the tube assembly measured.

A small desalination module based on such hydroformed tubes will be buile and operated.

It is further intended to develop a membrane regeneration procedure, in which inoperative or fouled membranes can be dissolved from the assembled tube system, and reformed in place without dismantling the system.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0269, MODIFICATION OF PROTEIN FILMS FOR USE IN DESALINATION

B.S. FISHER, Gillette Research Institute, *Rockville, Maryland* 20850 (14-01-0001-1811)

The over-all objective is to relate the physical structure and chemical constitution of modified protein films to their performance as reverse osmosis and pressure dialysis membranes. A variety of films of well defined structure and constitution will be examined in order to develop a rationale that will lead to novel improved practical membranes for desalination processes. Proteins such as zein, collagen and casein, possessing suitable solubility characteristics and exhibiting the ability to form certain selected membrane configurations will be selected for study. Preferred forms of the proteins (e.g., supported ultrathin films, unsupported films, tubing) will be prepared and suitably modified, to impart water insolubility and adequate wet strength. Such modification will include crosslinking and/or incorporation of hydrophobic end-capping groups onto the free amino groups of the protein. The intrinsic permeability properties to water, salt and other selected solutes will be determined with these films by simple osmosis experiments. Further modifications of the films by either physical processes (e.g., orientation) and/or chemical processes, such as impregnation with vinyl polymers via graft polymerization or in situ deposition from the monomer, will be carried out to impart desired permeability characteristics. The production of skinned or asymmetric membranes by this technique will be investigated. Specimens of the most promising materials found in this study will be submitted to the Office of Saline Water for evaluation in reverse osmosis or pressure dialysis tests.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0270, PARAMETRIC ECONOMIC AND ENGINEERING EVALUATION STUDY OF THE ELECTRODIALYSIS PROCESS

B.J. TRUETT, Booz Allen Applied Res. Inc. , *Washington - Bethesda, Maryland*

This study was undertaken to perform an economic and engineering evaluation of electrodialysis processes for desalting brackish waters. The major emphasis in the investigation will be on determining the most promising one of three basic stack designs for scale-up to large plant sizes. During this evaluation, plant performance parameters for each plant type that have major effect on water costs will be identified, and the susceptibility of each plant type to improvements will be examined.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0271, DISTRIBUTION AND ABUDANCE OF JUVENILE AMERICAN SHAD, ALOSA SAPIDISSIMA (WILSON), IN THE CONNECTICUT RIVER ABOVE HOLYOKE DAM, MASSACHUSETTS

J.A. MCCANN, Univ. of Massachusetts, Mass Cooperative Fishery Unit, *Amherst, Massachusetts* 01002

The recreational potential of the Connecticut River is now being evaluated by local, state and federal agencies. There have been several committees established to study the feasibility of extending the spawning runs of American shad and Atlantic salmon to their historical sites. The construction of a fish lift at the Holyoke Dam in 1955 increased the shad spawning migration by 32 river miles. In recent years, the Massachusetts Division of Fisheries and Game have stocked viable shad eggs above Turners and Vernon dams.

A doctoral study was initiated to: (1) estimate the population of juvenile shad in relation to the Holyoke Dam, Massachusetts, by marking throughout the field season with fin clips, brands, or some other method that does not cause excessive mortality; (2) estimate the mortality of juvenile shad in the study area by marking and recapture; (3) determine when migration occurs by weekly or bimonthly quantitative sampling in the Holyoke Canal System; (4) determine depth, speed, and other factors associated with migration by temporary marking with Neutral Red or Bismark Brown Y for short term mark and recapture.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Massachusetts State Government
University of Massachusetts

3.0272, FOOD HABITS OF LARVAL AND JUVENILE SHAD IN THE CONNECTICUT RIVER

R.J. REED, Univ. of Massachusetts, Mass Cooperative Fishery Unit, *Amherst, Massachusetts* 01002

The recreational potential of the Connecticut River is now being evaluated by local, state, and federal agencies. There have been several committees established to study the feasibility of extending the spawning runs of American shad and Atlantic salmon to their historical sites. The construction of a fish lift at the Holyoke Dam in 1955 increased the shad spawning migration by 32 river miles. In recent years, the Massachusetts Division of Fisheries and Game have stocked viable shad eggs above Turners and Vernon dams. Growth differences of young-of-the-year shad above and below Holyoke Dam have been documented.

A study was initiated to correlate young-of-the-year shad feeding habits to food availability by sampling both the benthic and planktonic communities within the river while collecting fish for stomach analysis and growth data.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Massachusetts State Government
University of Massachusetts

3.0273, A STUDY OF PRESSURE DIALYSIS AND COUPLING PHENOMENA IN SYNTHETIC AND NATURAL MEMBRANES

S.R. CAPLAN, Harvard University, School of Medicine, *Boston, Massachusetts*

A proposal is submitted for the study of the structural basis of coupling between different flows, and between flows and chemical reactions, in well-characterized synthetic membranes. The proposal incorporates three closely related topics:

1. flow in hyperfiltration membranes, and of the mechanism of 'salt rejection'. 2. The preparation and study, by similar methods, of fine -grained mosaic membranes, in which salt transport should be characterized by large negative values of the reflection coefficient. 3. The preparation and study, partly by similar methods, of membranes containing asymmetric arrangements of bound enzymes. In membranes of this kind coupling can occur between enzymic reactions and solute flows.

The theoretical framework on which the design and analysis of the experiments will be based includes primarily the treatment of membrane transport given by Kedem and Katchalsky, and the treatment of coupling given by Kedem and Caplan. The methods to be used in studying hyperfiltration membranes will be essentially those developed by Solomon and co-workers in the study of water flow across the human erythrocyte membrane.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0274, DEVELOPMENT OF A WATER DESALINATION SYSTEM BASED ON HOLLOW FINE FIBER MEMBRANES

R.S. TIMMINS, Abcor Incorporated, *Cambridge, Massachusetts* 02139

This contract outlines a program to demonstrate the advantages of using hollow fine fibers in reverse osmosis processes, to develop engineering information on their use in a reverse osmosis unit, and to construct a pilot plant capable of producing 1,000 gallons per day of purified water. A preliminary design for the utilization of fine fibers has been developed which provides particular advantages because of the fiber's efficient mass transfer, small size, low cost and freedom from fouling. Use of several different fiber sizes will be evaluated to select the best geometry for the unit. Cellulose acetate has been chosen as the basis for this design and will receive major attention because of its proven effectiveness in desalination work. A limited number of other materials which may offer particular advantages in fine hollow fibers will be evaluated. Examination will be made of a number of important operating problems such as feed pretreatment and membrane life.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0275, EVALUATION OF EXISTING AND UNCONVENTIONAL MEANS FOR PUMPING AND ENERGY RECOVERY IN A REVERSE OSMOSIS DESALINATION PLANT

E.J. FAHIMIAN, Dynatech Corporation, *Cambridge, Massachusetts*

The objective of this study is to perform economic analyses of pump and energy recovery units, potentially useful in reverse osmosis plants. Due to the large flows of high-pressure salt water needed, currently proposed systems require a large capital investment for the high-pressure pump. Furthermore, since a large fraction of the high- pressure water is rejected as concentrated brine, it might be economical to use a hydraulic turbine to recover part of the energy. Because current knowledge of pumps and turbines suitable for application in large size reverse osmosis plants is incomplete (data on the performance, cost, availability and reliability of these units are lacking), technical and cost information on existing pumps and turbines is being used together with information supplied by manufacturers to develop scaling relations describing cost and performance of large scale units. Similar information is being developed for potentially promising unconventional means for performing pumping and energy recovery. These scaling relations are then to be used in an optimization model of a complete reverse osmosis plant to study the influence of variations in pump and turbine size and performance on the cost of desalting water.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0276, JET-PUMP TOPPING-UNIT PILOT PLANT

E.F. KURTZ, J. Kaye & Company Inc. , *Cambridge, Massachusetts* 02138

A jet-pump topping unit is a means for improving the thermal efficiency of small to medium sized distillation desalination plants. The topping unit consists basically of a vapor-compression evaporator utilizing an ejector as the vapor compressor. The ejector is driven by high-temperature water from a boiler. Low temperature steam from the ejector exhaust is used to drive the distillation plant.

A pilot-plant jet-pump topping unit will be constructed at the OSW Test Station at Wrightsville Beach, N. C. This topping unit will utilize a multiple-phase ejector developed by Joseph Kaye & Company under OSW Contract 14-01-0001-429. The topping-unit-vapor-compression evaporator will product approximately 5000 lb/hr of distillate, and 2000 lb/hr of 265oF steam from ejector exhaust will drive a 5-stage vertical-tube evaporator to produce approximately 10,000 lb/hr of distillate. The total heat requirement will be approximately 150 Btu/lb of distillate.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0277, SOLIDIFICATION AND SEPARATION OF ICE FROM SALINE WATER

C.M. ADAMS, Mass. Inst. of Technology, School of Engineering, *Cambridge, Massachusetts* 02139

This investigation is concerned with crystallographic and chemical influences on the morphology of solid formed in the freezing of aqueous solutions containing substantial concentrations of ionic salts. These influences include liquid phase mass support by diffusion, natural convection, and forced convection, and the surface energies and preferred growth directions of ice crystals. The following specific items will be studied: a) the kinetics of single crystal growth using prepared starting crystals of known orientation, b) the use of controlled convection during single crystal growth to promote mass transfer and increase stable growth velocities, c) the effect of magnetic fields on the growth of individual crystal interfaces with and without convection, d) the controlled melting of specific interfaces of single crystals with and without convection, e) the use of very slow growth rates to produce large single dendrite plates, f) the effects of natural convection during dentrite and single crystal growth, g) mass transfer analyses covering convection as well as diffusion, and h) the influence of surfactants.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0278, DEVELOPMENT OF ULTRATHIN SKIN MEMBRANES - HEMA POLYMERS

A.S. HOFFMAN, Mass. Inst. of Technology, School of Engineering, *Cambridge, Massachusetts* 02139

New membrane systems are being prepared, and new techniques for skinning these systems on top of porous membranes are being developed for use in the process of desalination by reverse osmosis. The new systems are composed of acrylic monomer mixtures which can be thermoset during or after polymerization of these monomer systems on top of a porous membrane substrate, or on top of such a substrate on which has been deposited a tightly packed protein or polymer monolayer.

Tests are also being made on a new membrane module, to determine the significance of activity as a driving force for desalination.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0279, COUNTERWASHERS FOR FREEZE-DISTILLATION DESALINATION

R.F. PROBSTEIN, Mass. Inst. of Technology, School of Engineering, *Cambridge, Massachusetts* 02139

To develop from a hydrodynamic point of view a theoretical and experimental understanding of counterwashers of the type used in washing brine from ice crystals in order to determine criteria for the design and construction of higher performance columns than presently exist. Preliminary hydrodynamic studies, based on Darcy's Law, have been applied to the calculation of the displacement of the brine by fresh water from the interstices of the ice plug formed in the column. Theory indicates the main difficulty in obtaining large net production rates of fresh water in the counterwasher results from the fact that large quantities of brine must be discharged through the screens and before reaching the screens this brine must flow through the packed ice bed which presents a large resistance to the flow. The production rate is found to increase with decreasing the ice plug length below the screens and the back pressure at the screens, and increasing ice crystal size, pressure at bottom of plug, the wall friction. Experiments on a simulated counterwasher will be carried out with polyethylene beads and ice crystals to investigate the effects predicted. The theory will also be extended to determine an optimum design counterwasher from economic and dynamic considerations.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0280, THE ELECTROHYDRODYNAMICS OF ELECTRODIALYSIS SYSTEMS

R.F. PROBSTEIN, Mass. Inst. of Technology, School of Engineering, *Cambridge, Massachusetts* 02139

The objective of the proposed work is to develop from an electrohydrodynamic point of view a theoretical and experimental understanding of the electrodialysis process for saline water conversion. In the present research the properties of the membranes will be taken to be given and the objective will be to determine theoretically and experimentally the potential, concentration, and flow field distributions as well as the appropriate scaling and similarity parameters. The theoretical distributions will be determined for different geometrical and flow conditions and will take into account effects of water dissociation, several ionic species, finite thickness and partially selective membranes, as will as unsteady operating conditions. Based on the scaling and similarity parameters obtained from the theoretical work laboratory scale electrodialysis cells will be investigated with the aim of measuring both overall flow and field quantities as well as detailed potential and concentration distributions which may then be compared with the theoretical results. An important feature of the work will be to show the need to take into account the developing nature with distance along the channels of the electric and concentration field distributions as well as their spatial interactions. On the basis of the results obtained an appropriate redesign of electrodialysis units for more efficient and economical operation will be undertaken both theoretically and in the laboratory.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0281, FUNDAMENTAL STUDIES OF DESALINATION BY FREEZING

T.K. SHERWOOD, Mass. Inst. of Technology, School of Engineering, *Cambridge, Massachusetts* 02139

Experimental and theoretical studies of (a) the physics of nucleation and the growth of ice particles in subcooled brine, (b) the melting of masses of ice particles by direct condensation of refrigerant vapor (water or hydrocarbon), (c) the washing of brine from ice-brine slurries, (d) heat transfer from brine to refrigerant droplets in the freezer, and (e) the removal of hydrocarbons from product water.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0282, EFFECT OF ELECTROCHEMICAL AND METALLURGICAL FACTORS ON CORROSION OF METALS AND ALLOYS

H.H. UHLIG, Mass. Inst. of Technology, School of Engineering, *Cambridge, Massachusetts* 02139

The direction of the present research is toward making available accurately determined data, combined with a reasonable explanation of mechanism regarding corrosion of metals and alloys in aqueous media including saline solutions. Factors are being studied which account for pitting corrosion of passive alloys such as the stainless steels in chloride media. For example, critical potentials of 18-8 stainless steels are being measured below which pitting corrosion does not occur. The effect of environment on such potentials has been studied by us in some depth.

The current program is focussed on corresponding metallurgical factors. For example, chromium, nickel, molybdenum and cobalt, both as binary alloys and as alloying constituents of stainless steels, are being studied with regard to their critical potentials and pitting behavior. Alloys inherently more corrosion resistant on exposure to saline solutions can be expected from data of this kind.

Some measurements are also under way on the general corrosion rates of iron in deaerated water and NaCl solutions The purpose is to better understand the metallurgical factors that affect corrosion rates in these environments. Supplementary to these studies are measurements of passivity both in the region of potentials where pitting does not occur and in media which do not produce pitting corrosion at any potential.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0283, EFFECT OF ELECTROCHEMICAL AND METALLURGICAL FACTORS ON CORROSION OF METALSAND ALLOYS

H.H. UHLIG, Mass. Inst. of Technology, School of Engineering, *Cambridge, Massachusetts* 02139

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SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0284, BASIC STUDIES OF SCALE CONTROL

B.M. FABUSS, Monsanto Research Corporation, *Everett, Massachusetts* 02149

The objective of the project is to conduct laboratory investigations to obtain basic information on the slurry seeding process for control of calcium sulfate scaling from saline water concentrates. The effects of such factors as temperature, crystal size, composition and concentration, fluid dynamics, supersaturation, heat flux, fluidized or fixed bed on calcium sulfate precipitation will be determined.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0285, CONCEPTUAL DESIGN STUDY FOR ELECTRODIALYSIS

B.M. FABUSS, Monsanto Research Corporation, *Everett, Massachusetts* 02149

The proposed work of this contract is to carry out a six-month technical and economic evaluation of presently available electrodialysis installations and to develop and evaluate several new concepts. The primary goals to be attainable by the utilization of these innovations are: (1) an increase in effective membrane surface per unit geometrical area; (2) the reduction of resistance path by changes of fluid flow pattern; and (3) the elimination of separate gaskets and spacers to provide more complete membrane utilization and reduce membrane and labor costs.

3. WATER SUPPLY AUGMENTATION AND CONSERVATION

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0286, THERMOPHYSICAL PROPERTIES OF SEA WATER AND AQUEOUS ELECTROLYTE SOLUTIONS CONTAINING NACL, KCL, NA2SO4, AND MGSO4

A. KOROSI, Monsanto Research Corporation, *Everett, Massachusetts* 02149

Property values on the major sea water components NaCl, KCl, Na2SO4, and MgSO4 in their binary and ternary solutions and those on sea water and its concentrates will be presented in tabular form. The correlated data were derived from the author's measurements and were compared with other sources. The values to be tabulated include: Density, vapor pressure, boiling point elevation, viscosity, and thermal conductivity, given in cgs and engineering units with such frequency that linear interpolation will become permissible.

The concentration of salt solution in most cases will cover 0.l- 3.5 ionic strength levels in the temperature range of 20-150 degrees Centigrade. Sample calculations, the correlation technique used and a computer program applicable for sea water will be included.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0287, CONTROL OF CONCENTRATION POLARIZATION IN REVERSE OSMOSIS DESALINATION OF WATER

B. KEILIN, Amicon Corporation, *Lexington, Massachusetts* 02173

In the purification of water by reverse osmosis, a concentrated saline layer is formed at the membrane surface, reducing membrane efficiency and life. This concentration is reduced by inducing turbulent flow with high feed velocities and baffles--at high cost in power. The greater the membrane flux, the greater the cost.

The possibility that laminar flow in short, thin channels, could give high yields at low power cost was verified in OSW Contract No. 14-01-0001-965 in a 7-inch cell at Amicon Corporation.

Concentration polarization will now be determined for the entrance, fully-developed flow and exit regions for turbulent, laminar and intermediate flow regimes in one 30-inch long cell with variable channel height. Experimental results will be compared with predictions from theory for each type of flow and each region. Earlier work, indicating that the effects of membrane roughness and maldistribution of flow along the channel would be less critical in laminar than turbulent flow, will be extended. Practical means of forming thin, laminar flow channels between the membranes will also be investigated.

These studies will provide preliminary information for the design of a pilot reverse osmosis unit that would minimize concentration polarization effects at capital and operating costs.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0288, INVESTIGATION OF ANOMALOUS WATER

B.M. FABUSS, Lowell Technological Institute, Graduate School, *Lowell, Massachusetts* 01854

Although several theories and models have been proposed for the explanation of water properties, only most recently Academican B. V. Deryagin in the Physico-Chemical Institute of USSR Academy of Sciences prepared anomalous water. This water was formed by condensing water vapor in thin quartz capillaries. The anomalous water shows different properties, vapor pressure, density, expansion coefficient, viscosity and phase changes from those of regular water. The aim of the present work is to reproduce and confirm these observations and to develop techniques for producing anomalous water in larger quantities, thus permitting a more detailed investigation of its properties.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0289, MODIFIED ION-EXCHANGE MEMBRANES FOR WATER PURIFICATION BY REVERSE OSMOSIS

R.B. HODGDON, General Electric Company, *Lynn - West Lynn, Massachusetts*

The objective of this contract is to develop modified ion-exchange membranes having flux and salt rejection properties comparable to cellulose acetate for reverse osmosis application. The primary emphasis will be placed on developing materials and methods for the preparation of thin films resistant to compaction in high pressure reverse osmosis desalting environments. The two phases of work proposed are the thin film preparation and evaluation, and the preparation and evaluation of thin film composites.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0290, DEVELOPMENT OF LOW-COST, CORROSION-RESISTANT ALLOYS AND ON ELECTRO-CHEMICAL TECHNIQUES FOR THEIR PROTECTION IN DESALINATION SYSTEMS

A.C. MAKRIDES, Tyco Laboratories Incorporated, *Waltham, Massachusetts*

A series of alloys, based on the copper-zinc system, and electro- chemical methods for their protection will be developed. The new alloys will hopefully have lower cost, greater strength, better thermal conductivity, and better corrosion resistance than do current available materials. The experimental program includes:

(1) A systematic evaluation of the effect of incremental changes in minor alloying constituents, including P, As, Sb, Si, Ge, Sn, Pb, Fe, and Ni, on the properties of the Cu-Zn system.

(2) A systematic determination of the high temperature corrosion properties of available commercial materials, including 90:10 cupro- nickel, 70:30 cupro nickel, aluminum brass, arsenical Admiralty brass, and Naval brass, and of experimental alloys produced under the program. Both polarization measurements and weight loss techniques will be util- ized.

(3) The evaluation of electrochemical corrosion protection techniques, particularly of anodic protection, both for experimental alloys and for commercial materials.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0291, RESEARCH ON PIEZODIALYSIS

W.A. MCRAE, Ionics Incorporated, *Watertown, Massachusetts* (14-01-0001-611)

The objective of research performed to date was the determination of the practicality of desalination by the coupled transport process 'Piezodialysis' utilizing fine-grained mosaic membranes, comprised of alternating patterns of anion and cation selective regions having characteristic dimensions of about 10 microns. The Scope of Work is amended by the addition of the following tasks:

a. Improve flexibility of the resins utilized in the fabrication of the sheet piezodialysis membranes.

b. Establish technology for fabricating piezodialysis membranes having an active thickness of 1 micron.

c. Investigate the use of porous metal supports for the membranes to meet the requirement of 50% or greater stable porosity at 100 atmospheres pressure.

d. Investigate the use of hollow fibers which are cationic along half the circumference and anionic along the other half.

e. Performance tests will be made with the thin planar membranes, improved support materials and the fine tubular membranes.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0292, THE KINETICS OF COMPRESSIBILITY EFFECTS IN TWO PHASE SINGLE COMPONENT FLOW

C.L. FELDMAN, Worcester Polytechnic Inst. , School of Engineering, *Worcester, Massachusetts* 01609

This project is an investigation of the compressibility effects in single component two phase flow with the primary emphasis being on the kinetics of these compressibility effects. The investigation has as its primary goal a quantitative understanding of the rates of various physical reactions in a two phase fluid when it is perturbed from its equilibrium state. A knowledge of these reaction rates will then permit rational design of high performance two phase flow equipment. A secondary goal of the program will be the development of measurement techniques for general application to two phase flow work.

The fundamental experimental technique will be an extension of Mikol's method for obtaining an equilibrium low velocity two phase flow of known quality. Sonic velocity will be measured as a function of input frequency. Water will be used as a working fluid and the temperature varied from 80F to 300F. Emphasis will be on the low quality region and the sound absorption spectrum will be used as a measure of bubble size.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0293, STUDIES OF FUNDAMENTAL MECHANISMS IN THE DEPOSITION OF CALCIUM SULFATE SCALE

J.L. YORK, Univ. of Michigan, School of Engineering, *Ann Arbor, Michigan*

This fellowship grant supports doctoral research of three graduate students.

One study is on phase-transition kinetics for hydrates of calcium sulfate in water and brine solutions. The transformation from selenite to hemi-hydrate is the principal study, and others will be also investigated. Sensitive dilatometric measurements and microscopic observation are simultaneously employed.

Another study is on heterogeneous nucleation of calcium sulfate on metallic surfaces from aqueous solutions. Both electrical conductivity and electron microscope observations are employed.

A third study is on homogeneous nucleation of calcium sulfate from aqueous solutions. Filtered clear solutions in suspension in heavy oil are subjected to temperature changes and the drops are observed microscopically to study nucleation in the absence of nucleating solids.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0294, BOG AND SWAMP HYDROLOGY

R.R. BAY, U.S. Dept. of Agriculture, Forest Service, *Grand Rapids, Michigan*

Object: To develop management practices, through basic hydrologic studies, which will maintain and improve water yield including streamflow timing characteristics, water quality, lowflow augmentation, and total ground water recharge on northern forested peat lands.

Plan of work: The project staff is continuing to gather information on (1) the hydrology of forested bog watersheds while calibrating experimental watersheds, (2) physical properties and water transmissivity of organic soils, and (3) evapotranspiration rates of bog vegetation. They will begin studies on effect of timber management and water control practices on (1) water yield and groundwater recharge, (2) evapotranspiration, water storage, and changes in the properties of organic soils. They will also determine the energy balance regimes in peatlands and other bog-vegetation complexes.

SUPPORTED BY U.S. Dept. of Agriculture

3.0295, A STUDY OF THE DISPOSAL OF THE EFFLUENT FROM A LARGE DESALINATION PLANT

W.F. MCIIHENNY, Dow Chemical Company, *Midland, Michigan*

Preparation of a Handbook for Engineers to use in selecting shore sites for installation of large desalination-power plants. Includes considerations of oceanographic and meteorologic factors involved in plant protection. Discusses biological systems that one should take cognizance of in designing water intake and discharge units. Indicates the tolerances of key marine organisms for heat, salinity, copper concentrations, etc. that will be important factors in the effluent. Report will cover sites selected as actual or potential water-shortage regions on all coasts of the U. S., as well as one site in Mexico.

Analyze copper in effluent streams from existing desalt plants; determine chemistry and fate of copper in effluents diluted in the environmental sea water; and investigate methods of removing copper from effluent.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0296, DEEP WELL DISPOSAL OF DESALINATION BRINE WASTES

W.F. MCILHENNY, Dow Chemical Company, *Midland, Michigan*

Collect and correlate the geological factors, techniques and costs of deep well injection.

Collect and review brine and brackish water resources for desalination and compute waste compositions.

Survey legal aspects of deep well injection.

Analyze the designs and projected costs of deep well disposal in five representative communities.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0297, PREPARE AN OPERATIONAL PLAN, CONCEPTUAL DESIGN AND PLANS AND SPECIFICATIONS FOR A SEAWATER CORROSION TEST FACILITY

O. OSBORN, Dow Chemical Company, *Midland, Michigan* (14-01-0001-1139)

It is proposed to establish a Materials Test Center adjacent to the Freeport Test Bed where land, sea water, utilities, and technical services from nearby industry are readily available. (The Center would ultimately house a staff of engineers and scientists with assigned responsibilities to find more economical materials of construction for desalination plants. The physical facilities would consist of administrative offices, a capability of operating some ten environmental test units, and the needed support services such as analytical and metallurgical laboratories and a repair shop. Some 14,000 square feet of working space would ultimately be required.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0298, RESEARCH AND DEVELOPMENT OF ULTRATHIN FILM MEMBRANES FOR REVERSE OSMOSIS DESALINATION

L.T. ROZELLE, North Star Res. & Dev. Inst. , *Minneapolis, Minnesota*

The overall goal of this project is to develop ultrathin membranes (1000 to 2000 angstroms in thickness) for the desalination of water by reverse osmosis under test conditions for both sea water and brackish water.

A major objective is to apply ultrathin membranes to a tubular configuration for reverse osmosis. Casting studies using cellulose acetate (CA) will include drawing a module through (1) a membrane on a water surface and (2) a pool of polymer solution on a water surface. Deposition from an emulsion will also be studied. Reverse osmosis studies will be carried out to evaluate the ultrathin membranes and to indicate the research necessary to achieve optimum performance. Various support materials will be investigated. Preliminary studies will be carried out for evaluation of the ultrathin membrane module in an in situ regeneration process.

Another major objective is to optimize the reverse osmosis performance and characterize ultrathin CA membranes. The optimization parameters include membrane thickness, acetyl content, and degree of annealing. Membranes will be characterized by microscopy, intrinsic viscosity, infrared spectroscopy, and compressive property techniques.

One minor objective will be to optimize anisotropic membranes of beta glucan acetate and CA as compared to the Loeb and Manjikian membranes. The other objective will be to test readily available commercial polymers as ultrathin membranes for reverse osmosis.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0299, ELECTRIC FIELDS IN THE CONDENSATION AND COALESCENCE OF WATER

G.D. FREIER, Univ. of Minnesota, Graduate School, *Minneapolis, Minnesota* 55455

The general objective of this work is to relate precipitation and atmospheric electrical phenomena. To accomplish this goal an experimental program has been designed to observe some of the phenomena.

One of the experiments is designed to show that the rapid formation and subsequent rupturing of water surfaces produces many high mobility ions that can increase the air's conductivity. Another is designed to indicate that a limited current flow through a medium containing many small droplets will cause the droplets to disappear rapidly.

In order to gain insight into the above experiments, a light scattering technique will be used. The technique will consist of white light as well as alternate pulses of red and blue light. The split beams will pass through a strong electrical field in an expansion chamber. Measurements will be made of the transmission as well as of the temperature of the chamber in which the experiment takes place.

A study will be undertaken of nucleation centers using a spark gap in the pumping lines and a pair of expansion columns. Finally, a study will be made of the relations between electric fields and the condensation process using a small probe that gives an A-C signal proportional to the D-C field.

SUPPORTED BY U.S. National Science Foundation

3.0300, CHARACTERISTICS OF FARM ANIMAL MANURES AFFECTING DESIGN OF DISPOSAL FACILITIES

R.E. LARSON, Univ. of Minnesota, Agricultural Experiment Sta. , *Saint Paul, Minnesota*

Object: To identify and evaluate those physical and biological characteristics of farm animal manures that serve as criteria for the engineering design of economical and sanitary disposal facilities.

Plan of Work: This work will be carried out principally in the laboratory. Samples of the various manures will be obtained, cataloged, weighed, and analyzed for the various characteristics under investigation. Samples will be collected from the various livestock research farms of the University of Maryland, ARC at Beltsville, and from operating farms in the vicinity. Analyses will be in accordance with procedures in the current edition of Standard Methods for the Examination of Water and Wastewater or other accepted techniques. Special apparatus and instrumentation for determinations of soil sealing rates, sludge accumulation rates, and certain other factors will be devised and fabricated as needed.

SUPPORTED BY U.S. Dept. of Agriculture

3.0301, EFFECT OF FOREST TYPES AND CONDITIONS ON WATER MOVEMENT AND GROUND WATER RECHARGE

S.J. URSIC, U.S. Dept. of Agriculture, *Oxford, Mississippi*

Object: To determine the effect of soil, forest cover, and forest management on streamflow and ground-water recharge.

Plan of work: Twelve natural runoff plots are instrumented to measure hydrologic events and determine changes caused by forest manipulation. The staff is collecting and evaluating existing information on watershed soils and ground-water geology of the problem area. They are determining various components of the hydrologic cycle, such as infiltration rates, interception amounts, and deep seepage.

SUPPORTED BY U.S. Dept. of Agriculture

3.0302, DEVELOPING RESERVOIRS FOR SUPPLEMENTAL IRRIGATION

E.A. KIMBROUGH, Mississippi St. University, Agricultural Experiment Sta. , *State College, Mississippi* 39762

To investigate various methods of construction and/or repair to prevent seepage losses from reservoirs used for irrigation. To investigate the use of chemicals and other imported materials in the construction and/or repair of reservoirs to decrease seepage losses.

DESCRIPTION OF WORK - Typical reservoir sites with the problem of highly permeable soil strata will be selected for the construction of test reservoirs or repair reservoirs which have excessive losses. New test reservoirs will have a water surface of 1/3 acre when filled to the maximum depth. Methods of construction will include bulldozer, sheep foot roller, clay products sealing, and other imported materials that may be selected.

Water level recorders will be used to measure volume changes. Off-stream reservoirs of approximately 5 to 15 acre feet will be constructed to determine the effect of the higher hydraulic heads on the seepage losses. These reservoirs will be used for irrigation to determine problem associated with this type reservoir.

SUPPORTED BY U.S. Dept. of Agriculture
Mississippi State Government

3.0303, NITROGEN REQUIREMENT FOR SKIP-ROW COTTON

W.I. SPURGEON, Mississippi St. University, Agricultural Experiment Sta. , *Stoneville, Mississippi*

Objective: 1. To determine the quantity of nitrogen required for skip-row cotton where it is planed on previously fallowed skips.

Working Procedure: Field tests will be conducted using plant-4- fallow-4, plant-2-fallow-4 and a combination of plant-2-fallow-2 plus plant-2-fallow-4 as the main plots. Each main plot will be split with 4 rates of nitrogen -- 0, 60, 80, 100 pounds per acre. All treatments will be replicated 4 times.

SUPPORTED BY Mississipi State Government

3.0304, DISTRIBUTION, APPLICATION AND USE OF WATER

C.F. CROMWELL, Univ. of Missouri, Agricultural Experiment Sta. , *Columbia, Missouri* 65202

Study problems related to obtaining suitable water supplies for irrigation. Study different methods develop engineering design data, and improve techniques for applying irrigation water. Determine rate of moisture use of different crops under various levels of available soil moisture, and the distribution of moisture removal from various zones in the soil profile.

DESCRIPTION OF WORK - Two or more irrigation water supply wells will be developed for the Southeast Missouri Research Center at Portageville, Missouri. Records of soil stratification, development method, cost, and water yields will be kept.

Plots will be graded for irrigation studies. Records will be kept of equipment time. Comparisons will be made between crawler and rubber-tired prime movers.

Laboratory tests will be conducted to determine hydraulic parameters of flow in a model irrigation furrow. A range of roughness factors including several agricultural soils will be tested. An artificial intake rate will be applied beneath the material bed using ceramic tubes and a vacuum pump.

Intake rates of additional soil profiles will be determined in a vertical model.

SUPPORTED BY U.S. Dept. of Agriculture
Missouri State Government

3.0305, AN EXPERIMENTAL STUDY OF THE STRUCTURE, THERMODYNAMICS, AND KINETIC BEHAVIOR OF WATER

F.T. GREENE, Midwest Research Institute, *Kansas City, Missouri*

The proposed work involves the measurement of the equilibrium thermodynamic properties and rates of formation of clusters of water and other model compounds. The equilibrium studies will involve the measurement of the equilibrium cluster concentrations as a function of temperature using both molecular effusion and high pressure mass spectrometric sampling techniques. These data will yield heats of formation, free energies of formation, and bond strengths, which will in turn be interpreted in terms of their implications to intermolecular potential energy functions, nucleation theory and liquid structure. Rates of cluster formation will be studied by expanding appropriate gases and gas mixtures as a free jet, which is then sampled into the mass spectrometer. From the known free jet temperature-pressure history and the measured cluster concentrations, the rates of formation of the clusters can be evaluated.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0306, CORRELATION OF ANOMALOUS ULTRASONIC REFLECTIVITY WITH EARLY SCALE FORMATION

F.R. ROLLINS, Midwest Research Institute, *Kansas City, Missouri*

Recent research on ultrasonic reflectivity at liquid-solid boundaries has revealed some rather anomalous effects that occur when the angle of incidence is such that surface waves are excited at the boundary. These anomalous reflection effects often change significantly with minor variations in physical properties of the interface. Since the ultrasonic reflectivity is primarily influenced by density and elastic properties of the surface, and since these properties for most scale products are significantly different from that of the underlying metal, there is a high probability that the reflection technique may be a sensitive indicator of early scale formation. This program will establish the sensitivity of the reflection technique to various scale deposits on cupro nickel specimens and then explore the practical extension of the technique to environments and geometries representative of saline water conversion systems.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0307, HYDRAULICS OF SURFACE IRRIGATION

C.C. BOWMAN, Montana State University, Agricultural Experiment Sta., *Bozeman, Montana* 59715

Objectives: To provide fundamental surface irrigation design understanding through the investigation of the hydraulic characteristics of surface flow: 1. By further development of mathematical models describing the flow in terms of the many variables involved, including appropriate testing under controlled conditions. 2. By laboratory experiments for the description and evaluation of component variables. 3. By field trials to test the validity of mathematical equations and laboratory relationships as in (1) and (2) above.

Montana will collect field data required to test the equations developed by Montana, Utah and Washington.

SUPPORTED BY U.S. Dept. of Agriculture
Montana State Government

3.0308, CONTROL OF CANADA THISTLE AND WATER WEEDS

J.M. HODGSON, Montana State University, Agricultural Experiment Sta., *Bozeman, Montana* 59715

The life cycle and growth habits of Canada Thistle and Reed canary grass are being studied. Chemicals for the control of these weeds are being evaluated at the several locations on noncropland and the effects of differing climatic conditions are being observed. Selective treatments for control of Reed canary grass in Kentucky bluegrass and other grass species are made at Bozeman and Huntley, Montana. Promising herbicides for control of submersed pondweeds in irrigation systems are being evaluated.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

3.0309, MEMBRANES FOR REVERSE OSMOSIS DESALINATION BY DIRECT CASTING ON POROUS SUPPORTS

R.L. NICKERSON, Montana State University, School of Engineering, *Bozeman, Montana* 59715

Work is being done to develop a reverse osmosis membrane which is as good or better than those currently available and less expensive to produce. This will be accomplished by casting dense cellulose acetate films with a thickness of less than one micron directly on porous supports. Previous work of an exploratory nature has indicated the feasibility of the idea. Research is being done to reduce the film thickness as much as possible and at the same time obtain a flawless membrane with sufficient mechanical strength to allow for necessary handling.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0310, USE OF GROUND WATER IN EXCESS OF RECHARGE

L.K. FISCHER, Univ. of Nebraska, Agricultural Experiment Sta., *Lincoln, Nebraska* 68508

Objectives: 1. To identify and describe rights in water and the administrative arrangements that regulate water use in several states. 2. To analyze the economic consequences of different systems of water law with particular emphasis on the laws of the states in the North Central Region but including comparisons with legal systems in other regions. 3. To develop principles which will serve as guidelines in efforts to bring about optimum management and use of water resources.

Procedure: The Nebraska Station will engage in a legal-economic analysis of administrative and market procedures used to transfer water rights. The study will include the application of economic efficiency criteria to various procedures used both within and outside the region. Part of the effort will be to develop procedures for using electronic data processing methods in the analysis of water law. A concurrent effort with the Nebraska Law School will analyze the possible effects of alternative institutional arrangements on the use of ground water in Nebraska.

SUPPORTED BY U.S. Dept. of Agriculture
Nebraska State Government

3.0311, LAND SHAPING FOR WATER CONSERVATION

H. WITTMUSS, Univ. of Nebraska, Agricultural Experiment Sta., *Lincoln, Nebraska* 68508

Objectives: 1. To develop effective engineering practices and construction criteria for the most effective soil and water conservation systems.

2. To evaluate land shaping practices in regard to conservation of moisture as reflected in crop yields and stability of crop production.

3. To evaluate the influence of land shaping practices on runoff losses and to predict the effects of these influences on reduction of flood hazards on small watersheds.

4. To evaluate the effect of land shaping practices on increased ground water recharge or stabilized stream flow conditions on small watersheds.

5. To evaluate the economic feasibility of the different conservation systems.

Work Proposed: New conservation systems will be designed, installed and compared with existing conservation systems. Soil moisture, crop yields and weather data will be collected and analyzed to determine the effectiveness of each conservation system. Straight row farming, conventional terrace systems and parallel terraces with steep back slopes and tile waterways will be studied under the same management system. Engineering specifications and construction criteria will be developed and published for each new type conservation system.

SUPPORTED BY U.S. Dept. of Agriculture
Nebraska State Government

3.0312, ENGINEERING PHASES OF LAND SHAPING FOR SOIL AND WATER CONSERVATION

H.D. WITTMUSS, Univ. of Nebraska, School of Agriculture, *Lincoln, Nebraska* 68508

Rainfall in Nebraska is characterized by high intensities and short durations. These conditions cause high runoff losses which reduce the water available for crop production and ground water recharge as well as contribute to the destruction caused by flooding. The runoff losses can be eliminated by shaping the land to retain all water. Underground tile systems will be installed to prevent crop damage caused by saturated soils. Practices will also be developed which will increase the intake of water by the soil and extract the water productively from the soil.

Engineering principles needed to properly shape and farm the land will be developed. The different practices will be evaluated in terms of soil moisture storage, water use-efficiency, runoff losses from shaped areas and crop yields.

The project is expected to yield information on the most feasible methods of conserving our water resources on our vast agricultural areas. The water saved will be available for increased crop production and ground water recharge for municipal, agricultural and industrial uses.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Nebraska

3.0313, SPRING IRRIGATION OF ALFALFA

J.A. MCCORMICK, Univ. of Nevada, Agricultural Experiment Sta., *Fallon, Nevada* 89406

To determine the effects of spring irrigations, by the border method, of deep rooted forage crops when soil at various depths within the root zone exhibits soil temperatures above and below the critical limit for root activity.

Description of Work Proposed: Soil temperatures will be recorded from the surface to the lower root level, at the Newlands Field Station at Fallon Nevada, to establish a representative soil temperature pattern by seasons. The temperature of the irrigation water will be obtained by continuous recorder for the entire growing season. In addition to the temperature of the source water, temperatures will be taken at the upper and lower ends of the borders throughout a twenty-four hour period when irrigation is in progress.

Field trials will be established to study the effects of delaying spring irrigation until soil temperatures have exceeded various levels. Water table recorders will be used to determine the effect of such delay on water table depths.

SUPPORTED BY U.S. Dept. of Agriculture
Nevada State Government

3.0314, IRRIGATION SYSTEMS FOR EFFICIENT WATER USE IN THE GREAT BASIN

P.R. NIXON, U.S. Dept. of Agriculture, *Reno, Nevada*

Objective: Develop efficient surface and sprinkler irrigation system design and operation criteria and corollary evapotranspiration needs for cool desert areas.

Plan of Work: Continue use of lysimeter complex at University Farm to meter evapotranspiration. Augment instrumentation with data logger system to record energy budget. Investigate water use under 'clothesline' conditions prevalent in Great Basin irrigated valleys. Install and test root zone moisture tension devices. Record sprinkler efficiencies over lysimeters. Devise efficient methods for irrigation of Carson clay soils. Inaugurage tests and methods for automation of irrigation.

SUPPORTED BY U.S. Dept. of Agriculture

3.0315, SALVAGE AND USE OF WATER LOST TO PHREATOPHYTES IN THE GREAT BASIN

W.F. SPENCER, U.S. Dept. of Agriculture, *Reno, Nevada*

Objective: Measure evapotranspiration of native vegetation and relate to energy budget. Methods of capture and reuse of water or replacement of native species by economic vegetation. Role of soils and climate on forage species and composition.

Plan of Work: Continue evapotranspiration and energy budget measurements using lysimeters. Install replacement vegetation plots and devise methods for propagation using pumped wells. Devise laboratory models to study water-level fluctuations and optimum levels for propagation of forage plants. Survey soil factors which promote growth of greasewood and other non-economic forage plants. Study boron tolerance of tall wheat grass and the effects of cold desert climate on toxic properties of forage produced.

SUPPORTED BY U.S. Dept. of Agriculture

3.0316, IMPROVEMENT AND MANAGEMENT OF THE COMMUNITY PASTURES OF THE PERSHING COUNTY WATER CONSERVATION DISTRICT NEAR BATTLE MOUNTAIN, NEVADA

H.P. CORDS, Univ. of Nevada, Agricultural Experiment Sta., *Reno, Nevada* 89507

Objectives: (1) Determine the value of different factors in chemical control of phreatophytes, and its application to the question of upstream storage, and peak flow suspension on the Humboldt River. (2) Learn the relationships of water table level and other possible factors to forage yield and composition. (3) Learn the patterns of use most favorable to high sustained production of invaders such as poverty weed.

Description: Several new trials were begun on saltcedar during 1961. Among these were: a trial including five surfactants in combination with silvex at two rates; a new-materials trial including six new formulations of 2,4-D, 2,4,5-T and silvex; and a continuation of the time-of-spraying vs. carbohydrate-level study initiated in 1960. The surfactant trials begun in 1960 resulted in virtually 100% top kill in 1961 regardless of treatment. Consequently, evaluation has been delayed until spring, 1962. Root reserve studies are now virtually complete for both wild rose and saltcedar. They show that food reserves are at their lowest point quite a bit after full leaf stage in the spring for both species.

Two series of grazing treatments have been simulated since 1956 by mowing and clipping. Another study of rotational grazing on four different fields has been under way since 1959. In addition to these three studies, a number of 1 m2 permanent quadrats was established on widely scattered locations of the study area.

SUPPORTED BY Nevada State Government

3.0317, PHREATOPHYTE CONTROL - LAHONTAN AND HUMBOLDT BASINS

R.G. HOWARD, Univ. of Nevada, Agricultural Experiment Sta., *Reno, Nevada* 89507

Studies will be carried out to determine the translocation of systemic herbicides in saltcedar as affected by phenological stages and varying environmental conditions using C14 labeled materials.

Field studies will be made under natural conditions with environmental factors such as soil and air temperatures at and following the time of application. Greenhouse studies will be made with partially controlled environmental factors such as control of soil and air temperatures and root medium osmotic stress, and measurement of osmotic potential of root medium and expressed cell sap under varying environmental conditions.

These studies, in the greenhouse and on government lands near Rye Patch and Lahontan Reservoirs, should provide a better understanding of environmental effects upon the action of systemic herbicides on saltcedar and permit planning of more timely and effective control measures. While similar data have been obtained in other areas, further information is needed for the environmental conditions of the Lahontan and Humboldt Basins.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

3.0318, CONSERVATION OF GROUNDWATER THROUGH REPLACEMENT OF PHREATOPHYTES WITH FORAGES

J.H. ROBERTSON, Univ. of Nevada, Agricultural Experiment Sta., *Reno, Nevada* 89507

To explore the feasibility of using herbicides and fire in combination to clear brush for (a) conservation of ground water, (b) increased forage, (c) easier handling of livestock.

An attempt will be made to relate production of intermediate wheatgrass and pubescent wheatgrass to water table on similar soils. A graded series of piezometers has been installed with this purpose in mind. The first grazing of these 1962 pastures will be in the fall of 1964, thereafter in the spring.

The next two years will be spent in both quantitative and qualitative evaluation of the grass stands already established. Their production will be carefully evaluated in relation to the water table, their water usage will be estimated more closely, the data on hand will be analyzed, including that on evapotranspiration of sagebrush.

The data should be examined by the Department of Agricultural Economics; the State Fish & Game Commission should make an evaluation in terms of wildlife habitat. The Soil Conservation Service should examine the pastures for indicators of soil stability relative to that which prevailed under the big sagebrush canopy prior to 1962.

SUPPORTED BY U.S. Dept. of Agriculture
Nevada State Government

3.0319, STUDIES IN THE THERMOECONOMICS OF SEA AND BRACKISH WATER DEMINERALIZATION

M. TRIBUS, Dartmouth College, School of Engineering, *Hanover, New Hampshire* 03755

A study of the application of the exergy concept to the optimization of sea water and brackish water conversion systems; the development of thermoeconomic techniques under conditions of uncertainty. Reports are being prepared showing how to optimize the design of different kinds of sea water conversion systems and how to take into account uncertainties in either the design, characteristics or the requirements.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0320, DESIGN AND CONSTRUCTION OF A LOW PRESSURE HOUSEHOLD REVERSE OSMOSIS UNIT

M. TRIBUS, Dartmouth College, School of Engineering, *Hanover, New Hampshire* 03755

The purpose of this contract is to develop a low pressure household reverse osmosis unit capable of producing 5 to 10 gpd of potable water from brackish water (tap) for potential use by homeowners in brackish water areas. Specific objectives are to design and construct three prototype low pressure, household reverse osmosis units and field test them by installation into homes served with brackish water; to establish the optimum operating conditions of these units under household service conditions; and to prepare a cost estimate for the production of these units in commercial quantities.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0321, DEVELOPMENT OF NEAR NEUTRAL MEMBRANES FOR USE IN TRANSPORT DEPLETION SYSTEM

A.H. HEIT, Ritter Pfaudler Corporation, *Birmingham, New Jersey* 08011

This is a program in the development of membranes with moderated anion permselectivity. These will be applied in the transport depletion variation of electrodialysis.

Operational advantages, such as greater freedom from inorganic scaling, have been shown with the use of neutral cellulosic membranes in place of membranes of high anion permselectivity in the conventional stack. At the same time, the essential absence of anion selective function imposes a limitation on current efficiency. The cellulosic material is also more susceptible to deterioration due to hydrolytic and oxidational factors.

Our goal is to heighten the cation excluding role of the membrane by compromising concentrations of anion exchanger and base the membrane on non-cellulosic polymers so that current efficiency and long term stability may result. Special fabrication techniques have been devised to provide protection of anion exchange phase from organic fouling.

Data on fundamental properties, membrane potential, area resistance, salt leakage, mechanical strength, hydraulic permitivity, etc. is being collected from a variety of compositions. The most suitable membranes shall be evaluated with small and sub-pilot plant sized stacks for performance.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0322, DEVELOPMENT OF PARYLENE COATING FOR DROPWISE CONDENSATION OF WATER ON HEAT EXCHANGERS

W.E. LOEB, Union Carbide Corporation, *Bound Brook, New Jersey* 08805

A report of work for improved heat transfer with steam via dropwise condensation promoted by parylene. It covers the period from August, 1966 to July, 1967. Background studies on the mechanism of drop nucleation and condensation, together with parylene technology are presented. Lab scale tests with industrial quality steam, plus heat transfer analyses are included. Parylene is Union Carbide's hydrophobic polymer, uniquely vapor vacuum deposited in ultra-thin layers. Increase of some 30% overall heat transfer and coating durability exceeding two years (test continuing) were obtained with live steam. Coating, for large scale evaluation, of a sizeable heat exchanger from a desalination line at Wrightsville Beach is described together with process and equipment used. One micron of parylene was applied to the exterior (steam side) of the 56-90/10 CuNi tubes (3/4' O.D. 1-ft. diameter steel shell as the vacuum chamber. This experience demonstrates technical feasibility of large scale parylene coating. Treatment and deposition techniques have been developed which provide durable and uniform coatings. Application to long-tube vertical and multistage flash desalination plants is discussed.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0323, CONSTRUCTION AND OPERATION OF 7-GPM PILOT PLANT FOR SILICA REMOVAL

D.W. DAVIS, Johns Manville Corporation, *Manville, New Jersey* (14-01-0001-1710)

This project involves the pilot-scale testing of the activated alumina process developed under Contract 14-01-0001-954 which was reported in R&D Progress Report 286.

The 7-gpm pilot plant consists of a weak acid cation resin softener (sodium cycle) to further soften the effluent from the plant sodium cycle softener and four columns containing activated alumina.

The objective of the tests is to supply water at selected levels of silica and hardness to a pilot-scale evaporator for scale studies.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0324, AN EXPERIMENTAL INVESTIGATION OF CELLULOSE ACETATE MEMBRANE REGENERATION

E.A. HAMER, Amer. Standard Incorporated, *New Brunswick, New Jersey*

The investigation to be conducted under this contract is to determine the technical feasibility of restoring the desalination properties of cellulose acetate membranes in which the performance and quality rating has declined by using a combination of surface cleaning and membrane regeneration procedures. Membrane performance will be evaluated in an existing array of test cells which accept 2- inch diameter membrane samples and are designed to insure highly turbulent, saline water flow conditions. The two proposed tasks are the membrane surface cleaning and the membrane regeneration.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0325, COMBINED DESALINATION AND POWER-GENERATION BASED ON COAL ENERGY

G.T. SKAPERDAS, M.W. Kellogg Company, *New Market, New Jersey* 08654

The objective of this work is to combine all available information from the Office of Saline Water, the Geological Survey, the Bureau of Mines, and other sources to determine under what conditions coal can best be used to supply the energy required to produce fresh water from the ocean or underground brackish water resources in the Nation's present and future water-short areas.

The study is divided into two parts. The first will consider the application of well-established technology, such as the combination of multiple-flash distillation systems and standard coal coal-fired power generating plants, to coal supplies and water and power requirements.

The second, looking further into the future, will combine expected oncoming developments such as reverse osmosis desalination, coal-fixed MHD-power generation, and byproduct recovery, in larger complexes which would be most economically viable as the Nation's population increases.

Work on Part One has been completed and will be published in June 1966. Work on Part Two is well advanced. Final report is being prepared - contract still open in hope of doing further work in future.

SUPPORTED BY U.S. Dept. of Interior - Off. of Coal Rch.

3.0326, CONTROLLED FLASH EVAPORATOR, ECONOMIC ANALYSIS AND THE DESIGN OF A DEMONSTRATION PLANT

H. GITTERMAN, Burns & Roe Incorporated, *Oradell, New Jersey* 07649

A conceptual design of a Controlled Flash Evaporator having a Performance Ratio of approximately 11:1 and a capacity of 2.5 million gallons per day is to be compared with a Multi-Stage Flash Evaporator of similar capacity and performance.

After a review of the economic comparison by the O.S.W., plans and specifications will be prepared to permit the procurement of hardware for the erection of a pilot plant. The pilot plant is to be operated for one year to prove the economic application of the technology of the Controlled Flash Evaporation Process.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0327, ELECTROLYTIC REGENERATION OF ION EXCHANGE RESINS

R. PROBER, Aerochem Research Labs. Inc., *Princeton, New Jersey*

This study was undertaken to evaluate the technical and economic feasibility of electrically regenerating ion exchange resins used to desalt brackish waters. Information obtained in a state-of-the-art survey will serve as the starting point for laboratory studies which will provide sufficient data for realistic comparison of the cost of electrolytic regeneration with that for conventional chemical regeneration methods.

Two bench-scale test units, each with a product water capacity of 30 gallons/hr, are being built for the laboratory studies. The most favorable combination of commercially available ion exchange resins and arrangement of resin beds (mixed beds or separate anion and cation resin beds) are to be selected on the basis of the power requirements and regeneration efficiencies. Regeneration with constant terminal voltage will be compared with regeneration at constant current density. The effects of feed water temperature, pH and salinity on process efficiency will be determined. Long term tests will be conducted with several promising diaphragm materials.

Tests to be conducted with the most favorable resin combination and arrangement of resin beds will serve to define the optimum current density and the preferred electrolytic regeneration cell design for scaleup to larger units. Tentative design specifications for a 20,000 gpd pilot plant will be prepared.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0328, SIMULATION OF MULTISTAGE FLASH TEST MODULI (9-STAGE SAN DIEGO PLANT)

A.R. GLUECK, Electronic Associates Inc., *Princeton, New Jersey*

The differential and algebraic equations describing the dynamics of a single flash stage will be reviewed. The computational algorithms will also be re-examined and improved where possible, and the flexibility of the mathematical model for a complete flash train will be augmented.

A steady-state solution for the train will be produced by means of digital computing. Following this, the problem will be programmed for a large-scale hybrid computer, the EAI 8900 System, which will permit dynamic studies.

The data obtained from the hybrid computer runs will be compared with actual plant operating data to demonstrate the suitability of the computing technique to simulating these complex plants. Certain transient conditions will also be simulated, including the following: (1) Start-up, (2) shut-down, (3) loss of steam supply, (4) pump failures.

Two interim reports will be submitted and after completion of the above work, a complete final report will be prepared.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0329, DESIGN, CONSTRUCTION AND OPERATION OF A SKID-MOUNTED ION EXCHANGE PILOT PLANT

R.C. ADAMS, Ritter Pfaudler Corporation, *Princeton, New Jersey* 08540

To design, construct and operate a skid-mounted ion exchange pilot plant employing Rohm & Haas Company's Desal process. The unit will be field-tested at Roswell, N. M., Yuma, Arizona and Webster, S. D. Cost estimates for large size plants will be made after operating data are obtained. Field testing shall be completed within 16 months.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0330, THE INFLUENCE OF HYDROXYL RATIO ON THE PERFORMANCE OF REVERSE OSMOSIS DESALINATION MEMBRANES

L.A. LEE, Celanese Corporation of Amer., *Summit, New Jersey* (14-01-0001-1724)

The program will consist of investigation of the influence of polymer variables on the performance of cellulose acetate reverse osmosis membranes. Primarily, the study will be concerned with the influence of primary to secondary hydroxyl ratio and acetyl value on the flux-rejection performance of membranes. Secondarily, limited supporting work will be carried out on the influence of membrane morphology, polymer cross linking and membrane ageing phenomena.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0331, SOLAR HEATING OF WATER TO VERY HIGH TEMPERATURES

M.H. COBBLE, New Mexico State University, School of Engineering, *Las Cruces - University Park, New Mexico* 88001

Using the mathematical model for the process of radiation from a modified planckian source into a transparent solid having high transmission at short wave-lengths and low transmission at long wavelengths combined with a low thermal conductivity, very high temperatures for the interior of the slab have been predicted and verified experimentally.

It is proposed to extend the analysis to include the case of a transparent slab, irradiated by a modified planckian source, in contact with a well-mixed fluid (insulated) and solve the resulting equations, using complex variable methods and residue theory, for the temperature in the slab and the temperature of the fluid. An experiment will then be set up using the unconcentrated sun as the source, methyl methacrylate as the slab material, and water as the fluid to test the theory. It is certain from previous published work that the water will heat at least to 400oF.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
New Mexico State University

3.0332, CLIMATE AND PHENOLOGICAL PATTERNS FOR AGRICULTURE IN THE WESTERN REGION

M.D. FINKNER, New Mexico State University, Agricultural Experiment Sta., *Las Cruces - University Park, New Mexico* 88001

1. To determine patterns and variability of climate. 2. To associate phenological response with climatic data.

Sequential relationships of weather events related to precipitation will be described for the Western Region. Experience tables of the lengths of wet and dry spells which have occurred at various stations and at various times will be computed and published rather quickly for immediate use. The theory of Markov processes will be utilized in modeling the precipitation duration aspects of climate. This approach will involve in particular a study of the order of Markov Chains which best fits observed precipitation occurrences on different parts of the region, and the most efficient and reliable method for smoothing the empirical transition probabilities.

Approximately 10 main phenological stations will be established. Montana will develop and provide standardized data forms on which to report the various phenological observations and distribute plants by mail to observers. Geographical progression for different phases of plants in the network will be established. Emphasis will be placed on prediction of later phases of plant response by both early phenological and climatological observations. Relationships between phenological and environmental parameters will be explored with the objective of relating phenological response to meteorological parameters.

SUPPORTED BY U.S. Dept. of Agriculture
New Mexico State Government

3.0333, DISPOSAL OF BRINE BY SOLAR EVAPORATION

C.G. KEYES, New Mexico State University, School of Engineering, *Las Cruces - University Park, New Mexico* 88001

Objective of this work is to determine the evaporation of brine by methods of heat budget and mass transfer. Project will include studies in (1) the effect of solar radiation on brine, (2) albedo of brine and effect of dye on albedo, (3) salinity and saturation vapor pressure, (4) changes in brine temperatures and influences of depth on rates of evaporation and (5) exchange of heat between brine and air.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0334, WATER REQUIREMENTS FOR CROP PRODUCTION IN THE ROSWELL UNDERGROUND WATER BASIN

H.R. STUCKY, New Mexico State University, Water Resources Research Inst., *Las Cruces - University Park, New Mexico* 88001

General Objectives: 1. To assemble and analyze existing cropping patterns, water use, water quality, soil quality and crop yields for the Roswell Underground Water Basin. 2. To determine the water requirements by crops, by farms and the basin under various irrigation methods, efficiences and cropping patterns. 3. To determine farm and basin income effects from various irrigation methods, efficiencies and cropping patterns.

General Procedures: For Objective 1 - This information will be assembled from existing records and will be used in the analysis of each phase of the work in drawing the overall conclusions for the basin. For Objective 2 - There will be four specific areas from which more detailed information will be collected. a. Southeastern Branch station. 1. The work on general field crops and on three irrigation regimes on cotton (amounts applied and spacing of irrigation) will be continued at the station. 2. Two additional irrigation regimes will be added for cotton. 3. A new irrigation trial with several irrigation regimes for alfalfa will be instituted. measurements and soil moisture data will be secured on each of the trials above. b. One to three additional farms near the Branch Station, especially selected for observations similar to those on the Station under farm conditions but in somewhat less detail than the Station work. c. Up to seven to nine additional farms , selected for geographic location, irrigation practices, soil type, water quality and for some detailed records on the amounts of water pumped at various specified periods. . d. The five farms, on which meters have been installed since 1956, would be used for developing historical crop, fertilizer, weather and other records for analysis in comparison to the annual pumping records which are available. For Objective 3 - The information assembled under Objective 1 and 2 will be used as part of the income and cost analysis. Additional information will be secured by an agricultural engineer making random observations and measurements on irrigation practices and water applications on up to ten selected farms and the five metered farms, and on other farms where desirable conditions of cooperation and other factors are found.

SUPPORTED BY New Mexico State Government

3.0335, BIOLOGICAL CONTROL - TAMARISK AND OTHER PHREATOPHYTES

J.G. WATTS, New Mexico State University, Graduate School, *Las Cruces - University Park, New Mexico* 88001

The purpose of this study is to determine how the growth of tamarisk and other phreatophytic non-beneficial water loving plants can be controlled biologically. Since these plants are using enormous quantities of water and the costs of control by herbicides and mechanical methods are relatively high, a study to determine biological control measures is justified.

A Contract No. 14-06-500-1517, dated May 16, 1968, was executed between the Bureau of Reclamation and New Mexico State University to provide for the study. Approximately five years are expected to be required for this study.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

3.0336, COMPARATIVE PRODUCTIVITIES OF SMALL BODIES OF WATER IN DESERT AND MONTANE AREAS OF SOUTHERN NEW MEXICO

W.G. WHITFORD, New Mexico State University, Water Resources Research Inst. , *Las Cruces - University Park, New Mexico* 88001

This project will determine the biomass and productivity of phyto- and zooplankton during all seasons of the year in two types of ponds, possibly develop a system for quantifying the role of these organisms in the energy relationship of the ponds, determine the role of the rooted aquatics and the role of the insect and insect larvae in the total production, and the role of the vertebrate top consumer. The purpose of this study would be to determine the productivity and possible economic contribution the water in these ponds might have and still serve their original use of supplying stock water and limited recreational uses.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
New Mexico State University

3.0337, THE EFFECT OF IRRIGATION METHOD, AND MOISTURE AND FERTILITY LEVELS UPON MAXIMIZING WATER USE EFFICIENCY AND QUALITY COTTON FIBER PRODUCTION

B.C. WILLIAMS, New Mexico State University, School of Agriculture, *Las Cruces - University Park, New Mexico* 88001

Agricultural water-use efficiency is affected by many factors which include methods and levels of water and level of soil fertility.

The work proposed here is a field experiment using sub-irrigation and surface irrigation at two levels of application interacted with six levels of fertility: 1. To measure the water-use efficiency of acala cotton under different regimes of soil mositure and fertilizer levels. 2. To measure the amount of water which may be saved by minimizing evaporation with sub-irrigation as compared to surface irrigation practices. 3. To determine the influence of moisture level and fertility level on yield and quality of acala cotton. 4. To determine the influence of irrigation and fertilizer practices upon production of quality cotton fiber. 5. To determine a suitable design of a sub-irrigation system and recommended depths of placement for selected soils in New Mexico. 6. To determine operation and maintenance procedures to prevent clogging of sub-irrigation systems.

The sub-irrigation will be done with perforated plastic pipes buried under the crop rows and surface irrigation will be done by furrow system.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
New Mexico State University

3.0338, EFFECT OF RANGE AND WATER ON MULE DEER POPULATION

J.E. WOOD, New Mexico State University, Agricultural Experiment Sta. , *Las Cruces - University Park, New Mexico* 88001

Objectives: 1. To determine the distribution and density of deer in the various ecological habitats and record annual changes in population. 2. Determine for a known density of deer, the amount of summer and winter deer use of key browse species at various distances from water and on the various slopes and exposures. 3. Determine the effects of placing catchment game watering units in dry habitats on the distribution and abundance of deer and on the utilization of the range.

Description of work proposed: Deer abundance, distribution and use on the varying slopes and exposures and distances from water will be evaluated by sampling their density in the various areas by pellet transects, drives, reconnaissance, and permanent census routes. Utilization of browse in these areas will be determined by percentage of plants browsed and by a weight twig use method. The effects on deer numbers and distribution resulting from the installation of water catchment units placed two miles or more from permanent water will be determined by recording changes in numbers at annual censuses and changes in browse utilization.

SUPPORTED BY U.S. Dept. of Agriculture
New Mexico State Government

3.0339, ICE FORMATION BY CONTACT NUCLEATION

N.R. GOKHALE, State University of New York, Graduate School, *Albany, New York* 12203

This grant provides support for the third year of research begun under GA-328. The purpose of the research is to perform laboratory studies to determine whether dry nucleants in the atmosphere can produce freezing in supercooled water droplets upon contact at a warmer temperature than would be produced by the same nucleants which are already embedded in the droplet before supercooling takes place. It is believed that such an effort may be responsible for the observations of several research groups that large frozen droplets or graupel are usually found in the outer periphry of clouds and seldom in the central core.

Using a constant rate of cooling apparatus developed under a previous grant, the principal investigator will obtain median freezing temperatures of water drops by contact nucleation and determine how freezing depends on the volume of the drop, initial temperature of the drop, concentration and size of nucleating particles introduced in the vicinity of the drop, and the composition and crystallographic nature of the nucleating materials used. In addition, microphotography will be used to determine how the dry nucleating particle interacts with the droplet surface upon contact.

SUPPORTED BY U.S. National Science Foundation

3.0340, SYNTHESIS OF MODIFIED LOEB MEMBRANES BY GRAFTING

C. HOROWITZ, Polymer Res. Corp. of Amer. , *Brooklyn, New York*

Using a chemical grafting method developed by Polymer Research Corp. of America, various monomers will be attached by grafting to cellulose acetate Loeb membranes in order to increase their hydrophillic character, to increase the water transfer across the membrane, to increase their compactness, their desalting efficiency and salt rejection characteristics. The monomers to be grafted will cover a wide spectrum of polar and nonpolar molecules and they will be chemically attached by etherifying the free hydroxyl group of cellulose acetate. Grafting will be performed on cellulose acetate resin solution, before preparing the membranes and on prepared membranes. The membranes will be prepared both by casting and by continuous impregnation of a fabric. The membranes will be immersed in a precipitating water bath. The dense and porous effect will be produced by floating the impregnated fabric on water. Attempts will be made to control the depth of grafting in the membrane. The parameters of monomer and catalyst concentration and temperature will be evaluated. Long and short chain grafts will be produced.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0341, INORGANIC ION EXCHANGERS AND THE NUCLEATION OF SCALE FORMING MATERIALS

G.H. NANCOLLAS, State University of New York, Graduate School, *Buffalo, New York* 14214

(1) The kinetics of crystallization from solution of important scale-forming substances such as calcium sulfate, calcium carbonate and magnesium hydroxide will be investigated. Rates of crystallization will be followed, (a) conductimetrically, (b) potentiometrically, (c) analytically, and (d) by direct microscopic observation of the growing crystals. The crystallization processes will be characterised kinetically and the inhibiting effects of added substances will be quantitatively studied. The corresponding dissolution kinetics into subsaturated solutions will also be studied.

(2) Kinetic studies are to be made of the exchange of bivalent metal ions on zirconium phosphate. Ion-sieve behavior will be investigated using cations of different sizes both in equilibrium and kinetic experiments. The relationships between ion exchange capacity, structure of zirconium phosphates, pH, size and concentration of ingoing ions will continue to be actively investigated since these are all factors of direct influence upon the commercial use of this exchanger.

(3) Calorimetric investigations of the heats of cation exchange on polyvalent anion salts and of anion and cation exchange on the hydrated oxides will be continued. Both monovalent (e.g. alkali metal) and divalent (alkaline earth) cations will be studied, and the thermodynamic functions will be interpreted as described previously.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0342, MECHANICAL PROPERTIES OF ULTRA-THIN LIPID MEMBRANE

D. WOBSCHALL, State University of New York, School of Medicine, *Buffalo, New York* 14214

The objectives of this study are an examination of the mechanical properties and to a lesser extent the transport properties of ultra- thin membranes. These artificial bilayer membranes, formed from solutions of lipids such as cholesterol and lecithin using the techniques of Mueller and Rudin, are similar to natural cell membranes. Mechanical properties to be studied are: (1) surface tension, (2) breaking strength, and (3) elasticity and/or creep. Efforts will be made to fabricate a composite membrane (consistency of a lipid membrane with a porous backing) which will withstand hydrostatic pressure. The ion and water permabilities of these membranes will be measured.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0343, SALINE WATER BY FREEZING - A PROGRAM OF INVESTIGATION

H.F. WIEGANDT, Cornell University, School of Engineering, *Ithaca, New York*

This study is to contribute technically to the freezing process for saline water conversion which uses an immiscible refrigerant in the crystallization step and a piston-bed countercurrent washing step. There are six elements to the present program.

1. Growth of suspended ice crystals
2. Flash freezing
3. Piston-bed modification for achieving high wash rates
4. Crystallization of brine dispersed in the organic phase
5. Design improvements for direct-vaporization heat transfer
6. Techniques of microscopy for studies of nucleation.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0344, EVALUATION OF SOIL MOISTURE RECHARGE

P. ZWERMAN, State University of New York, Agricultural Experiment Sta. , *Ithaca, New York* 14850

Objectives: (1) To develop systems of crop production that are water conserving. (2) To evaluate 'good' and 'poor' conservation practices in terms of recharge and evaportranspiration.

Work Proposed: (1) A replicated system of 'good' and 'poor' soil and water conservation practices will be maintained for a rotation of corn-beans-wheat. (2) Surface run-off and tile-drain flow will be measured. (3) Soil moisture and water table will be measured as time permits.

SUPPORTED BY U.S. Dept. of Agriculture
New York State Government

3.0345, CONCEPTUAL DESIGN STUDY - REVERSE OSMOSIS MEMBRANE ASSEMBLY MODULAR UNIT

S.B. TUWINER, R A I Research Corporation, *Long Island City, New York* 11101

This work results from Office of Saline Water's invitation for proposals on new design concepts in reverse osmosis. The purpose of this study is to design a reverse osmosis module in which the individual elements, consisting of a pair of membranes and intervening separator, are suspended in a closely spaced, parallel array. The design is characterized by an absence of spacers between the flexible elements except for the minimum number which is required to stabilize the positions of the elements and the

flow channels. Advantages of this construction are a minimum use of material and the virtually unimpeded flow of solution parallel with, and between the membranes. Such a design leads to a compact array of membranes and results in the combination of moderate flow velocity and high water recovery ration per stage which is conductive to a high capacity at minimum cost.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0346, APPLICATION OF THE HIGH TEMPERATURE WATER JET COMPRESSOR TO THREE MAJOR DESALINATION PROCESSES

***B.S. BREITMAN*, Amer. Hydrotherm Corporation, *New York, New York* 10016**

A high temperature Water thermocompressor test installation is considered for three Office of Saline Water desalination plants, Roswell, Freeport, and Claire Engle. The test installation would reduce present water costs by 14 cents, 2.4 cents and 1.4 cents/1000 gal. respectively. The required process and equipment changes and capital cost for each process are shown. In each process the HTW jet compression cycle produces 4 to 5 pounds of product/1000 Btu heat input and rejects the heat as steam (200 degrees F to 300 degrees F) to a ME or MSF process producing an additional 5 to 20 pounds of product/100 Btu. A special process design is described for Roswell to enable operation on the slurry recycle system at a 30% capacity without the existing mechanical compressor. Fuel cost will be 36.5 cents/1000 gallons and installation cost will be $165,000 for this special installation.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0347, ENGINEERING ECONOMICS OF WATER DESALTING IN COMBINATION WITH NITROGEN FIXATION FOR AGRICULTURAL CHEMICALS MANUFACTURE

***S.A. BRESLER*, Chemical Engineering Assoc. , *New York, New York* 10025 (14-01-0001-1483)**

This study provides a preliminary economic evaluation of the cost of co-producing ammonia and desalted water from fossil and nuclear energy supplied from common energy centers. Four cases of fossil heat supply are under study for ammonia production rates ranging from 500 to 2000 tons per day, utilizing the waste heat for water desalting; two cases of ammonia and water production, in thermodynamically balanced systems which provide desalted water in a water-ammonia ratio nearer that required for irrigation applications, are being studied. A seventh case explores the preliminary economics of utilizing a high temperature gas cooled nuclear reactor for in-situ reforming of natural gas for ammonia manufacture and steam generation for power and desalted water production.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0348, ACTIVE AND PASSIVE ION FLUXES ACROSS INTERFACES AND MEMBRANES

***M. BLANK*, Columbia University, School of Medicine, *New York, New York* 10027**

The long term goal of these investigations is to gain an understanding of the mechanisms of membrane processes, specifically those having to do with ion transport. While earlier investigations dealt exclusively with the passive aspects of transport our recent work has enabled us to approach the far more complicated problem of active transport, an area that is much more interesting to the membrane physiologist and certainly more characteristic of the living state. The immediate aims of this project can be summarized as follows: 1. To study the active ion transport system of cells by several different approaches which include: a) study of the enzyme associated with the ion pump b) study of the binding of ions to the enzyme and to cell membranes in vivo c) study of the transport properties of the enzyme at interfaces. 2. To continue our theoretical approach to the problem of the ionic fluxes in excitable membranes utilizing our recent findings with regard to passive transport processes.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0349, A NUCLEAR MAGNETIC RELAXATION INVESTIGATION OF WATER-MEMBRANE INTERACTIONS

***J.A. GLASEL*, Columbia University, School of Medicine, *New York, New York* 10027 (14-01-0001-1700)**

The purpose of this research is to investigate the structure of water and aqueous solutions in the immediate vicinity of water-membrane interfaces by the methods of nuclear magnetic relaxation. In particular, the methods used will be those developed in this laboratory and elsewhere to study water structure by the relaxation of the isotopes 0-17 and H-2 in water enriched with them. The ultimate objective will be to determine the significance of structuring of water in pores and on the surface of membranes in the phenomenon of diffusion. In addition, information will be gathered on the effect of membrane structure, extensive thermodynamic variables and ionic composition on the structure of water in these environments. Special experimental apparatus, involving the interfacing of a digital computer to various types of N.M.R. apparatus, is being built as part of this project.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0350, STUDIES OF MEMBRANE PHENOMENA - PREPARATION OF NEW ELECTRODIALYSIS MEMBRANES

***H.P. GREGOR*, Columbia University, School of Engineering, *New York, New York* 10027**

This study calls for the preparation of omega-dialkylamino-alpha -olefins, their copolymerization and their incorporation into ion exchange membranes; theoretical and experimental studies of polarization phenomena with these membranes; parallel studies with membranes employing the vinylsulfonic monomer.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0351, STUDIES OF MEMBRANE PHENOMENA - PREPARATION OF NEW ELECTRODIALYSIS MEMBRANES

***H.P. GREGOR*, Columbia University, School of Engineering, *New York, New York* 10027**

This study calls for the preparation of W-dialkylamino- L-olefins, their copolymerization and their incorporation into ion-exchange membranes; theoretical and experimental studies of polarization phenomena with these membranes; parallel studies with membranes employing the vinylsulfonic monomer.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0352, ENGINEERING FEASIBILITY STUDY OF THE HORIZONTAL TUBE MULTIPLE EFFECT DISTILLATION PROCESS

***R.B. COX*, Univ. Desalting Corporation, *New York, New York* 10017 (14-01-001-1707)**

An engineering feasibility study of a new Horizontal Tube Multi- Effect (HTME) Desalination Plant will be performed. The HTME design shows promise of large reductions in capital cost compared with either LTV or MSF plants. In the new design, in each effect the evaporator tubes are horizontal with the vapor condensing in the inside and the brine boiling on the outside to provide very high heat transfer coefficients. These effects are then stacked vertically to form a compact structure with a minimum of pumps, valves, piping and controls, to provide large savings in both capital costs and power consumption. UDC will design, fabricate and install experimental equipment at the OSW Wrightsville Beach Test Facility and conduct an experimental program in order to: 1. obtain and confirm the factors that are pertinent to the design of an HTME Desalination Plant, and 2. determine the mechanism that is responsible for the high heat transfer rate in an HTME evaporation process. UDC will also make conceptual design studies to determine the capital and operating costs of 2.5 MGD-HTME plants.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0353, THE STRUCTURE OF THE ACTIVE LAYER OF THE ASSYMETRIC CELLULOSE ACETATE MEMBRANE - THE SALT AND WATER PERMEABILITY OF A BIOLOGICAL MEMBRANE

R.M. HAYS, Yeshiva University, School of Medicine, *New York, New York* 10033

It is proposed to determine the rates of water flow and water diffusion across the asymmetric cellulose acetate membrane (desalination membrane), under a variety of experimental conditiona. From these data, and from experimentally determined reflection coefficients of small solutes, the porosity of the 'skin' layer of the asymmetric membrane will be estimated.

A second line of investigation concerns the mechanism by which high water flows can take place across biological membranes. The isolated urinary bladder of the toad will be used in these studies. This is a tissue which is sensitive to the hormone vasopressin, and can increase water movement after hormone to a point that exceeds that of the asymmetric cellulose acetate membrane.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0354, STUDIES OF NATURALLY OCCURRING ACIDIC LIPIDS - IONIC, SURFACE AND MEMBRANE PROPERTIES

R. KATZMAN, Yeshiva University, School of Medicine, *New York, New York* 10033

The proposed research will continue the investigations of the micellar and membrane properties of lipids.

Aqueous micellar systems of mixed lipids will be formed by means of ultrasonic radiation. 'Zwitterion' lipids, lecithin, phosphatidylethanolamine or sphingomyelin will be incorporated with acidic lipids in mixed systems. Titration studies will indicate interaction of the different charged groups. The reactions of these micelles with cations will be studied by turbidimetric titrations and by chemical analysis of coagula. The cation selectivities will be determined for varying compositions of lipids. Light scattering studies will be made to measure the micellar sizes of these systems which will be related to their electron micrographs.

The mechanism of water transport through reconstituted lipid membranes will be investigated. Measurements of the temperature coefficient will give the 'activation energy'. Changing the lipid composition of the membrane and the addition of detergents or proteins will permit a study of the chemical nature of the membrane and its permeability.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0355, SEASONAL VARIATIONS OF SOME LIMNOLOGICAL FACTORS IN LITTLE SODUS BAY, NEW YORK

R. ENGEL, State University of New York, Graduate School, *Oswego, New York* 13126

The southern shoreline of Lake Ontario is interrupted by numerous small to large size bays. The openings of these bays into Lake Ontario are regulated by wave action of the lake or by dredging operations and breakwaters. Little Sodus Bay is located in the northwest corner of Cayaugo County and covers approximately 630 acres. With the Town of Fair Haven at its southern end, the bay provides a recreational facility and protected area for small boats and fisherman. Little is known about the biological productivity of this and similar bays on Lake Ontario, about physical and chemical factors that determine the productivity, or about the possible effect of the productivity of these shallow bays on Lake Ontario as an aquatic environment.

Thus it is proposed to study the protected waters of Little Sodus Bay to determine the seasonal variations of biological productivity and an analysis of the causitive factors. The data will provide an illustration of a special eutrophic situation and the possible influence of pollution from the surrounding area. The collected information will also be useful when studies on the adjacent open lake are undertaken. Because we lack a suitable research vessel at the present time, limnological investigations initiated by the field biology station must be carried out in protected waters.

Samples (from different locations and depths will be analyzed for dissolved oxygen, carbon dioxide, hardness, alkalinity, pH, phosphates, nitrates, and total dissolved solids) will be taken once every two weeks during the open water season and monthly when there is an ice cover. Physical factors of light transmittance, temperature (air and water), wind, current and turbidity will be observed.

SUPPORTED BY State University of New York

3.0356, A STUDY OF THE NUCLEATION AND GROWTH CHARACTERISTICS OF SLURRIES OF ICE CRYSTALS

J. ESTRIN, Clarkson College of Technology, School of Engineering, *Potsdam, New York* 13676

This proposed work involves an experimental and theoretical program whose goal it is to improve our understanding of secondary nucleation phenomena and the subsequent growth process associated with slurries of crystals. The experiments are to be carried out with the salt-ice- water system in a)super-saturated solutions dilute in suspended ice crystals and in b) concentrated slurries in well-defined fluid mechanical shear fields.

The primary independent variables are to be supersaturation, slurry concentration, fluid mechanical shear, concentration of salt; the dependent variables are to be size distribution of product crystals, number of crystals, nucleation rate, qualitative nature of crystals and Steady state, batch and transient-response type runs are to be carried out. Quantitative descriptions of the nucleation and growth phenomena are to be determined so that this information coupled with the 'Kinematic' description of particle growth processes (i.e., particle balance equations) well described in current literature, will permit the prediction of the nature of operation of full-size production equipment.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0357, A STUDY OF REVERSE OSMOSIS SYSTEMS FOR DESALINATION

W.N. GILL, Clarkson College of Technology, School of Engineering, *Potsdam, New York* 13676

The main objectives of this investigation of reverse osmosis systems are to: a) provide accurate information on the salt build up phenomenon in a variety of cases. b) determine effective means for minimizing concentration polarization effects in reverse osmosis. c) explore possible geometrical and physical arrangements of membranes which may contribute to making reverse osmosis an economically feasible process. d) provide design information on the productive capacity of systems in terms of operating conditions. e) examine experimentally the basic nature of turbulent exchange process in reverse osmosis systems.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0358, AN EXPERIMENTAL STUDY OF VARIABLE PHYSICAL PROPERTY AND NATURAL CONVECTION EFFECTS IN POROUS MEDIA

W.N. GILL, Clarkson College of Technology, School of Engineering, *Potsdam, New York* 13676 (14-01-0001-1792)

This grant is for the study of dispersion and miscible displacement processes. Data will be obtained to develop a generalized dispersion model which may be used to describe mass transfer processes in systems of complex geometry such as occurs in washing ice crystals. The ultimate objective is to be in a position to design and scale up systems with confidence.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0359, DESALINATION AND REDUCTION OF CONCENTRATION POLARIZATION EFFECTS IN REVERSE OSMOSIS SYSTEMS USING POROUS WALL SECTIONS

W.N. GILL, Clarkson College of Technology, School of Engineering, *Potsdam, New York* 13676 (14-01-0001-1816)

This grant is for studies of reverse osmosis systems for desalination in order to (a) develop practical means for minimizing concentration polarization effects in reverse osmosis; (b) examine experimentally the basic nature of turbulent exchange processes in reverse osmosis system; (c) develop methods for analyzing convective diffusion in time dependent (pulsed type) flow systems to better interrelate the interactions between the brine side flow, the properties of the membrane, and the product flow; and (d) for experimental studies to develop technology for reducing concentration polarization effects in reverse osmosis systems by the use of porous wall sections.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0360, DESALINATION BY HIGH PRESSURE SOLIDIFICATION OF WATER TO ICE

D.H. JELLINEK, Clarkson College of Technology, Graduate School, *Potsdam, New York* 13676 (14-01-0001-1789)

It is proposed to transform partially saline water under high pressure to ice VI at about 25oC. The mother liquor will be removed and the desalinated water will be recovered from Ice VI. A suitable apparatus will be constructed for this purpose.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0361, DIFFUSION PHENOMENA IN ICE - RECRYSTALLIZATION PHENOMENA IN ICE

H.H. JELLINEK, Clarkson College of Technology, Graduate School, *Potsdam, New York* 13676

I. Diffusion in, on and into ice of electrolytes will be studied as a function of concentration, temperature and crystallinity. There are no data available on substances relevant to sea water. Due to the large surface/mass ratio of the ice produced in desalination freezing processes, diffusion phenomena will be of practical importance in obtaining well defined ice products of suitable crystallite size.

II. Crystal growth (rate and habit) of ice will be studied as a function of small concentrations of electrolytes and especially organic substances as a function of temperature, pressure and concentration. Extremely small quantities of 'impurities' can be quite effective if they are adsorbed on growing crystal faces and hence have an important practical bearing on the type of ice obtained during freezing desalination processes.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0362, CHARACTERIZATION OF CELLULOSE ACETATE MEMBRANES AND ULTRATHIN FILMS FOR REVERSE OSMOSIS

C.P. BEAN, General Electric Company, *Schenectady, New York*

The objectives of this project are: a) to develop techniques for measurement of electrical impedance as a function of frequency and electrokinetic effects of cellulose acetate membranes used for reverse osmosis, b) to develop the theory for interpreting these results in terms of the physical and chemical structure of these membranes, c) to apply these techniques and theories to the characterization of both conventional and ultrathin membranes. An aim of this work is to provide information on the modes of salt and water transport and so provide theoretical guidelines for the subsequent development of new and/or improved reverse osmosis membranes.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0363, RESEARCH ON NEW ION-ADSORPTION ELECTRODES FOR DEMINERALIZATION OF SALINE WATER

T.O. ROUSE, General Electric Company, *Schenectady, New York* (14-01-0001-612)

A cation adsorption electrode is comprised of a conducting matrix, and an insoluble material capable of being electrochemically reduced and oxidized in the presence of saline water. In the reduced state, the insoluble material is capable of adsorbing cations from solution; in the oxidized state, of desorbing the cations into solution. An anion adsorption electrode is similar, adsorbing anions in the oxidized state and rejecting them in the reduced state. Together, the two electrodes form a cell capable of electrochemically desalinating flowing water for use. Regeneration of the electrodes is also accomplished electrochemically, rejecting the absorbed salts into a waste stream.

During the first two years of this program, several promising ion adsorption electrode materials were found. In general, these are polymeric materials with grafted functional groups to provide redox behavior. The program is now directed toward a detailed understanding redox mechanisms to be followed by electrode optimization studies, and finally by single cell desalination tests to evaluate operating parameters, power consumption, capacity, life, etc.

A second facet of the program will be a search for materials capable of preferentially adsorbing divalent cations.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0364, PREPARATION AND CHARACTERIZATION OF MEMBRANES FOR REVERSE OSMOSIS

P. LUNER, State University of New York, Graduate School, *Syracuse, New York* 13210

While cellulose acetate membranes for reverse osmosis compare favorably with other polymer membranes from the point of view of flux and salt rejection, they possess definite deficiencies. The most important of these are a decrease in permeability and a deterioration of the rejection ability during continued use. One objective of this research is, therefore: I. To prepare cellulose acetate membranes for reverse osmosis with improved mechanical properties (especially in the wet state) and stability. Achievement of this objective would considerably increase the feasibility of large-scale desalination.

The fact that cellulose acetate membranes show favorable transport properties and salt rejection raises the possibility of utilizing other polysaccharides as a starting material to prepare membranes for reverse osmosis. Another objective of this research program is, therefore: II. To prepare membranes from polysaccharide derivatives and evaluate them for desalination ability. While the specific objective is to find better membranes, the results of this work could give new information on the relationship between chemical structure and desalination ability.

To elucidate the mechanism of salt rejection and water diffusion in cellulose acetate membranes a number of approaches have been employed. These include water sorption studies (1), diffusion studies (2), water and salt transport phenomena (3). To add further knowledge to this important area, a further objective of this program is: III. To study the behavior of monolayers of cellulose derivatives on water and salt substrates.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0365, STUDIES ON THE FREEZING PROCESS FOR DESALTING SALINE WATERS

A.J. BARDUHN, Syracuse University, School of Engineering, *Syracuse, New York* 13210

The work to be undertaken is divided into three parts. 1. The occurrence and thermodynamic properties of the hydrates of normal and iso-butane are to be investigated because of the use of these hydrocarbons as direct contact refrigerants in several of the freezing processes. Normal butane has been thought not to form a hydrate but it has apprently given trouble in at least one process. Iso-butane hydrate is known to exist but it has not been reported to form in those freezing processes where a mixture of the butanes is used as the refrigerant.

2. It is postulated that the ice beds formed in a wash column must be strongly anisotropic and have a much higher permeability in the lateral direction than in the vertical direction in which they were formed. This should be studied since it should affect favorably the cost of wash columns when properly designed.

3. Studies on washing in porous media are to be continued and aimed more in the direction of design.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0366, STUDIES ON THE HYDRATE PROCESS FOR DEMINERALIZING SEA WATER

A.J. BARDUHN, Syracuse University, School of Engineering, *Syracuse, New York* 13210 (14-01-0001-1455)

1. Kinetics of the formation in a continuous stirring tank reactor (vol. 3.8 liters) of the hydrates of F-31 (CH2ClF), F-142b

(CH3CCIF2) and other agents which may include F-21 (CHCI2F) and methyl chloride. 2. Rates of hydrolysis of several important hydrating agents. 3. Growth rates of single crystals of ice and various hydrates in flowing subcooled aqueous solutions.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0367, REVERSE OSMOSIS PERMEATORS - DESIGN STUDY

H.W. MCROBBIE, Union Carbide Corporation, *Tarrytown, New York*

The objective of this contract is to determine the technical feasibility of modifying the commercial gaseous and liquid permeators for reverse osmosis desalination application. Design and membrane support materials suitable for construction of reverse osmosis modules of spiral and rectangular configuration will be developed if the design or materials of construction of these permeators are found to be inadequate for reverse osmosis application. A 1000 gpd pilot plant will be designed, constructed and test operated on synthetic brackish waters. Preliminary cost estimates will be prepared.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0368, LIFE TEST OF NOVEL EVAPORATOR

A.M. CZIKK, Union Carbide Corporation, *Tonawanda, New York*

A novel plate-fin evaporator, employing mechanically activated boiling surfaces was previously tested in sea water in falling film mode. An overall heat transfer coefficient of 3000 BTU/(Hr.) (square foot) (degree F) was obtained in 1967, in short-term tests.

The pilot plant at Wrightsvill Beach, North Carolina has now been modified for a 2000 hr. life test. A series of test runs, each of 200-300 hours, in deaerated, decarbonated sea water at 1 atm. are planned. The life test began on June 20, 1968. The overall coefficient was found to be still equal to the 3000BTU/(Hr.) (square foot) (degree F) obtained in the earlier tests. After 450 hours of operation, no change in overall coefficient has occurred.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0369, METALLIC CORROSION IN HALIDE ENVIRONMENTS

N.D. GREENE, Rensselaer Polytechnic Inst. , School of Engineering, *Troy, New York* 12181

The general aim of this research program is to understand and control metallic corrosion in halide environments using electrochemical measurements. Particular emphasis placed in corrosion phenomena associated with saline water conversion.

This investigation consists of three major topics: 1. Cathodic Protection. Theoretical and experimental studies to determine criteria for cathodically protecting metal structures exposed to halide media. 2. Alloy Studies. An investigation to develop new corrosion-resistant alloys using electrode kinetic measurements. Specific attention is being devoted to improving resistance to stress-corrosion cracking and pitting corrosion. 3. Exploratory Studies. Basic research on other topics related to corrosion in halide media including: anodic protection and passivity in chloride media and the specific effects of halides (F-, Cl-, Br-, I-) on electrochemical and corrosion reactions.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0370, THE CONTROL OF SCALING ON HEAT TRANSFER SURFACES BY DIRECT CONTACT WITH A FLUIDIZED BED OF GRANULAR MATERIAL

L.P. HATCH, Brookhaven Natl. Lab. , *Upton, New York*

The investigation is being continued and expanded to further evaluate the feasibility of using fluidized bed units in high temperature distillation of sea water. The program for 1968 includes the following items: 1. Continue and expand present studies on the performance characteristics of fluidized bed heat exchanger systems at about 350 degrees F with and without inline filters and under different patterns of flow, i.e., with different average residence times and recirculation rates. 2. Investigate methods of preventing or minimizing deposition of calcium sulfate downstream of the fluidized bed heat exchanger as a result of calcium sulfate super-saturation of the solution upon heating to temperatures in the range of 350-400 degrees F. 3. Continue and expand the studies at 400 degrees F to determine basic operational characteristics at this high temperature level with particular emphasis on a) improvement in over-all heat transfer values, b) reduction of calcium ion concentration, c) minimizing the formation of calcium sulfate deposits downstream of the fluidized bed exchanger, possible as a result of more immediate formation of anhydrite crystals at the high temperature with reduced tendency to produce adherent and cohesive solid masses, and d) reducing the problems of continuous operation of filters for removing the precipitated calcium sulfate because fo the non-cohesive nature of the solids remaining in the filter chamber. 4. Determine the upper limits of temperature for scale-free operation in a conventional heat exchanger after a) reducing the calcium and sulfate levels by means of heating to high temperature in a fluidized bed unit followed by high temperature filtering, and b) concentrating the total salts by simple evaporation. 5. Study the effect of seeding the solution with anhydrite calcium sulfate crystals on subsequent deposition of calcium sulfate downstream of the fluidized bed heat exchanger operating at temperatures of 350 degrees F or higher.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0371, STUDY OF FACTORS WHICH DETERMINE THE IONIC SELECTIVITY OF BIOLOGICAL AND ARTIFICIAL MEMBRANES

D.C. TOSTESON, Duke University, School of Medicine, *Durham, North Carolina* 27706

We propose to establish the relation between the chemical composition and structure of depsipeptides and their capacity to produce selective permeability of biological and artificial membranes. Various cyclic depsipeptides will be synthesized by the solid state method in the laboratory of R. B. Merrifield at Rockefeller Universiity. The ionic selectivity which these compounds produce in membranes will be evaluated in the laboratory of D. C. Tosteson at Duke University. The effect of the compounds on K and Na permeability of HK and LK sheep red cells as well as on thin membranes formed from lipids extracted from these cells will be measured. The effect of the compounds on the activities of K and Na in aqueous solution will also be evaluated.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0372, FLOOD RUNOFF & WATER YIELD FROM GLACIATED MOUNTAINS

R.S. PIERCE, U.S. Dept. of Agriculture, N.E. Forest & Rge. Expt. Sta. , *Durham, North Carolina* 03824

Object: To learn the characteristics of streamflow from forest lands and to find ways to limit streamflow extremes through manipulation of forest cover on glaciated mountainous terrain in New England.

Plan of work: The project staff is conducting work on two levels: plot studies and gaged experimental watershed studies. On the plots they are determining relationships between climatic factors, forest types, and soils. On the experimental watersheds they are testing hypotheses and vegetative treatments on streamflow. They are conducting detailed energy balance studies of solar radiation and sensible heat in terms of snowmelt and estimating evapotranspiration for water balance tabulations.

SUPPORTED BY U.S. Dept. of Agriculture

3.0373, MOSAIC MEMBRANES FOR DESALINATION

H. YASUDA, Res. Triangle Institute, *Durham - Research Triangle Pk. , North Carolina* 27709

Improved membranes processing a mosaic structure are proposed for use in reverse osmosis, electrodialysis, and piezodialysis. Such membranes, which have not been used heretofore in membrane technology, will be produced from ABA-type block copolymers in which the incompatibility of the A and B polymer blocks results in partial phase separation. By proper chemical modifications the necessary ionic domains will be formed.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0374, QUANTITY, QUALITY, AND TIMING OF WATER YIELDS IN THE SOUTHERN APPALACHIANS-PIEDMONT

J.E. DOUGLAS, U.S. Dept. of Agriculture, *Franklin, North Carolina*

Object: To develop principles, prediction methods, and techniques for managing watershed lands for improved water yield and other purposes.

Plan of Work: The Coweeta Hydrologic Laboratory has more than 20 calibrated experimental forested watersheds for empirical studies and for testing hypotheses. An increasing proportion of recent activity is on basic research. The program is organized under four interdisciplinary fields to develop understanding of climatic, biologic, and hydrologic processes and to derive relationships between these processes. The four fields are (1) hydro meteorology, in which the staff is studying precipitation variation, the radiant energy budget, and evaportranspiration; (2) plant-water relations including interception effects; (3) soil-water relations, including unsaturated flow studies; and (4) streamflow.

SUPPORTED BY U.S. Dept. of Agriculture

3.0375, ANALOG MODELING TO DETERMINE FRESH WATER AVAILABILITY ON THE OUTER BANKS OF NORTH CAROLINA

G.J. KRIZ, Univ. of North Carolina, School of Agriculture, *Raleigh, North Carolina* 27600

The amount of potable water available for human and plant usage on the Outer Banks of North Carolina has not been quantified because static rather than dynamic conditions have been used to describe the movement of water in this area. A Hele-Shaw model will be constructed to represent a cross section of the Outer Banks. The fresh water lens will be determined from the model by simulating known conditions of topography and rainfall, tidal and salinity conditions. The model will be compared with field data. The safe yield of the fresh water aquifer will be determined for various pumping rates and well depths in the model.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
North Carolina State University
North Carolina State Government

3.0376, SURVEY OF WATER UTILIZATION AND WASTE CONTROL IN THE PULP AND PAPER INDUSTRY

C.N. ROGERS, Univ. of North Carolina, Graduate School, *Raleigh, North Carolina* 27600

Rapid growth of the pulp and paper industry in the South, which now produces 60% of the Nation's pulp, accents that their effluent problem is becoming increasingly important. The problem involves not only the waste of valuable products, but the danger of pollution to the neighboring water bodies in either surface, sub-surface, or both.

The objective of this proposed research project is to conduct a broadly based, industry wide evaluation of methods of effluent improvement for various types of paper mills in the South. From such an evaluation, specific problem areas will be identified for subsequent research in depth, and baselines established for future guidance of the industry and priority of alternate approaches to solving the problems of effluent controls. Emphasis will be placed upon identifying in-plant processing opportunities from technical and economic aspects to reduce the effluent at its source.

These studies will include systems covering: A. Specific manufacturing processes producing effluent. B. In-plant systems reducing losses and quantity of effluent. C. Methods and costs of effluent improvement subsequent to the plant.

Important factors to be studied are characteristics and amounts of effluent; methods of water conservation, waste control and treatment; effectiveness; costs; and problems yet to be solved.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
North Carolina State University

3.0377, WATER UTILIZATION AND WASTE CONTROL IN THE TEXTILE INDUSTRY

H.A. RUTHERFORD, Univ. of North Carolina, Graduate School, *Raleigh, North Carolina* 27600

An exploratory investigation of water utilization and waste control in the textile industry leading up to plant-wide studies to identify opportunities for more efficient water use, water reuse, chemical substitution and recovery, process change, and other internal changes as alternatives to waste treatment.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
North Carolina State University

3.0378, PREPARATION AND PROPERTIES OF GRAFTED AND VECTORED MEMBRANES FOR USE IN DESALINATION

V.T. STANNETT, Univ. of North Carolina, School of Engineering, *Raleigh, North Carolina* 27600

The research will be concerned with two principal areas of membrane development. (1) the improvement of cellulose acetate as a membrane base. (2) The preparation and properties of novel membranes for reverse osmosis desalination.

The main emphasis in both phases of the research will be on the use of graft copolymerization techniques.

Specific areas to be studied include: 1. Investigate improvement of compaction resistance of the asymmetric cellulose (2.5) acetate 'tight' membrane (for desalination of sea water) via graft copolymerization of styrene monomer and/or alpha-methyl styrene-styrene monomer blends. a. The effect of grafting to the porous side of asymmetric cellulose acetate reverse osmosis membranes on their desalination and time dependent desalination properties will be studied. b. Preparation of styrene and alpha-methyl styrene on grafted cellulose acetate resin and subsequent asymmetric membrane fabrication from these novel resins will be attempted if 1.a. does not produce acceptable results. c. Early work will include grafting to VFHP CA/CN (100 Angstrom units) 'homogeneous' millipore filters. 2. The grafting of small hydrophilic gels or films across pores of various relatively non-deformable porous structures shall be investigated as an approach to develop desalination characteristics into the latter systems. 3. 'Vectoring' of selected porous hydrophilic/hydrophobic graft copolymer membranes shall be investigated as an approach to the formation of desalination surface films or layers, i.e., formation of appropriate asymmetric desalination membranes. 4. Candidate reverse osmosis membranes will be evaluated in reverse osmosis cells which effectively eliminate boundary layer concentration polarization.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0379, ECONOMIC EVALUATION OF IRRIGATION IN NORTH DAKOTA

D.O. ANDERSON, North Dakota State University, Agricultural Experiment Sta., *Fargo, North Dakota* 58102

Objectives: 1. To determine irrigation resource requirements and production response for selected crops, and to evaluate alternative methods of irrigation water application.

2. To interpret the irrigation production response studies in terms of economic criteria and determine optimum enterprise combination that maximizes profit or minimizes resource requirements.

3. To appraise the potential value of water used for irrigation in North Dakota.

Regression analysis and appropriate tests of significance will be used to fit production response data to functional relationships, and the resulting functions will be analyzed, utilizing economic criteria. Production response data will be analyzed to determine the profitability of applyin alternative levels of water. Linear programming will be used to develop profit maximizing and resource and cost minimizing plans for various resource situations. Value of water will be determined using production function analyses and linear programming methods.

SUPPORTED BY U.S. Dept. of Agriculture
North Dakota State Government

3.0380, THE EXTENT OF IRRIGATION DEVELOPMENT IN NORTH DAKOTA AND ITS ECONOMIC IMPACT

D.O. ANDERSON, North Dakota State University, Agricultural Experiment Sta., *Fargo, North Dakota* 58102

Objectives: 1. To develop methodology for determining the most profitable water resource development for irrigation. 2. To estimate future water use and development and levels of aggregate supply of presently produced and potentially feasible agricultural products. 3. To determine the market potential and price to producers of agricultural commodities produced. 4. To estimate the economic impact of alternative levels of agricultural water development on income and employment.

Description of Work Proposed: This study will develop a linear programming model of the entire state to determine the profit maximizing level of water development for irrigation. Market information will be generated in order to define demand conditions and market alternatives for products which can be produced in the state under irrigation. This study will utilize input-output analysis to determine the secondary impact of irrigation development on the North Dakota economy.

SUPPORTED BY North Dakota State Government

3.0381, EVALUATION OF EXTENSIVE IRRIGATION

H. HOLMEN, North Dakota State University, Agricultural Experiment Sta., *Fargo, North Dakota* 58102

1. To determine the operational characteristics of some mechanized sprinkler systems and to evaluate some irrigation efficiencies with extensive irrigation.

The project will be conducted jointly by the Agr. Engr. Dept., and the Carrington Irrigation Branch Station at Carrington, North Dakota. The first system to be studied will be one where the sprinkler line rotates in a circle about one end as a pivot. The system will be used on four fields adjacent to each other. Problems associated with transporting the system from field to field between irrigations will be studied. The uniformity of application and the distribution efficiency will be measured. A system of containers spaced 10 ft. radially from the pivot will be used to evaluate the distribution pattern. Climatic factors including wind, evaporation and air temperature will be recorded. Some runoff measurements will be made early in the experiment; and if runoff becomes a problem, a more extensive study will be developed.

A cropping system will be used where extensive irrigation will promote efficiency in use of the irrigation system. A low plant water stress will be maintained at the critical stage of plant development for each crop, and a minimum amount of water will be applied at other stages of plant growth depending upon the capacity of the sprinkler system. The yield and water use efficiency will determine if extensive irrigation is a practical means of using mechanical irrigation systems.

SUPPORTED BY U.S. Dept. of Agriculture
North Dakota State Government

3.0382, INFLUENCE OF WATER QUALITY IN MAINTAINING WHITENESS WHEN LAUNDERING WHITE FABRICS

C.M. JANECEK, North Dakota State University, Graduate School, *Fargo, North Dakota* 58102

Objectives: (1) To identify the factors that influence the discoloration of white fabrics when laundered in hard water and/or waters containing iron, manganese or organic coloring. (2) To determine methods that prevent discoloration of white fabrics during laundering. (3) To determine whether any of the methods used to retain whiteness cause a decrease in residual strength or cause other undesirable effects.

It is planned to work with State Extension personnel in enlisting cooperating homemakers. Swatches of white test fabric will be given to each cooperator to be laundered a specified number of times. The swatches will be returned to the laboratory for determination of the degree of discoloration. Information on water supply, iron removal and softening equipment, washing agents and methods will be obtained from each cooperator.

After the factors causing discoloration have been identified, various methods for preventing discoloration will be evaluated. These methods include removal of iron, water softening and the use of selected types of bleach and detergent. Laboratory analyses of the swatches will determine whether or not methods used to attain whiteness are detrimental to the fabric.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
North Dakota State University

3.0383, IRRIGATION WATER USE EVALUATION

E.C. STEGMAN, North Dakota State University, Agricultural Experiment Sta., *Fargo, North Dakota* 58102

1. To evaluate the water delivery requirements for a farm size unit subjected to a management level attainable by farm operators. 2. To determine the operational performance of graded borders and furrows which may be used to develop guides or design criteria for use in the Garrison Diversion area. 3. To develop functional criteria for planning and design of irrigation systems.

Work Proposed: Measurements will be made to determine inflow and outflow associated with irrigation in field size areas. Ground water levels will be observed. Runoff hydrographs associated with precipitation will be obtained. Soil moisture will be determined. Irrigation and drainage requirements will be established as a function of the vegetation species, climate, hydrologic performance of soil, and hydraulic performance of the irrigation system.

SUPPORTED BY U.S. Dept. of Agriculture
North Dakota State Government

3.0384, A PHYSICAL AND ECONOMIC ANALYSIS OF ALTERNATIVE IRRIGATION METHODS IN A SUB-HUMID CLIMATE

E.C. STEGMAN, North Dakota State University, Agricultural Experiment Sta., *Fargo, North Dakota* 58102

Objective: To evaluate alternative methods of irrigation for the purpose of identifying the design or designs which maximize returns to resources in a sub-humid climate.

Description of Work Proposed: Available crop water use data will be analyzed to develop techniques for estimating the evapotranspiration term in the daily water balance model to be employed in succeeding steps. Available crop yield and associated climatic data will be analyzed to develop production functions for potentially irrigable crops, i.e., yield data will be related to climatic or drought indices. A range of irrigation systems will be artificially applied to all combinations of a set of farm unit sizes, soil moisture storage capacities and crop rotations characteristic of proposed irrigation districts in Garrison Diversion unit. For each combination, irrigation programs will be synthesized for a significant period of climatic record by injecting an irrigation system of specified design or capacity into the water balance model by way of the irrigation term. The estimated yield distribution or expected return data, labor, operating, and investment costs associated with each of the irrigation systems and programs will provide the basis for an economic analysis.

SUPPORTED BY North Dakota State Government

3.0385, IMPROVEMENT AND MANAGEMENT OF SALINE AND SODIC SOILS OF THE NORTHERN PLAINS

A.R. GRABLE, U.S. Dept. of Agriculture, *Mandan, North Dakota*

Object: To develop and apply principles for the diagnosis and improvement of saline and sodic soils including amendment, leaching, soil and crop management practices, and to determine the effect of salinity and sodium on plant growth including species and varietal tolerance.

Plan of Work: Two approaches are involved. One is to conduct controlled field experiments involving variables of culture, irrigation, drainage, or amendment practices to replace salt or sodium from the soil with leaching water and to follow by chemical analysis changes in salt content and exchangeable sodium in problem areas in relation to water quality, water table height, precipitation, and topography and derivation of statistical and graphical relationships.

SUPPORTED BY U.S. Dept. of Agriculture

3.0386, MULTICOMPONENT MEMBRANE FOR REVERSE OSMOSIS

D. MCINTYRE, Univ. of Akron, Institute of Polymer Science, *Akron, Ohio* 44304

Theoretical and experimental studies of the mechanism of water transport in membranes used in reverse osmosis will be undertaken. Both block polymers and mixed polymers will be used. The polymer compositions will be tailored to include known amounts of hydrophilic and hydrophobic constituents. Also different types of intermolecular attractions will be allowed to simulate the semi-crystalline properties of cellulose acetate. The thermodynamic and transport properties of these membranes will be studied. The results of these studies are expected to allow improved reverse osmosis membranes.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0387, PREPARATION OF SMALL TUBES AND THE DETERMINATION OF THEIR PROPERTIES FOR REVERSE OSMOSIS

E.A. MEINECKE, Univ. of Akron, Institute of Polymer Science, *Akron, Ohio* 44304

The influence of the processing variables on the structure of small tubes of materials suitable for reverse osmosis; and the influence of the structure of the tubes on their mechanical properties and permeability is studied. Techniques for design and construction of efficient reverse osmosis configurations are developed. The study will involve (a) design and construction of extrusion and stretching equipment for making tubes approximately 0.001 inch in diameter, (b) preparation of tubes under various fabrication conditions, (c) characterization of tubes under varying operating conditions, (d) determining mechanical properties of the tubes, and (e) determining permeability of the tubes.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0388, STUDIES ON THE MOLECULAR STRUCTURE OF BIOLOGICAL MEMBRANES

J.E. ZULL, Case Western Reserve Univ. , Graduate School, *Cleveland, Ohio* 44106

Research on the structure and properties of biological membranes and model biological membranes is being carried out. The natural membrane currently under investigation is the red-blood cell ghost. Glucose transport sites are being investigated and proteins associated with these sites will hopefully be isolated. Radioactive tracer techniques are being used for this work.

C14 and H3 labeled hormones are being prepared (insulin, vasopressin), and will be used in attempts to identify and isolate transport protein involved in their action.

The model systems are primarily bimolecular leaflets of phospholipid and cholesterol, studied either directly or as suspensions in aqueous media. ATR spectroscopy is the primary tool currently being used for this work. The association of tracer labeled proteins with these model systems will be investigated as the model of lipid-protein interaction in biological membranes.

The primary aim of the work is to elucidate the structure of biological membranes at the molecular level, and the nature of the proteins involved in transport function in such membranes.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0389, FOAM FRACTIONATION

J.J. BIKERMAN, Horizons Incorporated, *Cleveland, Ohio* 44104

The ultimate objective of this study is development of the methods of foam fractionation and ion flotation for recovery of useful minerals and potable water from the sea or brackish waters. At present, it is intended to investigate the following processes: 1. Extraction of iron and manganese with anionic surfactants; the efficiency and the economics of the operation will be considered. 2. Extraction of calcium and magnesium with several commercial surfactants at various acidities. 3. Extraction of iron from solutions containing both ferrous and calcium ions and simultaneous extraction of iron and calcium from these solutions. 4. Extraction of potassium using surface-active derivatives of tetraphenylboron and 4,6-dinitro-2-octylphenol.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0390, SCALE CONTROL WITH GRAPHITE HEAT-TRANSFER TUBES OF CONTROLLED PERMEABILITY TO STEAM

L.E. VAALER, Union Carbide Corporation, *Cleveland - Parma, Ohio*

The objective of the proposed contract is to investigate a possible method of preventing scale in the distillation of saline water to produce potable water by taking advantage of the inherent permeability of heat-transfer tubes made from graphite. If a small portion of the steam condensate seeps through the wall of a graphite tube, the static film on the brine side, will presumably be diluted to a level of calcium sulfate super-saturation below that needed for scale formation. The investigation will involve three experiments with the LTV falling film evaporator, employing a temperature of 275 degrees F on the steam side and a vaporization temperature of 265 degrees F on the falling film side of the tube. The experiments will be carried out with unconcentrated synthetic sea water containing components that will normally deposit $CaSO_4$ and alkaline scale.

Specific objectives of this investigation are to compare the performance of an impervious tube and a permeable tube employing a vaporization temperature of about 265 degrees F on the falling film side of the tube to investigate the possibility of preventing alkaline scale using permeable graphite tubes.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0391, INVESTIGATION OF THE USE OF LOW-COST PLASTIC FILMS FOR SOLAR STILL CONSTRUCTION

J.A. EIBLING, Battelle Memorial Institute, *Columbus, Ohio* 43201

The objectives of this program were to determine, by means of a design study, the feasibility of using the very low-cost plastic films, such as polyethylene and polyvinyl chloride, as cover materials for large solar stills. This investigation was prompted by the good progress made in recent years in improving the weatherability of these films through the incorporation of various additives which provide some protection against deterioration caused by ultraviolet radiation.

Preliminary economic studies had shown that these films, because of their very low cost, might be suitable for solar stills even though their anticipated useful life was not more than one year. The approach taken during this study was to consider various still designs, choose one design well suited to the low-cost, short film life philosophy and make a thorough evaluation of this design. Samples of a few plastic films were exposed at a Florida site in fixtures simulating solar still conditions to supplement the information on film life available through other sources.

The results of the design study indicated that there was little or no economic advantage in using the low-cost films. Even if the useful life of the film is assumed to be one year, which the exposure tests during this program indicated is probably too optimistic, the low-cost films have such low mechanical strength that a relatively thick film is required to withstand the anticipated structural loads. As a result, the film cost is high enough that the product water cost from such a still would be no lower than one would expect from a glass- covered still.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0392, DOCTORAL DISSERTATION RESEARCH IN GEOGRAPHY

J.N. RAYNER, Ohio State University, Graduate School, *Columbus, Ohio* 43210

Shuh-Chai Lee, a doctoral candidate in Geography, is conducting his research on water vapor flux in the atmosphere and its relation to the water balance in the Ohio River basin. These relationships are vital for progress in atmospheric science. The NSF grant will be used primarily for obtaining from the U. S. Weather Bureau punched cards recording the twice daily meteorological observations from seven stations for the 15-year period, 1950-1965. These basic data will be used to estimate water vapor flux for the Ohio River Basin.

SUPPORTED BY U.S. National Science Foundation

3.0393, RELATION OF CLIMATIC AND WATERSHED PHYSIOGRAPHIC AND CULTURAL FACTORS TO WATER YIELD

L.L. HARROLD, U.S. Dept. of Agriculture, *Coshocton, Ohio*

Object: To identify the climatic and watershed factors influencing water yield of agricultural watersheds, both stream flow and ground water components; to evaluate the factors quantitatively; and to develop simple procedures by which the seasonal and annual net yield of water from ungaged watersheds may be reliably estimated for both local and downstream uses.

Plan of Work: Work is currently concentrated on the North Appalachian Experimental Watershed near Coshocton, Ohio; on agricultural watersheds in the vicinity of Fennimore and Madison, Wisconsin; and at Columbia, Missouri. Some of the factors required for the analyses and which are measured or otherwise documented for the study are: rates and duration of streamflow; precipitation patterns; antecedent mositure; season; soils; ;amd use; conservation and watershed management practices; ground water elevations; riparian vegetation; geology; gradients and hydraulic roughness of stream channels; and the size, shape and other geomorphic attributes of the watersheds.

SUPPORTED BY U.S. Dept. of Agriculture

3.0394, AQUIFER AND SUBSURFACE RELATIONSHIPS IN THE HYDROLOGY OF UPSTREAM AGRICULTURAL WATERSHEDS

L.L. HARROLD, U.S. Dept. of Agriculture, *Coshocton, Ohio*

Object: To develop procedures for estimating subsurface contributions to streamflow, transmission losses in stream channels and valleys, and groundwater movement and recharge in relation to watershed geology, soils, climate, land use, and other characteristics.

Plan of Work: The work is currently in progress at the North Appalachian Experimental Watershed near Coshocton, Ohio and from headquarters at Madison, Wisconsin and Columbia, Missouri. The investigations include: geologic mapping; ground water observations; soil moisture determinations; transmission capacities of soils and aquifers; and the consideration of influent and effluent streamflow.

SUPPORTED BY U.S. Dept. of Agriculture

3.0395, IMPROVED ION EXCHANGE POLYMERS AND MEMBRANES FOR ELECTRODIALYSIS OF SALINE WATER

E.V. KIRKLAND, Monsanto Research Corporation, *Dayton, Ohio* 45407

A contract project has been undertaken to develop an aliphatic anion exchange membrane for application in electrodialysis of saline and brackish water. Initial work will be directed toward the preparation of a membrane from a copolymer of ethylene and vinyl phthalimide, followed by hydrolysis and quaternization. Alternative approaches will be employed if necessary such as hydrogenation of an ethylene/acrylonitrile copolymer followed by quaternization. The copolymer precursors will be synthesized by high pressure copolymerization. The membranes will be evaluated in an electrodialysis stack and compared to commercial membranes.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0396, EVALUATION OF AN ELECTROCHEMICAL DESALINATION PROCESS FOR BRACKISH WATER

G.W. REID, Univ. of Oklahoma, Research Institute, *Norman, Oklahoma* 73069

This grant is for continuation of testing of the existing 20 gallon/day unit for a sufficient length of time to adequately determine its performance under field conditions. On completion, this data will be used for design and construction of a 500 gallons/day unit. This in turn will be field tested, including pretreatment requirements, and the data used for preliminary design of a 20,000 gallons/day or larger unit.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0397, INCREASING WATER SUPPLIES BY SUPPRESSION OF RESERVIOR EVAPORATION

F.R. CROW, Okla. St. Univ. of Agr. & Sci. , School of Agriculture, *Stillwater, Oklahoma* 74075

The general objective of this research is to study the broad problem of evaporation suppression methods using small experimental reservoirs as the principal test environment. A specific objective is to determine the evaporation retarding efficiency of monomolecular films and floating plastic membranes in relation to the proportion of total water surface covered by the evaporation retardant. The results of this research will have application in determining the accuracy of procedures for estimating evaporation suppression which are based on estimates of partial film cover.

Tests will also be made to determine the effect on evaporation resulting from disturbing the thermal gradient of small reservoirs by pumping, bubbling, or related techniques.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Oklahoma State University

3.0398, THE HYDRAULICS OF SPATIALLY VARIED STEADY FLOW IN AN IRRIGATION DISTRIBUTION CHANNEL WITH FURROW OUTLETS

J.E. GARTON, Okla. St. Univ. of Agr. & Sci. , School of Agriculture, *Stillwater, Oklahoma* 74075

The objectives of this project will be: 1. To determine the discharge characteristics of weirs, orifices, and short tubes installed in the side of a trapezoidal channel. 2. To evaluate the energy losses in the channel and determine values of roughness coefficients for a system of multiple furrow outlets. 3. To determine the distribution uniformity of irrigation systems in which weirs, orifices, and hooded inlet tubes are used to distribute the water in furrows. 4. To develop methods of predicting the water surface profiles and the distribution uniformity of irrigation systems in which discharge occurs through weirs, orifices, and short tubes.

The proposed experiments will be conducted in an existing horizontal concrete-lined irrigation channel, equipped so that the inflow and the resulting water surface profile is 320 feet long and has dimensions that are standard in current irrigation practice.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Oklahoma State University

3.0399, PLANT POPULATION EFFECTS ON THE EFFICIENT USE OF WATER

J.F. STONE, Okla. St. Univ. of Agr. & Sci. , School of Agriculture, *Stillwater, Oklahoma* 74075

Two years of preliminary studies in Oklahoma have shown that peanuts can be grown in narrow rows with an attendant increase in yield and quality. Water requirement for the increased production did not increase or even reduced (in one of the years). No micrometeorological measurements were made so the mechanisms responsible for the efficiency of water use are not known. The proposed study would characterize water loss both aerodynamically and from an energy budget standpoint. Degree of transferability of the information to other plants and regions will be sought.

Objectives: 1. Study aerodynamic and energy factors tending to cause water loss in peanuts cropped at economically high population levels. 2. Investigate and identify the factors tending to cause the observed reduction (or at least constant) water loss from peanuts as population increases. 3. Investigate the possibility for cropping with reduced water loss.

Procedures: Plant population will be varied by using different row spacings. Aerodynamic and energy factors will be obtained through measurement of such micrometeorological variables to determine energy budget and aeordynamic roughness and potential evapotranspiration. Reflectance of the field surfaces (crop and soil) condition of the plant stomates will be recorded.

If the foregoing measurements offer an explanation for the water loss efficiencies noted in the past, the causative factors will be manipulated for further enhancement during the later phases of this study. They can also be studied for transferability to other plants and other regions.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Oklahoma State University

3.0400, USE OF REACTOR COOLING WATER FROM NUCLEAR POWER PLANTS FOR IRRIGATION OF AGRICULTURAL CROPS

L.L. BOERSMA, Oregon State University, School of Agriculture, *Corvallis, Oregon* 97331

The proposed research plan involves laboratory investigations directed at determining the feasibility of using water heated in nuclear power plants for irrigation of agricultural crops. The main approach in the proposed investigations is to determine the influence of soil temperature and heated water on rates of photosynthesis, transpiration and respiration under controlled laboratory conditions.

Methods employed are: A special experimental arrangement has been designed in which soil water content and soil temperature can be maintained constant or can be varied at a programmed rate. Above ground conditions can be maintained constant or can be varied at a programmed rate independent of below ground conditions. The rates of photosynthesis, transpiration and respiration can be monitored on a continuously recording basis or measured at certain time intervals. The experimental arrangements provides for the simultaneous observation of 34 separate plant systems.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Oregon State University
Oregon State Government

3.0401, IMPROVING IRRIGATION WATER SUPPLY FORECASTS AND THEIR USE

B.L. WHALEY, Oregon State University, Agricultural Experiment Sta., *Corvallis, Oregon* 97331

A. To adopt methods of soil moisture measurement to Oregon mountain soils to obtain indices of soil moisture. B. Preparation of hydrologic data for machine processing. C. To improve water supply forecast methods. D. To study the effect of frost in the soils to runoff.

Locate and install soil measuring devices in areas of limited snow fall and determine the water holding capacity of the soils. Take readings on these sites often enough to be of value in correcting forecasts for soil moisture deficiency. Snow survey data will be punched on cards after each season so that this data deck may be used to print up-to-date summaries of all data measured in Oregon. All forecast procedures will be reviewed and available data and techniques studied for the improvement of forecast equations. Measurements of frost penetration will be taken at soil moisture stacks and other selected locations over the state and a comparison made of watershed yields from frozen and unfrozen soils.

SUPPORTED BY Oregon State Government

3.0402, THE ADAPTATION OF SPRINKLER IRRIGATION TO SOILS OF LOW INTAKE RATE

J.W. WOLFE, Oregon State University, Agricultural Experiment Sta., *Corvallis, Oregon* 97331

To develop a procedure for determining the optimum sprinkler application rate on low intake rate soils. To determine the adaptability of sprinkler equipment with modification if necessary for applying water at the required low rate.

Progress to Date. A prediction equation for the time required for ponding to appear under irrigation sprinklers on amity silt loam planted to pasture, was developed from field measurements made during two seasons. It was found that time to pond could be predicted if one knows the initial soil moisture content and the application rate from the sprinklers.

In a second series of experiments, the percentage of ponding of the surface was permitted to increase on graded plots and on flat plots. The uniformity of distribution of moisture in the soil after irrigation was lowered on the graded plots.

SUPPORTED BY Oregon State Government

3.0403, THE MEASUREMENT OF EVAPORATION AND CONDENSATION COEFFICIENTS OF WATER UNDER EQUILIBRIUM CONDITIONS

R.W. COUGHLIN, Lehigh University, School of Engineering, *Bethlehem, Pennsylvania* 18015

Accommodation coefficients of water will be measured using tritiated water as a tracer. This will permit the determination of these coefficients under equilibrium conditions. The following systems will be investigated: 1. liquid water - water vapor 2. ice - water vapor 3. liquid water - water vapor, in the presence of foreign gases 4. adsorbed water - water vapor.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0404, CORROSION PROTECTION BY INHIBITOR CROSS-LINKING AND SURFACE COATING GRAFTING

R.W. COUGHLIN, Lehigh University, School of Engineering, *Bethlehem, Pennsylvania* 18015

The proposed investigation will attempt to cross link polymeric inhibitors adsorbed on metal surfaces by using ionizing radiation. Attempts to graft polymeric films directly onto metals and onto adsorbed inhibitors will also be carried out. In addition, grafting of polymers onto concrete surfaces will be studied. The goal in this work will be to impart additional corrosion protection to the materials employed as substrates.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0405, POLYMERIC COATINGS FOR PROTECTION ON CONCRETE EXPOSED TO AQUEOUS SALINE ENVIRONMENTS

J. MANSON, Lehigh University, Institute of Research, *Bethlehem, Pennsylvania* 18015

This research program is for the investigation of basic factors affecting the adhesion of polymer coatings to concrete during exposure to a saline water environment. Factors to be considered include: (1) adhesion and debonding at the polymer-concrete interface and the effects of certain functional groups as adhesion promoters; (2) permeability of the film to moisture and ions and the effects of these on the polymer-concrete interface; and (3) physical and chemical degradation of the polymer itself.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0406, DEVELOPMENT OF DESALINATION MEMBRANES

N.D. FIELD, G A F Corporation, *Easton, Pennsylvania* 18042

The program will be devoted to the fabrication of water insoluble membranes based on polymers of vinylpyrrolidone and/or vinyl ethers. Among variables under consideration will be type and ratios of comonomers and degree of crosslinking. Random, graft and block copolymers will be synthesized. Blends and composite membranes will be fabricated. Some of these will be based on the tendency for vinylpyrrolidone-containing polymers to form complexes with carboxyl- containing polymers. For example, PVP solutions and poly (alkyl vinyl ether/maleic anhydride) solutions on mixing form insoluble coacervates. These on drying form water insoluble, tough materials. It is envisaged that multiple layered films can be prepared using this phenomenon. Sandwich structures will be prepared in which the hydrophilic hydrophobic balance of each layer will be a variable. In this fashion, membranes with a range of water flux and salt rejection should be possible. Optimum polymer mixtures and film composite structures will be chosen. The physical and mechanical properties of the membranes will be evaluated. Water flux and salt rejection will be utilized as screening tools. The best membranes will undergo intensive physico- chemical studies.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0407, IMPROVEMENT OF ECONOMICS OF ELECTRODIALYSIS SYSTEMS BY SELECTIVE PRETREATMENT

E.C. SPITZER, Crane Company, *King of Prussia, Pennsylvania* 19406

The four main objectives of this contract are: to develop effective and economical pretreatment methods for electrodialysis plants treating highly contaminated brackish surface waters; to characterize commercially available ion-selective membranes to determine the degree of their resistance to fouling by organics and other contaminants; to evaluate the overpotential static cell test as a means to predict the fouling tendency of an electrodialysis system treating highly contaminated brackish surface waters; and to develop a procedure for concentrating foulants in brackish ground waters in the field, suitable for use in conjunction with the overpotential static cell test.

The work to be accomplished includes the assembly and construction of the test units, laboratory testing and characterization, operation field testing, foulant concentration studies, and analysis of the test data.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0408, IMPROVEMENTS IN DESALINATION BY THE FLASH EVAPORATION PROCESS

R.A. TIDBALL, Baldwin Lima Hamilton Corp. , *Philadelphia, Pennsylvania* 19142

Two pilot plants are in operation. The 3 stage plant, a full scale 21 inch wide portion of a commercial flash evaporation desalination plant, is providing data on various plant parameters including interstage orifice coefficients, flashing efficiency, and non-equilibrium phenomena in the flash chambers. This pilot plant is fully instrumented for the very accurate measurement of temperatures, pressures, and fluid flows. Temperatures are measured by means of platinum resistance thermometers. Data points are automatically sequenced by a data logger, and results are rapidly recorded on punched cards.

A 16-stage pilot plant, simulating one-third the stages of a full- scale commercial plant, has been giving a valuable insight into the mechanism of scale formation during the distillation of sea water. During the past year, scale prevention techniques tested in this plant included acid addition and the use of additives to the feed stream. This plant has just been modified to incorporate a fluidized bed for the prevention of the deposition of scale on heat transfer surfaces. In addition, systems are being appended for the testing of slurry addition and also of ion exchange pretreatment of the feed.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0409, EVALUATION OF BRINE DESULFATING PROCESS AS APPLIED TO FEEDWATER FOR DESALINATION PLANTS

C.E. ENNIS, Catalytic Construction Company, *Philadelphia, Pennsylvania* 19102

An evaluation of a desulfating process conceived at the Department of Interior, Bureau of Mines Metallurgy Research Center, Salt Lake City, Utah, for application to feedwater supplied to large (50 MGD) desalting plants. The process was analyzed to determine the maximum brine temperature which could be used in a desalter operating on the desulfated feed. Flow sheets and equipment selections were made for a plant to supply feedwater to a 50 MGD desalting plant. Flow sheets and specifications (OSW Specification 1822) were prepared for a pilot plant to be installed and operated at OSW's Wrightsville Beach Test Center. An analysis of plant capital and operating cost is included, together with projected income from sale of by-product sulfuric acid, caustic soda, and soda ash indicates that the desulfating process could return a credit to the desulfating-desalting complex equal to $.07 per 1000 gallons of desalted product water.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0410, EVALUATION OF HIGH PRESSURE PUMPS FOR REVERSE OSMOSIS PROCESS

J.W. PETERSON, Catalytic Construction Company, *Philadelphia, Pennsylvania* 19102

The objectives of this program are to evaluate the suitability of commercial high pressure pumps for use in multi-million gallons per day brackish and sea water reverse osmosis plants, and to develop pump maintenance procedures that will significantly cut down plant down time.

Four phases of work are to be accomplished. These are pump selection; design and fabrication of test loops; pump evaluation; and recommendations and preparation of the final report.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0411, DEVELOPMENT OF PERMANENT SYSTEMS FOR DROPWISE CONDENSATION

R.A. ERB, Franklin Institute, *Philadelphia, Pennsylvania* (14-01-0001-744)

This program is aimed toward obtaining increases in heat transfer in distillation processes for desalination through the development and application of permanent systems for dropwise condensation on condenser surfaces. One dropwise system being studied involves the use of thin films of noble metals (e.g., gold with silver underlayer); another system is based on the parylenes (vapor-deposited polymers). Other possible permanent systems are also being investigated. The program, with a goal of the development of high-performance, low-cost systems, consists of several areas of study: 1) screening tests, for studying the dropwise behavior new or improved systems under continuous condensing conditions; 2) engineering tests and studies with small pilot plants, using steam generated from seawater and involving heat- transfer measurements and studies on the effect of aging, inundation, contamination, etc.; 3) fundamental studies on microcondensation phenomena; 4) cooperation toward dropwise condensation studies in larger-scale units for seawater distillation, with the aim of demonstrating performance under actual plant operating conditions. Preparations have been made for testing dropwise systems in a special unit at the Clair Engle plant, Chula Vista, California, and in a G.E./Navy still at Wrightsville Beach, North Carolina.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0412, ELLIPSOMETRIC STUDIES OF PASSIVATION, WITH SPECIAL REFERENCE TO THE ESSENTIAL ANIONIC CONSTITUENTS OF SALINE WATER

J.O. BOCKRIS, Univ. of Pennsylvania, Graduate School, *Philadelphia, Pennsylvania* 19104

The essential nature of the passivation process is to be studied using ellipsometry in conjunction with electrochemical measurements to follow the formation and growth of the passivating film. The growth of the passive film will also be studied to gain an understanding into its mechanism. Also, the influence of halide ions on passivity will be studied to analyze the way in which the passive film is broken down by halides.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0413, MAXIMUM RATE OF VAPORIZATION AND CONDENSATION OF WATER WITH DISSOLVED SALTS AND SURFACE CONTAMINATION

L.C. EAGLETON, Univ. of Pennsylvania, School of Engineering, *Philadelphia, Pennsylvania* 19104

The objective of the research is to measure the rate of evaporation or condensation, expressed in terms of the condensation coefficient, of water to which sodium chloride, a surface active material or a monomolecular film on the surface has been added. These experimental data will be compared to those of pure water. The research proposed here is an extension of that performed under OSW Grant No. 14-01-0001-462 titled 'Maximum Rate of Vaporization and Condensation of Water'.

Determination of the coefficient for salt water should enable this research to determine if dissolved salts inhibit the rate of vaporization of water other than through the vapor pressure lowering. Monomolecular films applied to the surface strongly retard evaporation but very small quantities of contaminants can destroy the action of these films. In view of this, the dissolved electrolytes and organic molecules that might collect at the surface of sea water are of particular interest. Previous measurements of the evaporation rates through monomolecular films have been limited to studying relative rates since the main resistance to evaporation has been the gas diffusion layer. The apparatus used in the previous grant and to be incorporated in this effort is unique in that it determines the absolute coefficient from a flat, stagnant liquid surface with no gas film resistance.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0414, STRUCTURE OD SEMIPERMEABLE POLYMER FILMS AND ITS EFFECT ON SALT REJECTION

T.G. FOX, Carnegie Mellon University, Mellon Institute, *Pittsburgh, Pennsylvania* 15213 (14-01-0001-1648)

The relationship of the morphological structure and chemical makeup of polymeric films to their effectiveness as membranes in salt rejection filtration is to be studied. The effect of the local morphology of the film on its salt filtration properties is one of the principal variables to be investigated. The nature and amount of crystalline order, orientation of crystalline regions, effects of inorganic and organic additives on crystalline properties of films and the morphology of void and channels will be investigated. It is expected that a variety of methods including light scattering, x-ray diffraction and electron diffraction will have to be employed in these studies. It is anticipated that in some filtration membranes, the degree of order, or departure from completely random mixing of the polymer chains, will be low. The identification and correlation of this type of order to salt rejection efficiency is one of our goals. In addition, the effects of chemical structure of the polymer repeat unit, of molecular weight, molecular confirmation, molecular weight distribution and similar characteristics at the molecular level will be considered.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0415, INVESTIGATION OF CORROSION FUNDAMENTALS AS RELATED TO ALLOYING

H.E. TROUT, Univ. of Pittsburgh, School of Engineering, *Pittsburgh, Pennsylvania* 15213

Potentiostatic study directed toward determination of effects of electronic structure of alloying agents on corrosion behavior of single phase alloys in aqueous solutions and toward further exploration of concept that two-phase alloys, properly selected as to electrochemical behavior of the phases, could be corrosion resistant.

Iron, aluminum- and copper-base alloys will be included with alloying agents common to all being studied as well as alloying agents peculiar to particular solvent metals. The study will extend through the range of solid solubility of any solvent and into the two-phase region.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0416, REVERSE OSMOSIS MEMBRANES CONTAINING GRAPHITIC OXIDE

D. BERG, Westinghouse Electric Corp., *Pittsburgh, Pennsylvania*

This contract continues the study initiated in June 1965 for investigating graphitic oxide as a possible membrane material in desalting water by the reverse osmosis process. Work during the past year demonstrated that thin (0.3 micron) films of graphitic oxide exhibited desalination properties with feed brines containing from 0.2% to 4.0% NaC1 and operated over a pressure range of 300 psi to 1700 psi. Improved membrane-forming techniques were developed and water flux rates up to 18.4 gal/ft2-day (77% salt rejection, 2.0% NaCl, 1700 psi) and salt rejection up to 85% were measured during a 390-hr run.

The continuation of these studies includes: (1) exploration of techniques for producing larger membranes from the present graphitic oxide without introducing more flaws or diminishing the reproducibility; (2) investigation of methods for scaling-up the preparation of bulk quantities of graphitic oxide; (3) further experiments in characterization of graphitic oxide membrane performance as affected by variables in reverse osmosis operating conditions; (4) modification of the present graphitic oxide and evaluation of desalination capability after modification; and (5) investigation of other inorganic membrane materials.

SUPPORTED BY U.S. Dept. of Interior - Cff. Saline Water

3.0417, INVESTIGATION OF DESALINATION BY FREEZING

D.R. HAMILTON, Westinghouse Electric Corp., *Pittsburgh, Pennsylvania*

The studies of the freezing of water to be conducted in this investigation fall in two categories: interface morphology studies and interaction effects in solute partitioning. The interface morphology studies are directed at characterizing quasi-steady-state growth forms; freezing interfaces which are not stable, but which may persist for long periods of time. Two examples are the cellular interface and the 'forest of dendrites' interfaces. The objective of the study in this area will be a theoretical analysis of the morphology and growth mode of the interface, especially in regard to macroscopic solute incorporation.

The studies of impurity interaction effects will be concerned with the partitioning of solute between the solid and liquid on a microscopic or molecular scale. The emphasis will be directed at the solute generated bonding defects in the solid and the resulting contribution of these defects to the system's free energy. Phenomena specific to interfacial regions may also be included if deemed appropriate as the work progresses. The approach to this problem will be both theoretical and experimental.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0418, DEVELOPMENT OF A LOW-COST IRON-BASE ALLOY TO RESIST CORROSION IN HOT SEA-WATER

N. PESSALL, Westinghouse Electric Corp., *Pittsburgh, Pennsylvania*

The proposed 12 month program will involve alloy development, corrosion testing and metallographic studies. The basic objective of the alloying additions will be to promote formation of passive films based on the current knowledge of corrosion-resistant iron-base alloys, on alloy economics and on current theories of the mechanism of passivation. Evaluation of the corrosion characteristics will be made using both electrochemical and loop test measurements, but emphasis will be laid heavily on potentiostatic and potentiokinetic studies. The corrosion tests will be made as functions of temperature, pH, C1- ion activity, degree of aeration, alloy heat treatment and composition. Studies of pitting potentials will be made and correlated with loop- test data. Alloy specimens will be examined after corrosion testing using both light and electron microscopy. The metallographic investigations will be aimed at evaluating the influence of grain boundary characteristics, the nucleation, frequency and depth of pitting, and the influence of crystallographic orientation.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0419, WATER YIELD IN RELATION TO CLIMATIC & WATERSHED CHARACTERISTICS OF LAND

E.T. ENGMAN, Penn. State University, U.S.D.A. Ne. Watersh. Res. Ct., *University Park, Pennsylvania* 16802

Object: To identify the climatic and watershed factors of land resource areas of the Northeast that influence water yield from agricultural watersheds; develop procedures for estimating surface and subsurface contributions to streamflow from parameters of climatic and watershed characteristics; and develop procedures and possible formulas to reliably estimate seasonal and annual water yields.

Plan of Work: The work is currently concentrated on the Sleepers River Experimental Watershed near Danville, Vermont; the Northeast Watershed Research Center, University Park, Pennsylvania, and on other agricultural watersheds in Virginia. Some of the factors required for the analyses and which are measured or otherwise documented for the study are: rates and duration of streamflow; precipitation patterns; antecedent moisture; season; soils; land use; conservation and watershed management practices; ground water elevations; riparian vegetation; geology; gradients and hydraulic roughness of stream channels; and the size, shape and other geomorphic attributes of the watersheds.

SUPPORTED BY U.S. Dept. of Agriculture

3.0420, WATERSHED CORRELATION AND SYNTHESIS

H.W. LULL, U.S. Dept. of Agriculture, *Upper Darby, Pennsylvania*

Object: To assemble, correlate, and synthesize forest watershed information for the prediction of the effects of forest watershed management practices on streamflow by major physiographic regions of the eastern United States; and through research on municipal watersheds and correlative information determine the practices that will meet municipal water-yield and water-quality management needs.

Plan of Work: Using longtime streamflow records from northeastern watersheds, this program will determine the hydrologic function of forest cover on yield and distribution of streamflow, the effects of historical changes in land use, and the effects of historical changes in land use, and the effects of present-day land use. It will also evaluate the present system of determining hydrologic conditions of forest land for river basin planning and flood prevention programs. In municipal watershed research, the staff will determine the effects of forest land treatment on increasing water yields through the use of numerous cooperative watershed studies.

SUPPORTED BY U.S. Dept. of Agriculture

3.0421, DESIGN AND ECONOMIC STUDY OF A GAS TURBINE POWERED VAPOR COMPRESSION PLANT FOR EVAPORATION OF SEAWATER

H. WIGHTMAN, Struthers Energy Systems Inc. , *Warren, Pennsylvania*

The study of two sizes of gas turbine drivers was conducted and a 12,500 SHP, dual shaft, gas turbine driver was chosen as the main power train. The plant is designed to produce 8.0 MGD. The cycle uses a VTE and a MSF unit in series. The gas turbine driven axial flow vapor compressor operates across 4 effects of the VTE. Gas turbine exhaust heat is recovered in a heat recovery boiler. Only on-site power is generated in the back pressure turbine rated from 1500 KW. The water cost developed for the plant is $0.39/1000 gal. The total capital cost of the plant is approximately $7,500,000. Drawings showing VTE tube sheet configurations and general outlines are provided. A heat and material balance is provided. Vendors' bids received from plant equipment are provided.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0422, SEASONAL VARIABLITY OF SOIL MOISTURE AND LEVELS OF GROUNDWATER TABLE ON LOWLAND AREAS

S. OSTROWSKI, Forest Research Institute, *Warsaw, Poland*

Plan of work: The field work will be done in three regions of Poland where stands of pine are established on sandy soils. Important environmental factors to be measured include precipitation; interception; soil and air temperatures; ground water levels; and soil moisture by gravimetric and lysimetric methods. Water balance computations will be made under several site and meteorological conditions. Laboratory research carried out in the greenhouse under controlled conditions of temperature, humidity, and precipitation will be used to strengthen and interpret the results from field research.

SUPPORTED BY U.S. Dept. of Agriculture

3.0423, REACTIONS BETWEEN MINERAL AND ORGANIC COMPONENTS IN SOIL.

B. SWIETOCHOWSKI, Coll. of Agriculture, *Wroclaw, Poland*

Object: To determine (1) the nature of the reactions between mineral and organic soil fractions, (2) the influence of these reactions on macro and micro soil structure, and (3) the indirect effect of soil structure on soil moisture and soil strength.

Plan of Work: A study will be made of the reactions between mineral and organic fractions of soil and the influence of these reactions on the macro and micro structure of the soil, emphasis being placed on reactions resulting from long time soil management practices that are presumed to be in equilibrium with the environmental and management conditions. This information is required to develop cultural practices and cropping systems conducive to sustained agricultural use of soil and water resources and as a guide to soil and water conservation practice development in different soil and climatatic conditions where soil structure problems exist. Thin sections of soil structure developed from long time tillage and rotation experiments will be prepared and optical procedures will be used in characterizing the nature of reactions and influence of these reactions on micro structure. The indirect effects of such structural arrangement will be evaluated in terms of structural stability and the interactions of structure and soil moisture in terms of moisture retention and soil strength.

SUPPORTED BY U.S. Dept. of Agriculture

3.0424, WATER REQUIREMENTS BY SUGARCANE UNDER IRRIGATION

R. VAZQUEZ, Univ. of Puerto Rico, Agricultural Experiment Sta. , *Lajas, Puerto Rico*

Two experiments will be conducted to study the water requirements of sugarcane under irrigation.

In one of these experiments the effect of 20 different soil moisture treatments on the consumptive use of water, yields and sucrose content of sugarcane will be studied. The interaction between fertilizer and water application also will be studied. Two levels of irrigation controlled with tensiometers and gypsum resistance blocks will be established. These irrigation treatments will be discontinued at 6, 5, 4, 3, 2, and 1 month prior to harvest, being irrigated with less frequency thereafter.

Another experiment will be conducted to correlate different levels of plant-tissue water content with cane yields and sucrose content in order to find a plant moisture index to control irrigations.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Puerto Rico

3.0425, LAND FORMING FOR IRRIGATION AND DRAINAGE IN SUGARCANE PRODUCTION UNDER PUERTO RICAN CONDITIONS

W.F. ALLISON, Univ. of Puerto Rico, Agricultural Experiment Sta. , *San Juan - Rio Piedras, Puerto Rico* 00931

To determine the practicability and feasibility of land-forming irrigated sugarcane soils in Puerto Rico. To determine the maximum depth of cuts allowable in the various irrigated soils that will not materially affect production. To determine the optimum gradients of furrows or borders. To determine the optimum length of runs for border and furrow irrigation systems. To compare planting of sugar-cane in furrows versus planting on the bed.

DESCRIPTION OF WORK: Data on plots leveled to a uniform plane surface will be assembled to determine the effects of the land forming operation on crop yields, the rate of recovery of the soil to normal production levels, and the land treatment needed to restore productivity following land forming. Also, these plots will be further used to determine the design criteria for gravity irrigation systems in Puerto Rico. Statistically designed field experiments will be performed in an attempt to verify the above-mentioned objectives. The results of these experiments will be interpreted and the conclusions therefrom will be published as journal articles or in bulletin form.

SUPPORTED BY Puerto Rico Government

3.0426, RECLAMATION OF SALTY LANDS IN PUERTO RICO

E.J. BRENES, Univ. of Puerto Rico, Agricultural Experiment Sta. , *San Juan - Rio Piedras, Puerto Rico* 00931

1. To determine the sodium content in the salty lands of Puerto Rico. 2. To determine the salt tolerance of crops that may be grown in the salty lands of Puerto Rico. 3. To determine practical means for the reclamation of the salty lands of Puerto Rico.

Description of work: Efforts will be focused toward the development of a rapid, practical, and economical method for the reclamation of the saline-sodic-soils of Lajas valley. Amendments such as sulfur, calcium chloride, bagasse, rum distillery slops, and molasses, providing water for irrigation and good drainage, will be used until the soil profile of the saline-sodic soil is converted to a normal soil.

A third experiment with Bermuda grass as a crop and different levels of sulfur, under irrigation and drainage, will also be used for reclamation.

Finally, sea water, salty or brackish water, will be used as a possible method to leach the sodium from the sodic soil as recommended by Reeve and Bower (Soil Sc. 90(Z): 130-144, Aug. 1960).

SUPPORTED BY U.S. Dept. of Agriculture
Puerto Rico Government

3.0427, FARM MANAGEMENT STUDY OF THE SUGARCANE FARMS SERVED BY THE LAJAS VALLEY IRRIGATION DISTRICT

A.A. LLORENS, Univ. of Puerto Rico, Agricultural Experiment Sta. , *San Juan - Rio Piedras, Puerto Rico* 00931

OBJECTIVES: (1) Obtain input-output data for sugarcane farms served by the Lajas Valley Irrigation District. (2) Determine the ability to pay water charges of these farms.

DESCRIPTION OF WORK: Sugarcane farmers served by the Lajas Valley Irrigation District will be interviewed to obtain quantitative input- output data for the 1966-67 and 1967-68 crop years. Information thus gathered will be analyzed considering factors such as the economic position of the farm, the value of the output attributable to water use, soil classification, farm size, number of acre-feet of water used, the presence of salinity problems, and if water was gravity fed or applied through pumping.

SUPPORTED BY Puerto Rico Government

3.0428, THE LOSS OF FERTILIZERS BY LEACHING FROM THE SOILS OF PUERTO RICO

G. SAMUELS, Univ. of Puerto Rico, Agricultural Experiment Sta. , *San Juan - Rio Piedras, Puerto Rico* 00931

To measure and collect leachings from various soils while used to produce economic crops. 2) To determine the chemical composition of the leachings so as to measure the plant nutrients lost by leaching. 3) To determine how the method and time of application and form of fertilizer influences the loss of fertilizer nutrients by leaching.

DESCRIPTION OF WORK: By means of special lysimeters constructed in the field the loss of fertilizers in the soils by leaching will be studied throughout the life of the crop in order to determine how the method and time and form of fertilizer application influence these losses.

SUPPORTED BY Puerto Rico Government

3.0429, SMALL DESALINATION UNIT TO TEST SCALE REDUCTION ADDITIVES

N. MADSEN, Univ. of Rhode Island, School of Engineering, *Kingston, Rhode Island* 02881

In order to determine economic factors involved in evaluation of scale reduction additives in evaporative desalination processes, it is proposed that a bench-size evaporator be constructed with the heating surface of stainless steel and jacket of pyrex glass for observation.

Additives to be tested include those found in a current study which produce a normal rather than an inverted solubility behavior for calcium sulfate and also others which seem to produce different crystalline forms with less tendency to scale formation.

Following construction of the unit, experimental work will involve continuous operation with varying concentrations of different additives to determine rates of heat and mass transfer, rate of scale build-up and comparative costs.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Rhode Island

3.0430, GROUNDWATER RECHARGE

C.M. PATTERSON, U.S. Atomic Energy Commission, Savannah River Plant & Labs. , *Aiken, South Carolina*

Water table fluctuations are the result of variations in climatic factors. A study is in progress to determine the reliability of calculating ground-water elevation fluctuations using available climatic data. For 4 years, monthly water level measurements have been made in 47 wells distributed over 10 square miles at SRP. The Southeast River Forecast Center, U. S. Weather Bureau in Augusta, Ga., collects climatic data for river forecasting. These data were used to calculate the volume of groundwater recharge, which in turn was used to calculate the change in the water table evaluation. The calculated values will be compared with measured values.

SUPPORTED BY U.S. Atomic Energy Commission

3.0431, HYDROLOGY AND MANAGEMENT OF WETLAND FORESTS

R.A. KLAWITTER, U.S. Dept. of Agriculture, *Charleston, South Carolina*

Object: To develop effective water control and soil management techniques through increased knowledge of the hydrology, soil properties, and soil-water-plant relations of wetland forests.

Plan of Work: The program will concentrate its effort on wet flatlands amd pond pine bay-pocosins. These wetland types have the greatest potential for forest growth improvement by water control. The project staff will conduct studies in three fields of work: (1) wetland forest hydrology, in which the water balance will be measured to determine amount and timing of surplus water; (2) soil-water-plant relations, the effect of soil and water availability on evapotranspiration; and (3) engineering and soil management including the development of water control techniques, land leveling, prescribed burning and fertilizing to improve forest growth.

SUPPORTED BY U.S. Dept. of Agriculture

3.0432, SOLID COORDINATION COMPOUNDS OF ALKALI METAL SALTS

N.P. MARULLO, Clemson University, Graduate School, *Clemson, South Carolina* 29631

An investigation will be conducted on the solid compounds formed by precipitation from aqueous solution of p,p'-diamino-2,3 diphenylbutane and alkali metal salts. Experiments will be directed to establish the structure of these compounds and to evaluate the significance of the size and charge of the ionic species and the requisite structural and electronic features of the organic material. A variety of other parameters which may influence the extent and specificity of this phenomenon and the extent to which these compounds exist in solution will be investigated.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0433, EVALUATION AND FUNCTIONAL OPERATION OF IRRIGATION SYSTEMS

D.D. BROSZ, South Dakota State University, Water Resources Institute, *Brookings, South Dakota* 57007

The objective of the study is to obtain information for the development of procedures to improve present irrigation practice, future irrigation management, and system selection.

The project will be initiated with a water application efficiency study which will be carried out on several sites throughout Eastern South Dakota. The main goal of this is to be able to supply the irrigator with information so that he may properly time a water application and apply the proper amount of water to insure a high irrigation efficiency.

A study will also be made of the distribution patterns of various automated and semi-automated systems and whether a relationship exists between application rate and crop yield. Along with the above studies an evaluation of the various irrigation systems will be made as to the labor required.

The project will then concentrate on how all this information could be coordinated and funneled to the individual irrigator.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
South Dakota State University

3.0434, EFFECTS OF MARGINAL QUALITY IRRIGATION WATER ON THE ACCUMULATION OF SALTS AND ALKALI IN SOUTH DAKOTA SOILS

W.D. LEMBKE, South Dakota State University, Water Resources Institute, *Brookings, South Dakota* 57007

The purpose of this research is to determine the effects of marginal quality irrigation water on the salt and alkali accumulation in soils peculiar to the sub-humid climate existing in South Dakota.

The approach used will be to determine initial exchangeable sodium percentage, pH, and conductivity of soils being developed for irrigation. The sodium adsorption ratio, residual sodium carbonate, pH, conductivity, and total soluble salts of the irrigation water will also be determined. The above determinations will be repeated periodically for the duration of the project and records of irrigation water applied, rainfall, and cropping practices will also be maintained.

The resulting data will be analyzed and used to test the equations and their modifications as developed by Gapon and others and their application for estimation of exchangeable sodium percentage of equilibrium on soils being considered for irrigation development in South Dakota.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
South Dakota State University

3.0435, BREEDING AND CULTURAL PRACTICES TO AID PRODUCTION OF VEGETABLES IN SOUTH DAKOTA

P. PRASHAR, South Dakota State University, School of Agriculture, *Brookings, South Dakota* 57007

a - The application of mist to cauliflower plants improved the quality and quantity of cauliflower heads. The mean temperature in the mist plots was reduced about 5.0 degrees F. The range of temperature reduction varied from 1 to 14 degrees F. A positive correlation of .76 was obtained between outside temperature and temperature under mist plots.

The mist lines)water lines) were 21 feet apart, and 6 1/2 feet high, and mist nozzles were 7 feet apart on each line. The pipe size was 1 1/2 inches for the main supply and 3/4 inches for laterals with the nozzles. On a hot day the mist system sometimes ran several hours at a time. The nozzles were adjusted so that each nozzle put out one- eight of an inch of water per hour with water pressure at 40 pounds. The main water line was connected to a constant water supply. An electric solenoid valve was controlled by a thermostat set for a given air temperature. The mist came on automatically at that temperature and shut off as temperature fell below it. Under mist irrigation less water was required to produce better crops than when the crops were grown under sprinkler irrigation. The study is being continued in 1968.

b - An experiment at Redfield is being carried on to understand better relationships of various types of fertilizers and rate of water to produce high yields of potatoes under field conditions.

SUPPORTED BY South Dakota State Government

3.0436, IMPROVEMENT OF WATER YIELDS AND SOIL STABILIZATION IN THE BLACK HILLS

H.K. ORR, South Dakota School of Mines, U.S.D.A Rocky Mt. For. & Rge. , *Rapid City, South Dakota* 57701

Plan of work: The project staff will continue to determine the effect of thinning ponderosa pine on soil moisture levels and the effect of various timber harvesting systems on streamflow and erosion from experimental watersheds. They are evaluating rehabilitation measures applied to burned watersheds, and methods for rehabilitating soil and vegetation on heavily used ranges. They will initiate studies on stand density of young ponderosa pine stands as related to soil moisture use.

SUPPORTED BY U.S. Dept. of Agriculture

3.0437, CONTINUOUS COUNTERCURRENT EXCHANGE SYSTEM FOR REMOVAL OF CALCIUM, MAGNESIUM AND DISSOLVED OXYGEN FROM FEED WATER

I.R. HIGGINS, Chemical Separations Corp. , *Oak Ridge, Tennessee* 37830

Previous work has been done using continuous countercurrent ion exchange to soften boiler feed water where the unique feature is the use of the boiler blowdown for regeneration. This is possible with brackish or saline water where there is enough salt content relative to the hardness to be removed that no new salt needs to be purchased. A Chem-Seps type continuous ion exchange unit capable of handling about 50 gpm sea water is to be tied in conjunction with a Baldwin-Lima Hamilton longtube evaporator. Sea water will be softened and fed to the evaporator blowdown and because of the removal of calcium scaling will be prevented in the evaporator. Evaporator blowdown will be fed back to the ion exchange unit and because of the higher salt concentration the ion exchange equilibria is shifted in a direction that will give more efficient removal of calcium which has been absorbed. The more calcium that is removed, the higher degree of concentration of the evaporator blowdown, the higher the degree of blowdown concentration, the greater the removal of calcium. The experimental reference points that have already been established are 65 percent removal of calcium from sea water with a concentration factor of 3 in the blowdown. With a concentration factor of 5, there is greater than 90 percent removal of calcium.

A second phase of the study is to continuously remove dissolved oxygen. Reference for this work is an article in the Journal of Applied Chemistry, Vol. 7, November 1957 by E. C. Potter and G. Whitehead with a title, 'Continuous Removal of Dissolved Oxygen by Established Ion Exchanges.' This oxygen removal will be done in another continuous ion exchange unit associated with the softening unit. Ferrous sulfate is absorbed on an ion exchange resin and the ion precipitated with sodium hydroxide to form ferrous hydroxide within the resin bead. This ferrous hydroxide form resin is mixed with the softening resin so that calcium and oxygen are removed at the same time. The spent resin which has been converted to ferric is regenerated by adding acid to slightly solubilize ferric hydroxide and to strip it of the concentrated brine used to remove hardness. In laboratory studies this method of oxygen removal has been determined to be very effective.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0438, WATER RESEARCH PROGRAM III CORROSION

E.G. BOHLMANN, U.S. Atomic Energy Commission, Oak Ridge National Lab. , *Oak Ridge, Tennessee*

The process of initiation of pitting corrosion of certain metals, particularly titanium, is being examined, with particular emphasis on the effects of electrode potential, chloride ion concentration, temperature, and alloy composition, in an effort to increase our understanding of factors responsible for the values and the temperature dependence of the pitting potentials of titanium and its alloys. The studies are being carried out with a small titanium loop equipped for carrying out electrochemical measurements to 225 degrees C. A similar Hastelloy C loop is being constructed for studies with solutions too aggressive for the titanium loop.

Studies on the crevice corrosion of titanium in saline waters at elevated temperatures are directed at developing an understanding of the mechanism of the attack and means of inhibiting or preventing it with alloy additions. The work thus far indicates an active-passive cell mechanism based on the formation of a concentrated, acidic (pH less than 1) chloride solution in the crevice. On this basis the alloy studies are being carried out in pH equal to or less than sodium chloride solutions at 100 degrees C.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0439, DISTILLATION PLANT AND COMPONENT STUDIES

R.P. HAMMOND, U.S. Atomic Energy Commission, Oak Ridge National Lab., *Oak Ridge, Tennessee*

JOHNSSON The Oak Ridge National Laboratory (ORNL) serves OSW as a technical laboratory for desalination studies, development, and engineering under an agreement between the OSW and the Atomic Energy Commission. ORNL provides experimental facilities, trained staff members and technical services which can be called upon as needed to support the OSW program for large evaporator plants. Development of vertical-tube evaporator plants is a major responsibility assigned to ORNL by the OSW, but supporting studies and development activities are performed for other types of evaporator plants also. In performing this work, ORNL relies on industry to develop and supply the needed commercial products and information.

The scope of active work orders includes the following: 010 Distillation information storage and retrieval, 070 Development of improved tube fabrication methods, 090 Condenser model tests and computerized design methods, 0110 Evaporator design, feasibility and cost studies, 0130 Development of the CO2-suppression method of controlling alkaline scale, 0140 Development of high-flux heat transfer systems, 0160 Deaerator development, 0170 Operation of the Vertical Tube Evaporator Pilot Plant at Wrightsville Beach, N.C., 0210 Development of computer programs for economic studies, 0220 Materials information center, 0230 Development of adjustable orifices for MSF process, 0240 Hydrodynamic aspects of reverse osmosis, 0260 Study of deep-well injection of waste brine, 0280 Design study of large vapor compression plants, 0300 System analysis of distillation processes, 0320 Preparation of an instrument guide manual, 0350 Study of very large desalting plant complexes.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0440, REACTIONS AND TRANSPORT PHENOMENA AT SURFACES

F.A. POSEY, U.S. Atomic Energy Commission, Oak Ridge National Lab., *Oak Ridge, Tennessee* (14-01-0001-931)

The process of initiation of pitting corrosion of certain metals, particularly titanium, is being examined with particular emphasis on the effects of electrode potential, chloride ion concentration, temperature, and alloy composition in an effort to increase our understanding of factors responsible for the values and the temperature dependence of the pitting potentials of titanium and its alloys.

Continuing studies on crevice corrosion are concerned with the kinetics of oxygen consumption and increase of acidity in crevices during the initiation period as a consequence of the rate of the corrosion reaction and of crevice geometry.

Novel electrode systems for carrying out reactions in flowing streams are being studied. Reactions of interest include redox processes, production of acid or base or chlorine, adsorption of ionic and molecular species from flowing solutions under controlled conditions for possible use in analysis and separations. Electrode systems of particular interest include new configurational variants which make use of porous electrodes in single compartment cells, thus eliminating the need for diaphragms in operation at high current densities. Other studies are concerned with the rectification properties of metallic electrodes at high current densities and with the development of special electrode assemblies for rapid and/or continuous analysis of components of sea water.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0441, WATER RESEARCH PROGRAM - SECTION IV. SEPARATIONS PROCESS

F.A. POSEY, U.S. Atomic Energy Commission, Oak Ridge National Lab., *Oak Ridge, Tennessee*

The separations process subprogram at present heavily emphasizes hyperfiltration (reverse osmosis), and in this area is particularly concerned with properties of membranes formed dynamically on porous bodies (pore sizes in the 0.15 micron range) by presence of certain additives in feeds. Films combining substantial salt filtration with high permeation rates are sometimes formed in this way. In addition, we are investigating boundary layer phenomena, particularly in order to understand the effects of buildup of solute at the membrane-feed interface during hyperfiltration and to develop turbulence promoters to ameliorate these effects.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0442, PROBABILITIES OF SEQUENCES OF DRY DAYS IN TEXAS

J.T. CARR, State Water Development Board, *Austin, Texas* 78711

Objective: To provide tables showing the probabilities of sequences of dry days of various lengths based on 1931 through 1960 precipitation records for Texas. These probabilities will be valuable in water supply planning, particularly as related to irrigation.

Approach: Precipitation records for Texas will be analyzed by computer to determine the empirical probabilities of sequences of dry days of varous lengths. Separate probabilities will be determined for arbitrary definitions of a wet day as one in which precipitation is 0.01, 0.1, 0.20, 0.30, 0.40, 0.50, 0.70, 1.00, 1.50, and 2.00 inches. Actual computer work is being performed at Texas A&M University, College Station, Texas, using a program furnished by the U. S. Weather Bureau.

SUPPORTED BY Texas State Government

3.0443, PRELIMINARY FEASIBILITY AND ECONOMICS OF DESALTING BRACKISH WATERS IN CANDIATE AREAS OF WEST TEXAS

H.D. HOLLOWAY, State Water Development Board, *Austin, Texas* 78711

Objective: To obtain information on the type and characteristics of desalting plants most suitable to the treatment of saline waters in West Texas and to compare the preliminary economics of desalting these saline waters with the alternative sources of water supply.

Approach: County groupings into six study areas based on similarity of present and potential water supply problems. Future water requirements and sources of supply evaluated. Saline water sources determined. Preliminary costs of desalted water determined for applicable desalting processes which included electrodialysis, reverse- osmosis, vacuum freeze-vapor compression, multistage flash distillation and vapor compressions-vertical tube evaporator distillation. Costs of desalted water include feedwater supply, feedwater pretreatment, desalting, brine disposal and desalted water conveyance. Desalted water cost for each study area compared with cost of water from all alternative conventional water sources available to each study area.

SUPPORTED BY Texas State Government
U.S. Dept. of Interior - Off. Saline Water

3.0444, IRRIGATION WATER MANAGEMENT FOR EFFICIENT WATER USE IN THE SOUTHERN PLAINS

J.T. MUSICK, U.S. Dept. of Agriculture, *Bushland, Texas*

Object: To develop methods and practices for efficient use of water supplies for irrigated lands involving: optimum use of limited irrigation water; soil moisture availability in relation to plant development; improved prediction of when and how much to irrigate; soil surface and profile modification for improved intake, transmission, and storage of water in the soil; and systems of design, including application method, equipment, flow hydraulics and management.

Plan of Work: Field plot and supporting laboratory studies, will be conducted in irrigated areas of the Southern High Plains and the Lower Rio Grande Valley. These studies will involve irrigation water management in relation to plant factors such as crops, cropping sequence, planting methods and dates, nutrient requirements, plant density, and plant development; soil properties that affect intake, transmission, storage, and distribution of irrigation water; systems design and management factors such as graded and level systems, alternate and every furrow irrigation, row grade, length of run, stream size, duration of application, timing of irrigations, automatic water control devices, reuse of runoff, application method, and distribution efficiency; factors relating to climate such as actual and potential evapotranspiration, soil water evaporation during noncropped periods, irrigation water requirements and need for and developing and testing of indicators for predicting when to irrigate, such as plant characteristics, soil factors, and use of climatic instrumentation and data.

Cooperation: Texas Agricultural Experiment Station; SCS; U. S. Bureau of Reclamation; soil conservation and irrigation districts; private agencies.

SUPPORTED BY U.S. Dept. of Agriculture

3.0445, GRADED FURROWS FOR RUNOFF AND EROSION CONTROL

R.W. BAIRD, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

Numerous methods have been used to lessen the erosion in cultivated fields by runoff water. Most of the methods entail considerable installation cost and reduce the efficiency of farm equipment. Another method that has been used experimentally is maintaining ridges and furrows laid out on specified grade so that no furrow will receive runoff water except that falling in one row width. These furrows and ridges are maintained through the year by ordinary farm operations.

Graded furrows have been established with lengths of 340, 520, and 930 feet, and runoff and erosion measuring equipment installed. Information obtained will determine if this system is satisfactory for erosion and runoff control. It will also furnish the information needed for design and layout of this system.

Results from the first two years indicate good runoff and erosion control and crop yields have been equal to those with more conventional treatment. Only minor modifications have been required to adapt ordinary farm equipment to this practice. If some of the cultural problems involved can be effectively solved, this system should reduce the costs of farm operations on many fields where control of runoff water and erosion is a serious problem.

SUPPORTED BY Texas State Government

3.0446, CROP RESPONSE TO STATIC AND FLUCTUATING WATER TABLES

E.A. HILER, Texas A & M University System, School of Agriculture, *College Station, Texas* 77843

The objectives of this research are as follows: (1) To quantitatively determine the effect of static water-table level on crop response; (2) To quantitatively ascertain the effect of water-table fluctuations on crop response; (3) To quantitatively evaluate how soil salinity level affects optimum values determined in (1) and (2); and, (4) To evaluate other factors such as soil aeration status, soil temperature and moisture content, for use as drainage design criteria.

Field lysimeters will be utilized to determine quantitative results regarding drainage and irrigation requirements of grain sorghum and sugar beets. Undisturbed cores of characteristic sandy loan and loam soils of Texas will be utilized in the lysimeters. The lysimeters will be three feet in diameter and seven feet deep.

Crop response to static water tables of two, four, and six feet and a well-drained condition will be evaluated. Objective 4 will be considered during these tests. Fluctuating water-table experiments will be directed toward determining how fast the water table must be lowered from the surface to prevent reduction in potential crop production. Salinity studies will be initiated only after achievement of satisfactory results regarding objectives 1 and 2.

A portion of the first year will be spent installing the lysimeter, the shelter, the weather station and auxiliary equipment. It is intended that the installation will be complete by the spring of 1968, so that the experiments with grain sorghum may be initiated at that time.

SUPPORTED BY Texas State Government

3.0447, FEASIBILITY OF THE ESTABLISHMENT OF PERMANENT SALINE-TYPE AGRICULTURE ON ALLUVIAL SOILS OF THE PECOS RIVER VALLEY OF TEXAS

D.E. LONGENECKER, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

Objective: 1. To determine the more immediate equilibrium effects of continued application of highly saline irrigation to Pecos River Valley soils on the following: a. The composition and concentration of soluble salts at various depths in the soil profile. b. The composition and ratio of adsorbed ions (sodium, calcium, magnesium and potassium) on soil exchange complex. 2. To determine the longer range or cumulative effects of application of these waters on soluble salts and exchangeable ions in these soils. 3. To determine the effect of supplementary additions of better quality water (possibly soil amendments) on the above soil chemical equilibriums. 4. To correlate the effects of irrigation water management and control practices on rate and degree of soil salinization. 5. to determine the germination, growth, production and longevity of certain salt tolerant grasses, legumes, field crops grown on these soils and irrigated with saline pump waters. 6. To continue to evaluate and select highly salt tolerant grass, legume and field crop varieties and strains as to their suitability for hay, pasture or crop production on these saline soils.

SUPPORTED BY Texas State Government

3.0448, VARIABLE ROW SPACING AS A MEANS FOR REDUCING COSTS AND CONSERVING WATER IN IRRIGATED COTTON PRODUCTION

D.E. LONGENECKER, Texas A & M University System, Graduate School, *College Station, Texas* 77843

Objectives: 1. To evaluate a new system of variable-row cotton spacing, and to compare yields and cost reductions with normal planting systems. 2. To study physiological implications of the new system, including varietal response, plant growth, boll characteristics and fiber properties, as compared with current systems. 3. To investigate agronomic and engineering aspects of the system, including plant spacing, fertility, water requirements, need for cultivation and weed control, and changes in design of mechanical harvesting equipment. 4. To determine the effect of the new system on the incidence of cotton diseases, primarily Verticillium wilt and bacterial blight.

Variable row spacing is herein defined as an alternate 26-54 inch row spacing, with narrow furrows between the 26 inch rows for less total water application, reduced evaporation rates, better water utilization efficiency by the crop, and better weed control. The 54 inch spacing constitute wide double row beds. Comparisons would be made with standard 38-40 inch evenly spaced rows, the current planting method.

SUPPORTED BY Texas State Government

3.0449, THE EFFECT OF BENCH LEVELING AND CONTRIBUTING WATERSHED AREAS ON SOIL MOISTURE STORAGE AND CROP YIELDS IN THE ROLLING PLAINS

P.T. MARION, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

Project Objectives and Description of Work Proposed: A. To evaluate the practice of dryland bench leveling on Abilene and Tillman clay loam soil as related to: (1) water storage and use by cotton and other selected field crops, (2) yield and quality of cotton and other crops. B. To determine the feasibility of using contributing watersheds to bench leveled land as an additional source of water. C. To determine the correct spacing of leveled land as an additional source of water. C. To determine the correct spacing of level borders for maximum conservation of water consistent with cost and yield. D. To determine the economic feasibility of a dryland level-border system by maintaining cost records and relating such cost to yield increases.

Previous work at Spur and other locations has shown a potential benefit from bench leveling in water retention, runoff distribution, and crop yield. Measurements and determinations will be made on moisture, yield, and soil physics. Costs will be determined for each treatment.

SUPPORTED BY Texas State Government

3.0450, INTERROW WATERSHEDS AS A MEANS OF INCREASING RAINFALL EFFICIENCY

J.R. MULKEY, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

Objectives: a) To compare moisture utilization of cotton planted in skip row systems with solid planted cotton. b) To investigate the feasibility of establishing interrow watersheds in skip-row planted cotton as a means of diverting additional water into the root zone of growing plants. c) To evaluate the use of chemical and physical barriers which retard or restrict water infiltration as a means of establishing efficient interrow watersheds. d) To evaluate the potential of using interrow watersheds in wide row spaced vegetable crops as a means of producing vegetables on nonirrigated soils in the Rolling Plains of Texas.

Work Proposed: Interrow watersheds are herein defined as the unplanted areas in skip-row planted crops or the unplanted area between rows in crops planted in wide row spacing. The full potential of diverting rainfall from these areas onto growing crops will be evaluated. A screening process will be used to select chemical and physical barriers to be used in such a system from both the standpoint of efficiency and cost.

SUPPORTED BY Texas State Government

3.0451, CONSERVATION AND UTILIZATION OF RAINFALL AND IRRIGATION WATER

J.S. NEWMAN, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

Objectives: (1) To determine the influence of slope under different moisture levels on the following: runoff, subsurface moisture content and distributien, irrigation efficiency, and crop production. (2) To determine the influence of conservation practices including level, side-slope, and graded benches, field leveling, and parallel terrace on runoff, subsurface moisture content and distribution, crop yields and irrigation efficiency. (3) To determine cultural practices necessary to restore high yields capabilities in cut and fill areas resulting from land forming.

This project deals with the influence that slope, land forming and irrigation practices have on more efficient utilization of rainfall and irrigation water, soil productivity and crop yields.

SUPPORTED BY Texas State Government

3.0452, THE ECONOMICS OF IRRIGATED CROP PRODUCTION BY LOW CAPACITY WELLS AND BY SPRINKLER SYSTEMS ON TEXAS FARMS

J.S. WEHRLEY, Texas A & M University System, School of Agriculture, *College Station, Texas* 77843

Three alternative water management programs for a typical resource situation in an area of the Texas High Plains where water supplies are becoming critical were analyzed. A program which maintained constant acreage by increasing irrigation facilities to compensate for declining water levels was found to be uneconomical. Even though this program most nearly reflects the historical changes that have occurred in the water management programs and the average annual rate of static water level decline in the area, it would result in excessive unrecovered investment at the end of its economic life.

A water management program of maintaining only existing wells and equipment would utilize the existing water resources over the longest time period but also leave unrecovered investment when the economic life of the irrigation water is exhausted according to the depreciation assumptions used. A program under which new irrigation facilities would be purchased only when the investment could be recovered in a four year period would result in the last unrecovered investment, the highest return to labor and water and the greatest net returns.

The complete results of this analysis are being detailed in a Master's thesis. This analysis presented the two logical extremes of irrigation water utilization in Subarea 3-3 and guidelines for a program which would obtain the optimum econommic returns over the life of the water resources. The results will be extremely valuable to producers in the area who must decide on their future irrigation program under declining water levels.

SUPPORTED BY Texas State Government

3.0453, ASSEMBLY AND EVALUATION OF AN IMPROVED PPB OXYGEN ANALYZER FOR SEA WATER

H.C. BEHRENS, Dow Chemical Company, *Freeport, Texas* (14-01-0001-1832)

This program will consist of the development and proving of an on-stream oxygen analyzer with an automatic calibrator to form a system with a capability for accurate dissolved oxygen measurement in the range of 0 to 10 parts per billion for sea water application.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0454, SEAWATER CORROSION CONTROL BY ENVIRONMENT MODIFICATION

R.A. LEGAULT, Dow Chemical Company, *Freeport, Texas*

This program will consist of a laboratory study to explore the possibility that environmental changes can be employed to permit the economic use of steel or aluminum as materials of construction for heat exchanger surfaces in desalination plants. The environmental variables to be examined in this study are as follows: pH, concentration of dissolved oxygen, heavy metal ion concentration, and the addition of a variety of corrosion inhibiting materials. The environmental changes which appear most promising in static corrosion tests will then be studied under dynamic conditions.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0455, SEA WATER CORROSION TEST PROGRAM

L. RICE, Dow Chemical Company, *Freeport, Texas* (14-01-0001-2150)

The program will consist of a 19-month study having the basic purpose of developing a better understanding of the interaction of metals with sea water environments, particularly under the conditions of temperature, pH, dissolved gases, concentration, and chemical treatment encountered in distillation-type desalination plants. This contract is a continuation of Contract No. 14-01-0001-1090.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0456, A STUDY OF HEAT TRANSFER IN THE FLUTED VERTICAL TUBE EVAPORATOR

L.C. ELLIOTT, Houston Research Institute, *Houston, Texas*

The General Electric double fluted tube has shown promise for use in distillation type desalting plants. Measurements of average individual heat transfer coefficients, pressure drop and entrainment are being made on a 3 in. nominal diameter by 10 ft. long fluted tube. Pressure levels for the evaporation side range from 26 in. Hg vacuum to 1 atm. The results have shown that the condensing heat transfer coefficient is about five times higher than the evaporation heat transfer coefficient. Additional studies will further define the effects of: a. sea water versus fresh water; b. baffling to give induced interfacial shear on the evaporated side; c. presence of air in the condensing steam; d. reduction in diameter of the tube.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0457, INSTALLATION OF INSTRUMENTATION FOR CLAIR ENGLE PLANT

R.J. SILBERMAN, Houston Research Institute, *Houston, Texas*

Highly accurate instrumentation with data acquisition and computer hardware is being installed in a flash evaporator desalination plant. The purpose of the system is to provide equipment for fast data retrieval and for calculation of the performance characteristics of horizontal tubular exchangers in the plant. Specially designed RTD temperature probes are installed inside and outside of the exchanger tubes. Flowmeters monitor production of exchanger sections being investigated. Absolute and pressure differential instruments further define operating conditions. Other installed equipment enables the investigator to get supplementary information such as flow profiles across exchanger tubes and process and product troughs; pressure profiles in vapor channels; gas analyses at particular vessel vapor points; and data on plant process operating conditions. Approximately 450 points of data are scanned through a multiplexer at a rate of 10 per second, or sampled individually. The data may be displayed digitally or printed out on a teletype. It is anticipated that the system be utilized for other program controlled investigations of plant operation.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0458, FUNDAMENTAL STUDIES IN METASTABLE FLASHING FLOW

A.E. DUKLER, Univ. of Houston, School of Engineering, *Houston, Texas* 77004

This is an investigation to determine the variables governing flash vaporization under flowing conditions. Studies will be made to characterize flow and phase distribution in flashing devices, and the effects of the geometry of the flashing device on flow and mass transfer will be evaluated. The results are expected to contribute to the understanding of metastable flashing flow and to the design of more efficient devices for flash evaporation.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0459, THEORETICAL AND EXPERIMENTAL STUDIES OF TURBULENCE AND MIXING NEAR ROUGH SURFACES

F.L. WORLEY, Univ. of Houston, School of Engineering, *Houston, Texas* 77004

The objective of this investigation is to obtain experimental data regarding the turbulence and mixing characteristics in flow adjacent to a rough surface. These data will be obtained by using a new type laser anemometer which will permit the study of the turbulence properties closer to the rough surface than has ever been possible before. In addition this new system will be used to measure for the first time correlation coefficients which describe the turbulent mixing and energy dissipation process.

These data will be used to obtain a better understanding of the role of surface roughness in the mechanism for turbulent energy dissipation and should lead to techniques for predicting this quantity as well as the allied problems of mass and thermal energy transport.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0460, THE MINERALOGY AND CHEMISTRY OF SOILS AND SEDIMENTS OF HIGH PLAINS PLAYAS

B.L. ALLEN, Texas Technological College, Water Resources Center, *Lubbock, Texas* 79409

Almost all of the runoff water of the interior High Plains of Texas and New Mexico collects in shallow enclosed depressions called playas. Probably very little of the collected water percolates into the important aquifer, the Ogallala formation, because of the very low permeability of the playa floor soils. Apparently, most of the water evaporates. The mineralogy and certain chemical properties of the clays in the soils and sediments from playas selected according to soil type and topography will be determined. They will be related to similar properties of surrounding soils. Similar determinations will be made of material suspended in the playa water. These data are needed for the proper design of mechanical filters or for the removal of sediment by chemical flocculation in developing effective recharge systems. Additionally, the information will be beneficial in the modification of playas to concentrate water for irrigation, wildlife habitats, sewage effluent storage, and mosquito control.

Standard techniques, including X-ray diffraction, differential thermal, and infrared absorption will be used to study the clays. Absorption and emission spectrophotometric determinations will be made of the soil water and adsorbed cations. The effects of the clay mineralogy and chemistry upon soil permeabilities will be evaluated.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Texas Technological College

3.0461, THE ECONOMICS OF A REGIONAL MUNICIPAL DESALTING SYSTEM IN THE LOWER RIO GRANDE VALLEY OF TEXAS

W.L. PREHN, Southwest Research Institute, *San Antonio, Texas* (603)

An investigation of the economics of a regional municipal desalting system in the lower Rio Grande Valley of Texas as a part of the comprehensive Texas Water Plan. The study investigated the comparative economics of nine cases of desalting to serve municipal and industrial water needs in this region.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0462, RELATION OF CLIMATIC AND WATERSHED PHYSIOGRAPHIC AND CULTURAL FACTORS TO WATER YIELD

R.W. BAIRD, U.S. Dept. of Agriculture, *Temple, Texas*

Object: To identify the climatic and watershed factors influencing water yield from agricultural watersheds, to evaluate the factors quantitatively; and to develop simple field procedures by which seasonal, annual, and long period yield of water for ungaged watersheds may be reliably estimated.

Plan of Work: The work is currently concentrated on a segment of the Wishita River Watershed in the vicinity of Chickasha, Oklahoma; on small agricultural watersheds near Stillwater, Oklahoma; at the Blacklands Experimental Watershed, Riesel, Texas; and on Lowrey Draw at Sonora, Texas. Some of the factors required for the analyses and which are measured or otherwise documented for the study are: rates and duration of streamflow; precipitation patterns; antecedent moisture; season soils; land use; conservation and watershed management practices; ground water elevations; riparian vegetation; geology; gradients and hydraulic roughness of stream channels, and the size, shape, and other geomorphic attributes of the watersheds. The downstream effects on flow regimes associated with improvement works in upstream tributaries is a primary phase of the study on the Washita River Watershed.

SUPPORTED BY U.S. Dept. of Agriculture

3.0463, STRUCTURE AND MORPHOLOGY OF INORGANIC MEMBRANES

W.O. MILLIGAN, Baylor University, Graduate School, *Waco, Texas* 76703

A detailed investigation of the structure and morphology of inorganic membranes, particularly semi-permeable membranes such as the classical cupric ferrocyanide membrane, is being undertaken using x- ray diffraction, electron diffraction, electron microscopy, and dehydration isobaric methods.

Electron microscopic studies of the freshly precipitated cupric ferrocyanide confirm that the gel is a finely-divided precipitate containing particles in the range of 10 to 20 A. Upon further aging in distilled water for a period of 48 hours or more, cupric ferrocyanide will form very thin sheets several hundred A units in cross-section. With the appearance of this sheet material, several new lines appear in the electron diffraction pattern and in the x-ray diffraction pattern, indicating a larger unit cell. (A detailed structure analysis of this larger unit cell is underway.) These large spacings appear and disappear as a function of water content, thus indicating a possible water transport mechanism thru the crystals.

At the present time, crystal structure and aging studies are being carried out on some thirty or more heavy metal ferrocyanides, ferricyanides, and cobalticyanides which are isomorphous with cupric ferrocyanide.

Series of these inorganic substances giving both the large and small unit cell will be made into support membranes and tested for semi-permeable properties. The results of such experiments may be helpful in formulating a transport mechanism for the desalting of water through the use of inorganic semi-permeable membranes.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0464, INFLUENCE OF TRANSPIRATION SUPPRESSANTS, SPRINKLER IRRIGATION & MOISTURE LEVELS ON TRANSPIRATION & EVAPOTRANSPIRATION

C.J. GERARD, Texas A & M University System, Agricultural Experiment Sta., *Weslaco, Texas*

Water is one of our most important resources and is often a limiting factor in irrigation areas. Past research indicate that in an irrigated agriculture conservation of water, as much as 25% can be achieved by applying less water and applying water to plants during their critical demand periods. The proposed research project plans to determine if significant reduction in water requirement can be achieved by modifying the microclimate in the plant canopy. The use of transpiration suppressants and sprinkler irrigation may offer opportunities to modify the microclimate and therefore reduce transpiration and evapotranspiration.

Field experiments with tomatoes and citrus will be conducted to determine the influence of transpiration suppressants (reflective coatings), sprinkler irrigation and moisture levels of evapotranspiration and microclimate of plant canopy. The influence of the above treatments on transpiration will be evaluated using a thermoelectric method under field and controlled chamber conditions.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Texas A. & M. University System

3.0465, SPECTRAL RECONNAISSANCE FOR DIAGNOSIS OF SOIL AND WATER MANAGEMENT PROBLEMS

V.I. MYERS, U.S. Dept. of Agriculture, *Weslaco, Texas*

Object: To determine mechanisms affecting reflectance from plant and soil surfaces and the interactions of environmental conditions with reflectance using multispectral techniques; and to develop diagnostic procedures for laboratory and field use by remote sensing.

Plan of Work: This work will be conducted first in the laboratory and greenhouse to determine the consequences of such factors as salinity, drought, toxic ions, disease and fertility levels to the physiological and morphological characteristics of internal plant tissue. Plant and soil conditions which may result in markedly different spectral reflectance will be established under controlled conditions that will include different levels of soil moisture, salinity and fertility, disease incidence, and presence or absence of toxic salts or growth regulator chemicals. Cotton will be used as the indicator crop during the first studies but other biological materials will be subsequently used. The second phase of the work will include field plantings under different environmental and biological conditions as indicated by the laboratory studies. This will be followed by aerial flights over the fields using multispectral sensing equipment and techniques for the development of predictive procedures.

Cooperation: Texas Agricultural Experiment Station, Soil Conservation Districts in the Lower Rio Grande Valley, National Aeronautics and Space Administration, Department of Defense, SCS.

SUPPORTED BY U.S. Dept. of Agriculture

3.0466, SALINE AND SODIC SOILS AND IRRIGATION WATER QUALITY PROBLEMS IN THE RIO GRANDE RIVER BASIN

C.L. WIEGAND, U.S. Dept. of Agriculture, *Weslaco, Texas*

Object: To study the distribution and quantity of salts and exchangable cations in soils as affected by leaching, water quality, drainage and management practices; to evaluate the effectiveness of practices for removal of soluble salts and exchangeable sodium; to determine the effects of the salinity and sodium status of soils on plant growth; and to develop cultural and soil management systems to improve growth, production and quality of crops grown on saline and sodic soils.

Plan of Work: Various cultural, irrigation, drainage, and amendment practices will be conducted to displace or replace soluble salts and exchangeable sodium from soils with leaching water or by other processes. Changes in salt and sodium status of soils under study will be determined by chemical analyses. Soluble salt and exchangeable sodium content in problem areas will be investigated in relation to water quality, water table height, precipitation, topography, and farming practices with subsequent derivation of statistical and graphical relationships. Various crops and varieties of crops will be grown on soils of different levels of salt and exchangeable sodium to determine the effects of salt and sodium on crop yield and quality. Quantitative relationships between yield reduction and the salt and sodium status of soils will be developed.

Cooperation: Texas Agricultural Experiment Station; U.S. Salinity Laboratory; soil conservation districts.

SUPPORTED BY U.S. Dept. of Agriculture

3.0467, THE TRANSPORT OF SALTS AND WATER ACROSS A CATION EXCHANGER UNDER A GRADIENT OF HYDROSTATIC PRESSURE.

P. MEARES, Univ. of Aberdeen, *Aberdeen - Old Alberdeen, United Kingdom*

Very little work has been published on transport across ion exchange membranes under a mechanical pressure gradient. It is proposed to study the rates of flow of water, and the streaming potentials and streaming currents across a phenol sulphonic cation exchange membrane in contact with solutions of sodium, strontium and caesium bromides.

The mechanical transference numbers of the ions in the resin will be measured by observing the movement of radio tracers along a strip of membrane to one end of which a high pressure is applied.

By combining a pressure gradient with other force fields it is hoped to examine some of the unstable and oscillatory flux phenomena which have been reported recently.

The data will be combined with the information already secured on this membrane in contact with these electrolytes when acted on by other force fields. This will allow a rigorous test of the non equilibrium thermodynamic theory of membrane transport.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0468, NEW SYNTHETIC MEMBRANES FOR REVERSE OSMOSIS DESALINATION

A. SHARPLES, Arthur D. Little Research Inst, *Midlothian - Scotland, United Kingdom*

Previous studies in our laboratories have shown that copolymers based on galactose methacrylate, and methyl methacrylate show promise in connection with the formation of membranes for reverse osmosis. The present project is concerned with optimizing the system in order to obtain high throughput products.

In addition, two new systems are being studied. The first uses glyceryl methacrylate as the hydrophilic component to replace galactose methacrylate. The second uses vinyl carbazole as the hydrophilic component, in order to obtain a high resistance to compaction.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0469, ANALYSIS OF DESALTING PLANTS AS A SOURCE OF SUPPLEMENTAL SAFE YIELD

C. CLYDE, Utah State University, Utah Water Research Laboratory, *Logan, Utah* 84321 (14-01-0001-1711)

The objectives of this study are to develop a computer program using a methodology consistent with techniques and methods now being used to assess natural water supply systems to (1) determine the optimum fashion in which to operate desalting plants to provide supplemental safe yield; (2) assess impact of such operation on the performance characteristics and design of a desalting plant used in this service, as well as in the identification of unique operating features of the plant.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0470, OPTIMIZATION IN THE USE OF VARIABLE QUALITY DESALTED WATER AND AN ARTIFICAL UNDERGROUND RESERVOIR TO SUPPLY PEAK MUNICIPAL WATER DEMANDS

R.N. DEVRIES, Utah State University, School of Engineering, *Logan, Utah* 84321

The objective of this research is to develop a mathematical model of a municipal water supply system that includes a supply source from a variable quality output desalting plant to be used in conjunction with an artificially recharged underground aquifer reservoir.

Testing of the model will be done on an actual situation, namely that of supplying the City of Lincoln, Nebraska with additional water to meet its future demands.

Three methods of desalting are being considered. These are: total distillation, electrodialysis, and reverse osmosis. These were chosen since the study is limited to the desalting of brackish ground water available in inland cities.

Optimization techniques, such as linear, non-linear and dynamic programming will be used in completing the study.

SUPPORTED BY Utah State Government
Utah State University

3.0471, EVALUATION OF FIVE METHODS FOR SAMPLING DESERT AND WETLAND VEGETATION

N. FOLKS, Utah State University, State Coop. Wildlife Res. Unit, *Logan, Utah* 84321

Five vegetation sampling methods--the point-frame transect, the 100-square-foot plot, the 0.20-square-foot plot, and the step-point, estimation-plot method--will be compared on three different ecological types. Comparisons will be made on Desert Shrub-Grass Polygonum-Marsh, and Eleocharis-Marsh types.

This work is to be done on the Ouray National Wildlife Refuge in northeastern Utah and on the Monte Vista National Wildlife Refuge in southwestern Colorado.

At the Ouray Refuge, two cover types will be chosen for study due to ecological position and uniformity of vegetational composition. One study area will be located on a dry sandy bench, the other in a moist river clay-loam flood bottom commonly called a river oxbow. A third cover type will be located at the Monte Vista Refuge because of its ecological position and uniformity of vegetation at a higher elevation.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Utah State University

3.0472, IRRIGATED PASTURE AND MEADOW ESTABLISHMENT AND MANAGEMENT

W. KELLER, Utah State University, Agricultural Experiment Sta. , *Logan, Utah* 84321

Object: To develop high producing grass-legume mixtures for irrigated pastures, dependable procedures for establishing them, and management practices to insure maximum productivity; to determine effective management practices for flood meadows, including methods for destroying the native sod and establishing more productive species.

Plan of work: Irrigated pasture studies will include methods of establishing various combinations of grasses and legumes in replicated plots seeded at different seasons, using different types of seedbed preparation, with and without companion crops, with varying amounts and frequencies of irrigation water and fertilizer. If possible, plots will be harvested by grazing animals but the vegetation will be sampled to measure dry-weight yields, obtain chemical analysis and botanical composition. Climatic and environmental characteristics will be documented and all management practices accurately standardized in order to project experience to areas not experimented upon. Studies on flood irrigated meadows will include management of existing vegetation for greater forage yields (regulation of water, introduction or management to increase legumes, fertilizer treatment, harvesting at different stages to determine proper stage for maximum nutrient yield, etc.). Search will be continued for means of destroying existing sod and replacing it with high-production species.

SUPPORTED BY U.S. Dept. of Agriculture

3.0473, FARM CONVEYANCE AND WATER APPLICATION

C.W. LAURITZEN, Utah State University, Agricultural Experiment Sta. , *Logan, Utah* 84321

Objectives: To develop 1. Improved methods of conveying water on the farm. 2. Improved methods of applying water to the land.

Work Proposed: The design, development, and testing of conveyance, diversion, and application structures will be undertaken. Emphasis will be on new materials such as butyl and plastics, but not necessarily confined to these, and will include both surface and overhead applications.

SUPPORTED BY Utah State Government

3.0474, THE IMPROVED USE OF WET AND SALTED SOILS FOR FORAGE PRODUCTION

H.B. PETERSON, Utah State University, Agricultural Experiment Sta. , *Logan, Utah* 84321

To improve production on the wet and salted soils of the state by: (1) reclamation methods adapted to the special conditions on marginal lands. (2) finding cultural practices that will improve the soil conditions for plant growth and minimize the adverse factors. (3) a physiological study to determine how salts and exchangeable sodium in soil adversely affect plants.

The field studies will be conducted in Cache Valley on an experimental drainage farm where such things as salt removal by special techniques, mole drains, species performance, soil amendments, etc. can be evaluated.

SUPPORTED BY Utah State Government

3.0475, UNDESIRABLE SHRUB AND TREE CONTROL

G.A. VANEPPS, Utah State University, Agricultural Experiment Sta. , *Logan, Utah* 84321

Objective: To develop economical and effective methods in controlling certain low use undesirable shrubs and trees that may be high users of water.

Work Description: Study sites will be obtained on private, state and federal lands located in Central Utah. Initial stages of the study will deal with Gambel oak (Quercus gambellii), with aspen, chokecherry and others included later. Treatments will be chemical herbicides, mechanical and fire or combinations, with major emphasis on herbicides. Herbicide treatments to include various chemicals, rates, times and methods of application, such as foliar, basal and soil treatments. Climatic and soil data will be obtained. Data will be gathered on plant regrowth, top kill, total kill, or other abnormal symptoms arising from the various treatments.

SUPPORTED BY Utah State Government

3.0476, VEGETATION AND SOIL RESPONSE TO SOIL SURFACE TREATMENTS

N.E. WEST, Utah State University, Agricultural Experiment Sta. , *Logan, Utah* 84321

Objectives: To determine the effects of pitting and contour furrowing on productivity and vigor of vegetation, temperature microclimates, soil moisture economy, and erosion reduction.

Description: Paired plots on previously treated and untreated areas of shadscale zone rangeland will be evaluated for response of production and vigor of vegetation, temperature micro-climate, soil moisture and erosion control. Economic evaluation of these practices will also be attempted.

SUPPORTED BY Utah State Government

3.0477, DESIGN FACTORS IN SURFACE IRRIGATION

L.S. WILLARDSON, Utah State University, Agricultural Experiment Sta., *Logan, Utah* 84321

1. To determine the effect of furrow stream sizes on irrigation efficiencies. 2. To determine the magnitude of seasonal infiltration variations on some classified soils. 3. To develop a relation between infiltration as measured in furrows and by infiltration cylinders.

Work will be done to develop a method of accurately measuring the amount of water absorbed along a furrow at different times. Knowledge of the amounts being absorbed in various reaches of the furrow is required. Present methods of measuring water will be considered for their adaptability to the problem. When a satisfactory method has been developed it will be tested in the field. Water distribution patterns along furrows will be determined. The effect of furrow stream advance rate and of irrigation duration on water application efficiency will be determined. Analyses, using electronic computer techniques will continue on data already collected for objective No. 3. Further collection of data in the field may be required to check equations developed.

SUPPORTED BY Utah State Government

3.0478, LEACHING AND RECOVERY OF COPPER FROM ORES AND WASTE DUMPS

J.B. ROSENBAUM, U.S. Dept. of Interior, Metallurgy Research Ctr., *Salt Lake City, Utah* 84112

Study and determine major factors that contribute to mechanisms of heap leaching copper oxide or silicate ores. Seek means of expediting extraction. Also seek methods of improving leachability of sulfide-type ores. Investigate improvements in the recovery and processing of cement copper from leach liquors to obtain a usable finished product.

SUPPORTED BY U.S. Dept. of Interior - Bureau of Mines

3.0479, STUDY OF BIOLOGICAL DESALINATION PHENOMENA AND SALT TRANSPORT MECHNAISMS OF SELECTIVE AVIAN SALT GLANDS

J.M. SPURLOCK, Susquehanna Corporation, *Alexandria, Virginia* 22314

The program includes two major phases. The first phase consists of an analytical study of various biological ion transport systems and, based upon results of recent research on these systems, new approaches or concepts will be defined for the application of these research results to the development of new or improved practical desalination processes. The second phase involves an investigation to elucidate the salient mechanisms and structural characteristics associated with selective ion transport by the avian salt glands of white china geese as a specific biological model related to sea gulls. Included in the second phase is the development of techniques for handling and assaying salt gland membranes from white china geese.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0480, DEVELOPMENT OF ECONOMICAL METHODS OF BORON REMOVAL FROM IRRIGATION RETURN WATERS

E.W. DUNKLIN, Melpar Inc., *Falls Church, Virginia*

The primary objective of this program is to develop economical methods of boron removal in irrigation return waters for subsequent use in multi-million gpd capacity reverse osmosis plants. Under the scope of work, the effectiveness of conventional water pre-treatment methods for boron removal using a synthetic irrigation return water will be investigated and laboratory tests to develop new methods of boron removal will be conducted. Cost estimates for each method will also be made. The two or three most promising methods will be selected for field evaluation and design drawings for the construction of a test unit will be prepared.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0481, DEMONSTRATION OF ALUMINUM IN SEA-WATER DESALTING

D.A. FAUTH, Reynolds Metals Company, *Richmond, Virginia* (14-01-0001-1095)

To design and build a 50,000 gpd flash distillation desalination unit for evaluating the performance and to determine the useful life of aluminum alloys as the material of construction for the heat exchanger tubing in this environment. The unit is built using carbon steel flash chambers and 3003, 5052, 6061, and 3004 clad aluminum tubing. The water boxes, interstage partitions, tube sheets, degassifier, and deaerator are made of 6061 aluminum. The aluminum components are isolated from electrical contact to the steel. The unit is designed for automatic operation and has a top brine temperature of 250 degrees F. The design is conventional flash distillation process with 24 heat recovery and two heat reject stages. Sulphuric acid is used for scale control. Corrosion probes are located throughout the plant for recording instantaneous corrosion rates. The water boxes can be removed for inspecting the internal surfaces of the aluminum tubing by use of a borescope. Top and side access covers can be removed for inspection of the external surfaces.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0482, FACTORS AFFECTING WATER CONSERVATION FOR PLANT GROWTH IN THE LOW RAINFALL AREA OF EASTERN WASHINGTON

F.E. KOEHLER, Washington State University, School of Agriculture, *Pullman, Washington* 99163

Objectives: 1. To identify and determine the significance of factors affecting moisture intake and retention of soils of the low rainfall area of Eastern Washington with special reference to moisture in the seeding zone. 2. To determine moisture movement in the soil during the fallow year and crop year of summer-fallow cycle, as affected by initial soil moisture level and by fall and spring density and depth of loose topsoil. 3. To correlate moisture in the seeding zone with density of the surface and subsurface soil as established by various tillage treatments.

Soil moisture level will be followed through the fallow and growing season in the dry area of eastern Washington (10 inches annual precipitation). The influence of different tillage practices during the fall after harvest and in the spring of the fallow year will be studied. Special emphasis will be placed on the soil moisture level in the seeding zone.

SUPPORTED BY Washington State Government

3.0483, THERMODYNAMICS AND TRANSPORT PROPERTIES OF MULTICOMPONENT INTERFACES

J.C. BERG, Univ. of Washington, School of Engineering, *Seattle, Washington* 98122

The primary objectives of the proposed work are to measure and to correlate thermodynamic and transport properties associated with monolayer surfactant films at interfaces separating multicomponent bulk phases. Thermodynamic data will be obtained as interfacial pressure vs. molar area isotherms, and these will be correlated using models suggested by statistical mechanics. Transport data, i.e., surface viscosity and perhaps other rheological properties, together with surface diffusivity will be obtained for a number of multicomponent bulk systems. Both the thermodynamic and the transport data will be put to use in formulating the fluid mechanical boundary conditions which are required to describe the influence of surfactants on many of the common fluid-fluid separation processes such as distillation, absorption, and extraction.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0484, EFFECTS OF FOREST COVER MANIPULATION ON WATER YIELD AS STUDIED BY AN ELECTRIC ANALOG

S.P. GESSEL, Univ. of Washington, Graduate School, *Seattle, Washington* 98122

The proposed research would establish electric analogy models for study of the impact of forest cover manipulation on water yield for certain soils, forest types and climatic zones in Washington State. Such model studies could also evaluate the influences of combinations of precipitation and temperature extremes in addition to varying densities and ages of forest stands. If studies of this nature are successful, the need for expensive experimental watershed studies would be greatly reduced and the results of such studies would be more useful.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Washington

3.0485, NATURAL RESOURCE MANAGEMENT AND CONSERVATION IN THE SOVIET UNION

P.R. PRYDE, Univ. of Washington, Graduate School, *Seattle, Washington* 98122

The dissertation is intended to serve as a survey of the present status of natural resource consdervation in the Soviet Union. Water resources will be a major, though not the only, theme. At least one full chapter will be devoted to the utilization and conservation of water resources. A primary focus of the sections on water resources will be the manner in which Soviet planners have handled the uses of a given resource complex, externalities, etc. Sections of other chapters will deal with pollution, fisheries, marshland, drainage, and other associated problems. It is expected that the dissertation will be completed in the spring of 1969.

SUPPORTED BY Social Science Research Council

3.0486, WATER YIELD IMPROVEMENT, EROSION CONTROL, AND SEDIMENT REDUCTION IN FORESTS

H.W. BERNDT, U.S. Dept. of Agriculture, *Wenatchee, Washington*

Object: To determine how moisture disposition and use are influenced by environment, climate and types of vegetative cover and soil; to relate erosion to soil, vegetation, topography, climate, and land use; and to devise ways to improve water yield, and prevent erosion and restore land stability in the mixed-conifer and forest range types.

Plan of Work: The project will continue: (1) to study erosion rates in major soil types, to analyze the characteristics of soil that affects erosion, and to develop methods of erosion control by invigorating vegetation; and (2) to investigate factors affecting distribution and use of water: solar-energy, soil, moisture, evapotranspiration, surface runoff, riparian use, and humus types. Recent work includes use of radioactive tracers to tag soils to measure downslope movement, studies of nutrient levels of soils and fertilization, soil densities relating to root systems and water absorption, water movement through juvenile plants, and snow accumulation and melt rates.

SUPPORTED BY U.S. Dept. of Agriculture

3.0487, DEVELOPMENT OF THE VACUUM FREEZING VAPOR COMPRESSION PROCESS FOR USE WITH BRACKISH WATERS

R.R. BRIDGE, Colt Industries Incorporated, *Beloit, Wisconsin*

The vacuum freezing vapor compression process is based on freezing by flash evaporation, with compression of the vapor and subsequent condensation on ice which has been cleaned of brine in a counter-washing column. A 60,000 gpd pilot plant has been in operation at Wrightsville Beach, N.C., during FY 1966 and will operate into FY 1967 and possibly into FY 1968. A mobile unit using the process will be built during FY 1967 and operated in FY 1968 on brackish water to determine its applicability for use on such waters.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0488, SPRING POND ECOLOGY AND MANAGEMENT

O.M. BRYNILDSON, State Div. of Conservation, *Madison, Wisconsin* 53701

Objectives: To determine the effectiveness of dredging spring ponds as a trout habitat management practice and develop management guidelines; to describe the biological, chemical, and physical characteristics of spring ponds; to determine the cost-benefit ratio in terms of trout production and angling quality.

Procedures: Ponds will be mapped and sounded and extent of various substrates determined. Peterson type population estimates of the fish population will be made by means of electro-fishing gear in spring and fall in both the pond and a section of the out-flowing stream immediately below the pond. Angler harvest will be determined by a stratified contact-type creel census throughout the season. Growth rate and age-class composition of trout will be determined by scale analysis, to be supplemented in later years by measurements of marked known-age fish. Two-way weirs will be installed to determine the extent of fish movement into and out of the pond.

Recording thermometers will be installed in the ponds at the outlets, and in the open area of the ponds, and periodic vertical thermal-chemical analyses will be made.

Water stage recorders will be installed at spring pond outlets to determine outlet volume and to detect changes attributable to dredging. Test wells will be driven in the vicinity of the ponds to determine changes in ground water levels. The cooperation of the U.S.G.S. will be sought on this phase of the project.

Pre- and post-dredging sampling of bottom fauna will be undertaken, probably under contract with the University of Wisconsin.

Three to four ponds will be included under the dredging phase of this study and one to two ponds, which presently are considered to support a good trout population and provide satisfactory angling (i.e., not proposed for dredging), will be included as reference ponds.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Wisconsin State Government

3.0489, AN INTERFEROMETRIC INVESTIGATION OF TRANSPORT PHENOMENA IN PARTIAL PRESSURE DISTILLATION

M.M. ELWAKIL, Univ. of Wisconsin, School of Engineering, *Madison, Wisconsin*

The study will be both experimental and analytical. A dual wavelength interferometric technique which does not physically interfere with the boundary layers will permit measurements of very low heat and mass transfer rates from measured temperature and concentration gradients at the walls. In addition, the interferograms will show the shape and extent as well as development of boundary layers. The most promising approach to further analytical studies now appears to be through the application of finite difference techniques to solution of the boundary layer regime, and a study of the effects of geometry on boundary layer development. The experimental studies will include the construction of an evaporator-condenser of variable geometry to fit within the bounds of the interferometric set up.

The air-water vapor system of interest in sea water demineralization processes will be studied, and the best method of solutions for temperature and concentration gradients determined. It may be necessary or desirable to consider systems other than water and air in order that reasonable accuracy may be obtained on both temperature and concentration gradients; selection of systems will be based on molecular mass, vapor pressure, indices of refraction and other considerations so that meaningful results can be interpreted in terms of the air-water system. There is also the possibility of modification of the experimental techniques, for example by use of porous evaporator plate rather than a falling water film.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0490, SOIL CONSERVATION AND FERTILITY OF RED CLAY AND PRAIRIE SOILS OF WISCONSIN

A.E. PETERSON, Univ. of Wisconsin, Agricultural Experiment Sta., *Madison, Wisconsin*

To determine the most profitable and satisfactory soil management practices for crop production and soil conservation. The eastern red clay area will be concerned with the effect of various rotations and soil tillage practices on soil and water loss. The northern red clay soil studies will determine the feasibility of establishing seeding on farm waterways, gullies, and stream bank slopes using a combination of bituminous mulches, soil stabilizers, seeding mixtures and fertility treatments. The prairie soils studies will include effect of minimum soil tillage on continuous corn cultural studies which include various population, maturity and fertility levels. The effect of various methods of minimum soil tillage on pasture renewing will be included.

DESCRIPTION OF WORK: In the red clay area soil and water loss measuring equipment will be installed on 20 acres of land near Valders, leased by Maintowoc County. Some of tho measuring equipment has been provided by the Soil and Water Conservation Sections of the Agricultural Research Service, U.S.D.A. Waterway, and stream bank stabilization will be conducted at the Ashland Experiment Station and in the nearby Whittlesey Watershed in cooperation with the Wisconsin Conservation Department, the Whittlesey Watershed group and the Soil Conservation Service on the prairie soils, cultural studies of corn using 4 populations (13,000, 16,000, 19,000 and 22,000 plants), six corn varieties and three fertility levels, will be studied in conjunction with minimum soil tillage (wheel track planting). Pasture renewal studies using herbicides and minimum tillage methods of planting both small grain (plow press grain drill) and corn.

SUPPORTED BY U.S. Dept. of Agriculture
Wisconsin State Government

3.0491, TRAINING, TECHNICAL SUPERVISION, AND ASSISTANCE REGARDING THE OPERATION OF A SKID-MOUNTED MSF UNIT

R.D. GEIGER, Aqua Chem Incorporated, *Waukesha, Wisconsin* 53186

The project consists of evaluating the performance of a skid mounted self-contained multistage distillate pilot plant which is to operate on different kinds of feed water, such as seawater and highly polluted water such as rivers and bays containing raw sewage and algae. The unit is intended to determine the effect of polluted waters on such conditions as foaming, product water contamination, scale formation, rate of corrosion due to high gas content, and the ability to eliminate high gas content with conventional deaerating equipment.

The pilot plant is designed to stimulate performance under polluted water conditions of large scale MSF distillation plants up to and including 150,000 gallons per day. The plant is skid-mounted and adaptable to barge or rail car mountings to provide maximum transportability to various sites by common carriers. The weight, height, width, and length permit movement over rails to sites throughout the Continental United States. The plant is moved to the railroad siding nearest to the prpopsed test site and then skidded or hauled by low-bed trailers to the final site location. The unit is incorporated in two modules to enable it to be placed in operation in the shortest time.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

3.0492, IRRIGATION REQUIREMENTS FOR WYOMING

R.D. BURMAN, Univ. of Wyoming, Agricultural Experiment Sta. , *Laramie, Wyoming* 82071

1. Estimate growing season evapotranspiration for principal crops for each major weather station in Wyoming. 2. Estimate the number of irrigations required, the total amount of irrigation water required, and the dates of irrigations based upon evapotranspiration estimates, historic rainfall data and soil moisture retention characteristics of major soil types. 3. Determine probabilities of seasonal rainfall, numbers of irrigations required, dates of irrigation, and total water required for each weather station.

1. Evapotranspiration for each station will be estimated by commonly accepted methods, which have been compared with results from the nearest field studies. 2. A soil moisture balance will be maintained for each location, crop and soil. When the soil moisture level reaches a minimum an irrigation will be credited to the season. Any excess rainfall moisture over field capacity will be considered to be waste. 3. Results from Objective 2 will be portrayed as empirical probabilities. The results will be organized and published as an experiment station bulletin for use by engineers, irrigation equipment dealers and farmers.

SUPPORTED BY Wyoming State Government

3.0493, HIGH ALTITUDE EVAPOTRANSPIRATION FROM NATIVE MEADOWS

R.D. BURMAN, Univ. of Wyoming, Agricultural Experiment Sta. , *Laramie, Wyoming* 82071

1. To design and calibrate a lysimeter to directly measure evapotranspiration from native hay on an hourly basis.

2. To measure evapotranspiration from native hay under oasis conditions.

3. To measure and analyze evapotranspiration from Russian wildrye, intermediate wheatgrass and mixtures of these grasses with alfalfa.

1. Three alternate designs of lysimeters will be evaluated at the Agronomy Farm in Laramie by comparing evapotranspiration measured by the lysimeters with measurements made by microclimate measurements and the Energy Balance theory.

2. A long, narrow site along preferably the Platte River near Elk Mountain will be selected for lysimeter installation before the second summer season. Insight into the small scale oasis effect will be possibly from noting the variation in evapotranspiration across a field and the large-scale effect may be deduced by theoretical analysis or a comparison between results obtained at Laramie in native meadows in larger irrigated areas.

3. Evapotranspiration will be measured by neutron soil moisture probes on a split plot design having alfalfa or no alfalfa as the main plot effect and the superimposition of Russian wildrye and intermediate wheatgrass as the split plot effect.

SUPPORTED BY Wyoming State Government

3.0494, STUDIES IN SOILS AND AGRONOMIC PRACTICES - SHOSHONE PROJECT, WYOMING

L.I. PAINTER, Univ. of Wyoming, School of Agriculture, *Laramie, Wyoming* 82071

A study of the management factors necessary to improve the productivity of the Christianberg soil series, a saline soil with a poor production record in the Shoshone Irrigation Project area of the Bighorn Basin, Wyoming. Determination of the effects of gypsum and manure on physical properties of the soil at seedbed levels, and on crop yields and quality, is being observed. Adequate levels of nitrogen, phosphorous, and potassium are being maintained. The study plots are located on the experiment station. Crops grown will include sugar beets, corn, small grains, and alfalfa.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

3.0495, IMPROVEMENT OF WATER YIELDS AND SOIL STABILIZATION IN RIVER BASINS

R.D. TABLER, Univ. of Wyoming, School of Agriculture, *Laramie, Wyoming* 82071

Object: To provide information required to manage related forest and range lands of the Big Horn, Powder River, and North Platte drainages for more sustained summer water supplies and minimum erosion and sedimentation.

Plan of Work: The project staff is continuing to investigate the effect of sagebrush removal on water yield. At present, the effect is determined by soil moisture measurements, but treatment will also be applied to a gaged watershed after calibration. They are also studying the effect of sagebrush removal on snow disposition. On lodgepole pine forests, they are determining the effect of stand density on soil moisture and water use.

SUPPORTED BY U.S. Dept. of Agriculture

3.0496, CONTROLLING UNDESIRABLE PHREATOPHYTES

F.L. TIMMONS, Univ. of Wyoming, Agricultural Experiment Sta. , *Laramie, Wyoming* 82071

Object: To determine for phreatophyte control (1) the best herbicides and application methods, (2) the effect of various climatic, soil and plant factors on response to herbicides, (3) the value of new chemicals, and (4) the value of different combinations of chemicals, burning and mowing or other mechanical treatments; and to develop suitable methods for long range control of undesirable phreatophytes.

Plan of work: Herbicides will be applied as foliage sprays by aerial or ground equipment, as basal and cut stump treatments, and as soil treatments to evaluate their effectiveness on individual species of phreatophytes. Treatments will be made at various rates, dates, and locations to correlate plant responses with conditions for growth, stage of growth, soil characteristics, competing vegetation, etc. Various burning, mowing and other control methods alone and combined with chemical treatments will be compared. New chemicals will be evaluated for effectiveness on salt cedar and other phreatophytes in greenhouse and outdoor nursery trials. All herbicides, surfactants and other chemicals that show promise will be further evaluated in field trials.

SUPPORTED BY U.S. Dept. of Agriculture

4. WATER QUANTITY MANAGEMENT AND CONTROL

Control of Water on The Land; Groundwater Management; Effects of MansRelated Activities on Water; Watershed Protection.

4.0001, WRAGG SWAMP CANAL INVESTIGATION, ALABAMA

J.F. MCCAIN, U.S. Dept. of Interior, Water Resources Division, *Tuscaloosa, Alabama*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with State and local agencies in Alabama.

Purpose - To determine relationships between peak rates of runoff and rainfall intensity and duration. To verify channel capacities, gradients, roughness factors, and runoff coefficients. To investigate the effects of increasing urbanization in Mobile County on time of concentration and runoff coefficients.

Methods - Rainfall-streamflow records will be collected at two sites and high water information at eleven sites. A streambed profile will be prepared at least once each year to evaluate siltation and dredging operations. A high water profile will be obtained after each flood of approximately five year recurrence intervals. Areal photos and maps will be used to evaluate changes in urbanization.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Alabama State Government

4.0002, PINK SALMON INVESTIGATIONS - FRESHWATER ECOLOGY

W.J. MCNEIL, U.S. Dept. of Interior, Biological Laboratory, *Auke Bay, Alaska*

Total freshwater mortality of pink salmon (Oncorhynchus gorbuscha) has been measured in Sashin Creek since 1940. For the average brood year, only 6 percent of the total eggs potentially available for deposition produce fry migrating to the estuary, but survival may vary between 0.2 and 23 percent. Other studies have revealed that mortality occurs mostly between the time of egg deposition and fry emergence.

One goal of research conducted at Little Port Walter is to identify the factors causing mortality in spawning beds, determining which are density dependent and which are nondensity dependent. Environmental factors including water flow and temperature, dissolved oxygen supply, and gravel composition and permeability are measured and related to mortality rates. Biological factors including density, temporal and spatial distribution, and size of spawning adults are also measured and related to mortality rate.

Another research goal is to develop a better understanding of the factors responsible for ecological change in spawning beds. In this regard, we are investigating rates of oxygen removal due to decomposing organic matter and the mechanics and kinetics of spawningbed siltation.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

4.0003, EFFECTS OF WATERSHED MANIPULATION ON DEER AND ELK USE

D.J. NEFF, State Game & Fish Department, *Phoenix, Arizona*

Objective: To determine deer and elk use on watershed on which the vegetation is being manipulated to increase water yield.

Procedures: 1. Conduct one annual pellet group count on each of the 18 Beaver Creek pilot watersheds using the existing sampling systems. 2. Calculate deer and elk pellet group densities and test for significant differences among years and watersheds with reference to experimental treatments. 3. Locate consistent pellet group concentration areas within individual watersheds and utilize all available site characteristics data to identify the causes of such concentrations.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Arizona State Government

4.0004, DEER FOODS ON WATERSHEDS TREATED FOR INCREASED WATER YIELD

D.J. NEFF, State Game & Fish Department, *Phoenix, Arizona*

Procedures: 1. Maintain at least two tame trained deer for field feeding trials. 2. Continue field feeding observations with tame deer on a wide variety of sites to test the palatability of as many plant species as possible. Supplement field feeding observations with pen feeding observations as appropriate. 3. Collect and analyze rumen samples from road killed and hunter killed deer in the pine and juniper types for comparison with forage preferences of the tame deer. 4. Record occurrence by species of grasses, forbs and browse plants during spring and summer on all pellet group plots before treatment. 5. Record forage plant species occurrence on pellet group plots after treatment, with timing of observations as indicated by development of post treatment plant communities. 6. Compile and analyze data and prepare completion reports. Prepare and present information at the frequent Beaver Creek show-me trips.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Arizona State Government

4.0005, METHODS FOR WATER QUALITY IMPROVEMENT AND ITS STORAGE UNDERGROUND

L.E. MYERS, U.S. Dept. of Agriculture, *Phoenix, Arizona*

Objective: To investigate the effectiveness of vegetation filtration, soil percolation, and underground storage for renovating secondary sewage effluent.

Plan of Work: Laboratory and field studies are conducted to study the flow process in a soil profile under intermittent inundation and to evaluate the quality improvement of the effluent and the optimum management of recharge basins. The possibilities for nitrate control in the final product by induced denitrification will be investigated. The laboratory studies involve soil columns with recording tensiometers, gamma ray densitometry, and computer applications. The field studies are carried out at a three-acre pilot recharge project now under construction west of Phoenix.

SUPPORTED BY U.S. Dept. of Agriculture

4.0006, WATER YIELD IMPROVEMENT FROM RIPARIAN AND UPLAND AREA OF RIVER BASINS

J.S. HORTON, Arizona State University, U.S.D.A. Forest Service, *Tempe, Arizona* 85281

Object: To determine evapotranspiration losses from phreatophyte vegetation growing on moist and wet watershed areas in the Southwest; to develop management practices designed to reduce uneconomic or wasteful water use by floodplain and riparian vegetation; to determine ways to improve water yield and reduce erosion and sediment movement in chaparral, woodland, forest, and mountain grassland through management of plant cover.

Plan of work: In riparian areas, work will be continued on methods for and measurement of evapotranspiration losses from phreatophyte species and possible replacement vegetation; determination of effect of submergence of tamarisk; taxonomy and successional studies of phreatophyte species. In chaparral areas work will be continued on water and sediment yield from small watersheds as affected by wildfire, brush regrowth following fire, and suppression of woody growth by chemical sprays. In woodland areas the effect of size of plant, soil moisture, and climatic factors on water use by juniper will be determined. In pine-fir areas water use and sediment yield as affected by timber management will be studied, as will be the yield of upper tributaries of Salt River as influenced by snow accumulation and melt.

SUPPORTED BY U.S. Dept. of Agriculture

4.0007, CLIMATE, SOIL AND VEGETATION INFLUENCES ON HYDROLOGY OF RANGELANDS IN THE SOUTHWEST

R.B. HICKOK, U.S. Dept. of Agriculture, *Tucson, Arizona*

Objective: Methods of predicting influences of microclimate, soils, vegetative cover, and cultural practices on flood runoff and the net yields of water and sediment from semiarid watersheds.

Plan of Work: Determine influences of soil and vegetation differences and cultural practices on the soil moisture regime, runoff generation and sediment production at the rain-site; on runoff abstractions and their disposition; and on sediment transport, overland and in watershed channel systems.

SUPPORTED BY U.S. Dept. of Agriculture

4.0008, FLOOD WAVE MOVEMENT IN NATURAL EPHEMERAL STREAM CHANNELS

R.B. HICKOK, U.S. Dept. of Agriculture, *Tucson, Arizona*

Objective: Determine cause and nature of impulse waves generated by runoff resulting from cloudburst type thunderstorms; predict flood wave crest heights and travel velocities.

Plan of Work: Relate measured crest heights and velocities of travel of impulse waves to location and nature of storms causing the runoff, to preceding flow conditions, debris in transport, and hydraulic parameters of the channels.

SUPPORTED BY U.S. Dept. of Agriculture

4.0009, STREAM FLOW REGIMES OF SEMIARID RANGELAND WATERSHEDS IN THE SOUTHWEST

R.B. HICKOK, U.S. Dept. of Agriculture, *Tucson, Arizona*

Objective: Determine relations of stream flows to storm patterns, runoff source-area characteristics, and hydraulics of the stream channel system, and derive improved equations for predicting the flow regimes of complex watersheds.

Plan of Work: Categorize storm patterns according to runoff producing potentials and relate to frequencies of occurence for particular localities, determine runoff response characteristics of varying land types and conditions as affected by topography, geology, soils, vegetation, and cultural practices, and determine runoff transmission characteristics on varying stream channel systems. Determine how runoff generation and down-slope runoff abstraction processes are affected by varying rainfall parameters, depending on land conditions, and the manner in which resulting runoff inputs to major channels are modified by hydraulics of the channel system to affect their outflow hydrographs.

SUPPORTED BY U.S. Dept. of Agriculture

4.0010, TRACE AND TRACER ELEMENTS IN GROUND WATER

G.R. DUTT, Univ. of Arizona, Water Resources Research Ctr. , *Tucson, Arizona* 85721

The concentration of Sr, Co, Cd, Pb, Zn, Cu, Ni, Cr, Mn, Fe, Li, SiO2, B, K, NO3, F, CO3, HCO3, SO4, Cl, Na, Mg and Ca were measured in groundwater and in effluents from municipal treatment plants, industry and agriculture. The concentration of the above elements varied greatly throughout the state of Arizona. Concentrations higher than recommended by the Public Health Service were found for several of the wells studied. The composition of water from treatment plants varied greatly from water supplies. When these effluents were recharged the concentrations of metals in the percolating water was not a function of these concentrations in the influent.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Arizona

4.0011, CONTROL OF UNDESIRABLE SHRUBS AND REVEGETATION OF SOUTHERN ARIZONA RANGES

J.H. EHRENREICH, Univ. of Arizona, Agricultural Experiment Sta. , *Tucson, Arizona* 85721

The major objective of this study is to determine the effectiveness of various techniques for increasing forage production on desert shrub areas. This is to be done by: (1) Evaluating the effectiveness of brush control methods, both cultural and chemical, on creosotebush, honey mesquite, and tarbush. (2) Evaluating techniques and equipment for seeding and establishing desirable forage species in conjunction with brush control. (3) Determining forage species that can best be seeded and established under prevailing climatic and edaphic conditions. (4) Determine physiological and cultural requirements necessary to establish adapted species.

A number of mechanical and chemical brush control treatments are applied in combinations with different seeding methods on plots of various sizes. Two vegetative communities--mesquite and creosotebush- -are used. The treatments will be replicated, and results analyzed statistically. Laboratory and field tests of moisture and temperature factors affecting germination of grass species will be made.

A variety of grass species are to be tested for adaptability on treated areas. Small plots will be used and treatments replicated.

Gravimetric soil moisture determinations will be made at various dates of seeding and druing growing season.

SUPPORTED BY U.S. Dept. of Interior - Bu. Land Mgmt.

4.0012, SEEDING ARID RANGELANDS OF ARIZONA

J.H. EHRENREICH, Univ. of Arizona, Agricultural Experiment Sta. , *Tucson, Arizona* 85721

Experimental work will be done at two widely separated areas in northern and southeastern Arizona. The main objectives of the project are: (1) To evaluate seedbed preparation and methods of seeding in order to effectively revegetate range types under study. (2) To evaluate both chemical and mechanical methods of shrub control. (3) To select those forage species which are best adapted to the particular range type. (4) To determine, by the use of appropriate instrumentation, the microenvironmental conditions limiting the germination, growth and establishment of grass seedlings.

Various combinations of seedbed preparations, brush control treatments, and seeding techniques will be used on replicated, randomized, one-half acre plots. Results will be statistically analyzed.

On the plot area, ants will be controlled with Mirex bait, and rabbits and rodents with appropriate poison baits applied in cooperation with the Bureau of Sport Fisheries and Wildlife.

Vegetation data collected will include species composition, frequency, and density. Permanent photo plots will be established to indicate ground cover changes. Soil moisture will be measured by means of gypsum blocks, and precipitation and atmospheric humidity will be obtained from recording rain gauges and hygrothermographs. A variety of grass species will be tested for adaptability on the different sites.

SUPPORTED BY U.S. Dept. of Interior - Bu. Land Mgmt.

4.0013, INFILTRATION CAPACITIES UNDER VARIOUS VEGETATION TYPES AS INFLUENCED BY WATERSHED MANAGEMENT PRACTICES

M.J. ZWOLINSKI, Univ. of Arizona, Agricultural Experiment Sta. , *Tucson, Arizona* 85721

The objective of this study will be to determine the infiltration capacities of various soils under different vegetation types and conditions and to relate this information to overall watershed performance. Other objectives will be to examine infiltration curves and determine if non-wettability factors exist to change the shape of these curves.

A sampling scheme is being designed whereby infiltration measurements are taken on areas most representative of a particular vegetation type and watershed condition. Infiltration measurements will be made principally with a modified North Fork sprinkling infiltrometer equipped with a constant head tank. Field data will be analyzed by computer and infiltration curves will be obtained from an incremental digital plotter. The study will obtain infiltration data which can be used to make meaningful comparisons between various vegetation types and watershed practices.

SUPPORTED BY University of Arizona
Arizona State Government

4.0014, MORTALITY RATES AND RECRUITMENT

H.E. BRYANT, U.S. Dept. of Interior, South Cen. Reservr. Invtgs. , *Fayetteville, Arkansas*

From fish samples taken annually by gill nets and rotenone, growth rate studies will be conducted for selected major species in Bull Shoals and Beaver Reservoirs. Scale samples will be utilized to identify age-groups and all collections will be analyzed to determine year-class composition, recruitment and mortality estimates. In addition, sex ratios, length-weight relationships and condition indices will be computed for all major species.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

4.0015, COOPERATIVE AGREEMENT FOR BEAVER RESERVOIR CREEL CENSUS STUDY

T.O. DUNCAN, U.S. Dept. of Interior, South Cen. Reservr. Invtgs. , *Fayetteville, Arkansas*

Plan of Work: To study angler's catch, effort, and related factors during impoundment of Beaver Reservoir. A cooperative program.

Objective: To estimate: (1) sport fishing harvest as numbers and pounds of fish by species per acre for each season of the census year; (2) fishing success in numbers and pounds by species per angler- hour; and (3) total harvest and effort.

Procedure: Estimates of fishing pressure to be obtained by the progressive count method using observations from aerial flights and from boats. Fishing success estimated by fisherman interviews. Harvest estimates based on information obtained from fisherman's catch. Traffic data counts will be used in comparison of boat and aerial counts.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

4.0016, DESIGN AND CONSTRUCTION OF GEAR FOR MIDWATER TRAWLING

A. HOUSER, U.S. Dept. of Interior, South Cen. Reservr. Invtgs. , *Fayetteville, Arkansas*

The utility of midwater trawls for sampling fish populations in reservoirs has been demonstrated in previous work units. The technique has been shown to be highly efficient for capturing young shad. Exploratory fishing in other lakes and in certain studies in Bull Shoals and Beaver reservoirs have demonstrated that other species can also be captured in sufficient numbers to provide population estimates. The efficiency of the method can be greatly improved with improved designs for the various gear components, such as nets, otterboards, depressors, hydrofoils, winches, etc. Each component will be evaluated, redesigned, constructed and tested as continued use reveals that a need exists.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

4.0017, ESTIMATES OF COMPOSITION, ABUNDANCE AND FLUCTUATION IN FISH POPULATIONS IN BULL SHOALS AND BEAVER RESERVOIRS

A. HOUSER, U.S. Dept. of Interior, South Cen. Reservr. Invtgs. , *Fayetteville, Arkansas*

Knowledge of species composition, estimates of abundance, recruitment, growth and mortality is required in interpreting the population dynamics of fish populations in these two reservoirs. The necessary data must be obtained from fish samples which will be taken annually. Scale samples, measurements of length, weight and sex will be taken from fish obtained in gill net and rotenone samples. Relative abundance estimates will be derived from these samples. In addition, electrofishing will be used for further sampling to derive estimates of abundance. Through samples taken by these methods, changes in populations of adult fish will be defined.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

4.0018, SEDIMENTATION AND IN-PLACE FILTRATION DURING FLOW THROUGH EARTH FRACTURES

R.E. BABCOCK, Univ. of Arkansas, Water Resources Research Ctr. , *Fayetteville, Arkansas* 72701

This work consists of a combined theoretical-experimental study of sedimentation during the flow of fluid particle slurries through earth fractures. The experimental program is designed to measure steady-state sedimentation variables. The analogy between other rate processes is stressed. In-place filtration through the walls of the fracture is being studied using a 'dynamic' filter press. An AD-80 analog computer is being used to solve the mathematical model describing the process. The results will apply primarily to the disposal of granular waste. This project was initiated FY67 and its anticipated completion date is FY69.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Arkansas

4.0019, ENGINEERING PHASES OF SURFACE DRAINAGE

W.S. HARRIS, Univ. of Arkansas, Agricultural Experiment Sta. , *Fayetteville, Arkansas* 72701

(1) Determine the minimum requirements for adequate row drainage. (2) Determine the minimum requirements for adequate surface drainage of individual fields.

Description of Work: a. Row studies, begun in 1959, were continued. It is felt that positive statements concerning the physical requirements for adequate drainage of individual rows in delta soils and topography can now be made. b. Two shallow field ditches have been constructed to test the theory that such ditches will have adequate capacity if they have continuous slope and are designed for maintenance with ordinary farm equipment. Construction techniques have been investigated but only limited observations have been made concerning maintenance requirements and operating efficiency.

SUPPORTED BY U.S. Dept. of Agriculture
Arkansas State Government

4.0020, GROUNDWATER - SURFACE WATER INTEGRATION STUDY IN THE GRAND PRAIRIE REGION OF ARKANSAS

J.P. HOSKYN, Univ. of Arkansas, Water Resources Research Ctr. , *Fayetteville, Arkansas* 72701

OBJECTIVES: 1. From collection, compilation, and analysis of current hydrologic and geologic data, to evaluate the projected demand on the ground water resource in the Grand Prairie in comparison with the available supply. 2. Quantify the recharge occurring from a selected reach of a natural channel within the Grand Prairie and to investigate the possibility of increasing this recharge. This will be accomplished using both laboratory model studies and on-site field evaluation of the most promising methods as indicated by the lab investigations. 3. Evaluate this increased recharge in light of objective Number 1 to determine the feasibility of substantially increasing the total ground water resource in the Grand Prairie.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Arkansas

4.0021, CHEMICAL AND MINERALOGICAL RELATIONSHIPS BETWEEN SUBMERGED SOILS AND RICE CULTURE

G.A. PLACE, Univ. of Arkansas, Agricultural Experiment Sta. , *Fayetteville, Arkansas* 72701

Objectives: 1. To investigate the physical, physico-chemical, and chemical characteristics of submerged soils. 2. To determine the effect of changes in soil chemical, biological, physical, and mineralogical properties on uptake of nutrient elements. (To be carried out in cooperation with Project 650, University of Arkansas.) 3. To learn what hapens to the applied and soil phosphorus, potassium, and minor elements under submerged conditions when the weed population is controlled. 4. To study the effect of placement and time of application of the above elements upon rice yields. 5. To determine the accumulation effects of salts contained in the irrigation water upon the physical and chemical properties of the rice soils. (To be carried out in cooperation with Projects 397, and 443, University of Arkansas.) Work Proposed: Laboratory and greenhouse experiments will be conducted with appropriate field plot design being used to support the fundamental hypotheses. An attempt will be made to identify the major soil types used for growing rice and then characterize them physically, chemically, and mineralogically. Laboratory and greenhouse experiments will be conducted on these soils to determine the physical, physico-chemical, and chemical changes that occur under submerged conditions. With studies of this type investigators should be able to more accurately predict the response of fertilizer applications.

SUPPORTED BY U.S. Dept. of Agriculture
Arkansas State Government

4.0022, COOPERATIVE WATERSHED MANAGEMENT IN SNOWLANDS AND LOWER CONIFER ZONES OF CALIFORNIA

W.E. STEINER, U.S. Dept. of Agriculture, Pac. Sw. For. & Rg. Expt. Sta., *Berkeley, California*

The Forest and Range Experiment Station is performing research for the Department of Water Resources on a matching fund basis in the snowlands and commercial conifer zones of California for the ultimate purpose of discovering best watershed management practices on such lands.

This year, the physics of snow hydrology and snowmelt will be studied, and temperatures and moisture of soils before, under, and after the snowpack. Measurements of soil moisture and climate will continue on lower conifer zone plots with varying degrees of vegetation removal and intensive measurement will be made around single trees isolated last year by tree and brush removal.

SUPPORTED BY California State Government

4.0023, FEEDBACK CONTROL OF CANAL CHECK GATES

J.A. HARDER, Univ. of California, School of Engineering, *Berkeley, California* 94720

Increased multipurpose use and variable demands on canals has resulted in making water conveyance to meet delivery requirements increasingly difficult by manual operation. A satisfactory method of automatically adjusting check gates in response to water demands would improve control and might produce savings in operational costs. For a particular canal reach, a lowering of the water level would be compensated for by opening the gate at the upstream end. Conversely, a rise would result in a closure of the upstream gate and, if the downstream reach is not full, to a opening of the downstream gate. This control underscores the need for considering the effects of hydraulic transients on the function and stability of automatic features.

This project will develop a numerical solution with the aid of a digital computer that will give response to any combination of boundary conditions for a canal reach between checks and include adjustable parameters to describe the characteristics of feedback control of canal checks. The computer program will be used to search for the optimum value of the parameters to be built into the prototype controller that will control water levels and flow automatically with minimum supervision by ditchriders. An examination will be made of the reaction of an entire canal system with automatic downstream control equipment through the use of the digital computer program. Also a comparative study shall be made to determine the effectiveness of various proportional and two position ('on-'off') controllers and combinations thereof on the response of the canal system. The project was started in FY 1966 and should be completed in FY 1968.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

4.0024, ECONOMIC EVALUATION OF PRIMARY BENEFITS FROM FISHING AND HUNTING BASED ON THE NATIONAL SURVEYS OF FISHING AND HUNTING

S.V. WANTRUP, Univ. of California, Water Resources Center, *Berkeley, California* 94720

The primary objective is to appraise and analyze the data collected in the National Survey of Fishing and Hunting with a view to improving the projections of demand for five fishing and hunting activities. The principal determinants of participation in these sports will be elicited from the information available to improve regional demand formulations.

SUPPORTED BY University of California

4.0025, EVALUATION OF GROUNDWATER RESOURCES, LIVERMORE VALLEY, CALIFORNIA

P.A. WITHERSPOON, Univ. of California, School of Engineering, *Berkeley, California* 94720

A predicted rapid increase in the population of Livermore Valley, California over the next few decades points to the need for a master plan of water management. The main objective of this investigation is to provide quantitative data on the hydrologic characteristics of the groundwater basin of this valley that can be used in formulating this plan. An improved mathematical model has recently been developed at the University of California and will be the principal analytical tool.

A three year program of investigation is proposed. The first year will be spent in collecting basic hydrologic data. The geology has recently been worked out by the California Department of Water Resources. The second year will be spent in setting up two-dimensional and three-dimensional models of the basin. With this approach, it will be possible to investigate: (1) subsurface rates and directions of flow, (2) effectiveness of existing hydrologic barriers (vertical and horizontal), and (3) effect on subsurface flow patterns of current and future rates of recharge and discharge. The third year will be devoted to an analysis of the probable impact on subsurface hydrologic conditions over the basin of anticipated rates of water withdrawal and waste water disposal.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of California

4.0026, DRAINAGE SYSTEMS FOR THE IMPERIAL VALLEY

L. WILLARDSON, U.S. Dept. of Agriculture, *Brawley, California*

Objective: Develop and evaluate surface and subsurface drainage systems and provide criteria and specifications for their design, efficiency, durability, installation, maintenance, and rehabilitation.

Plan of Work: With models, analogs, and digital computers develop theoretical and rational equations that describe movement of water in the soil toward drains. Develop, test, and evaluate tools and techniques to acquire data on physical and chemical phenomenon associated with drainage. Design and test prototype drainage systems under field conditions, including drain tube materials, filters, vertical and horizontal alignment, and installation and maintenance techniques.

Cooperation: Agricultural Experiment Stations, SCS, U. S. Bureau of Reclamation, State Engineers, State Water Resources Agencies, and other irrigation, water management, or soil conservation district agencies.

SUPPORTED BY U.S. Dept. of Agriculture

4.0027, THE PROCESSES AND CONDITIONS CONTRIBUTING TO THE ACCUMULATION OF NUTRIENTS IN DRAINAGE WATER FROM IRRIGATED AREA AND SOIL RECLAMATION

L.D. DONEEN, Univ. of California, School of Agriculture, *Davis, California* 95616

The process and conditions contributing to the accumulation of nutrients and other salts from irrigated lands, and the reclamation of salty and high boron soils, as a water pollution study. The relations between the quantity of water required to leach high nitrate and boron soil profiles and the effect of these constituents on the subsurface drains and deeply percolating waters.

Laboratory investigations include sorption, desorption and movement of boron in laboratory studies in conjunction with field work. These results are being applied to computer programming to estimate the quantity of leaching water required. The removal of high nitrates from these soils is also being studied.

Field investigations include the reclamation of soils high in boron, nitrate and salinity by progressively leaching the soil in eight prepared basins and a study of the conditions of the natural subsoil profile in relation to the production of crops and the effluent or drainage water from the leached soils.

SUPPORTED BY University of California

4.0028, SOIL SOLUTION DISTRIBUTIONS AND CROP RESPONSES RELATED TO IRRIGATION PRACTICES

R.J. MILLER, Univ. of California, Agricultural Experiment Sta., *Davis, California* 95616

Objectives: (1) Study the distribution and movement of nutrient elements and other salts in the crop root zone in relation to different irrigation practices; (2) Determine the optimum distribution of nutrient salts with relation to plants at different stages of growth and development; (3) Study crop yield responses on salt affected soils in relation to controlled fertilization and water management; (4) Study the mechanisms involved in transfer of salts and water through soil and subsequent uptake by crop plants.

Description: (1) Improve techniques to study the transfer of salts in the soil profile under different water management practices; (2) Through plant analyses, root, soil moisture, and salt distribution studies, determine optimum nutrient distribution in soil at particular stages of plant growth; (3) Based on new sampling techniques and current knowledge of salt and water movement in soils, determine fertilization requirements of crops grown on salt affects soils; (4) Correlate changes in salt concentration and soil-water content with nutrient uptake by crop plants during growth and development. Root distribution, and chemical analyses of plant material and soil solution will be utilized in these studies.

SUPPORTED BY California State Government

4.0029, PREDICTIONS OF WATER REQUIREMENTS OF CROPS FROM MICROCLIMATIC PARAMETERS

W.O. PRUITT, Univ. of California, Agricultural Experiment Sta., *Davis, California* 95616

Objectives and work proposed: 1. Determine evapotranspiration (ET) for a number of crops at various stages of growth and maturity including a crop of tall fescue as an indication of potential ET. 2. Compare above with predicted potential ET based on various empirical, semi empirical and theoretical methods for hourly or longer periods. 3. Determine the energy balance on a diurnal and seasonal basis. 4. In cooperation with Dept. of Agricultural Engineering personnel, study eddy transfer mechanisms for heat, moisture and momentum under both advection and non-advection conditions. 5. Study the influence on ET of several plant-soil-atmosphere conditions. ET for alfalfa tomatoes and sugar beets will be measured using the neutron moisture meter. A new 6' x 8' hydraulic lysimeter will also be used in the sugar beets in 1964 and in other crops later. ET for grass will be determined hourly using the two 40' lysimeters.

To accomplish objectives 2-5, a near-continuous measure of net radiation, soil heat flux, and evaporative heat flux will be obtained. In addition profiles of air temperature, humidity and wind speed as well as the flux of convective heat and momentum, will be determined for 1/2-hour periods under various climatic conditions during a number of days of the year.

SUPPORTED BY California State Government

4.0030, MOISTURE REQUIREMENTS OF DECIDUOUS ORCHARDS

K. URIU, Univ. of California, Agricultural Experiment Sta., *Davis, California* 95616

Objectives: This project was started to study the relation of soil moisture to the growth and production of fruit trees. (1) Study of the effect of irrigation on the end and side cracking of the prune. (2) Study of the effect of different soil moisture tensions in the upper ranges of available moisture on the vegetative and fruit growth of cling peaches.

SUPPORTED BY California State Government

4.0031, WATER RESERVOIR SYSTEMS

J.J. KALVINSKAS, North Amer. Rockwell Corp., *El Segundo, California*

POUNDERS

A program is proposed to investigate a reservoir system network in an urban area to alleviate problems of storm water runoff, eliminate costly and cumbersome sewer networks for storm drainage, and simultaneously provide for rainfall conservation. The study would be accomplished by conducting a systematic analysis of water runoff in an urban area, evaluating the location of a multiplicity of reservoirs throughout the area, and investigating both surface and subterranean reservoirs for rainfall storage.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

4.0032, NUTRIENT REMOVAL FROM AGRICULTURAL WASTE WATERS

L.A. BECK, State Dept. of Water Resources, *Fresno, California* 93723

Drainage facilities are being constructed in the San Joaquin Valley to remove perched brackish ground waters from the Valley. These drainage facilities are planned to discharge into San Francisco Bay. Nutrients in the drainage waters may cause algal growths in the Bay.

Studies are being conducted near Firebaugh, California, to develop a practical biological treatment method for nutrient removal and by use of pilot plant facilities determine the efficiency and design criteria and costs of construction, operation, and maintenance.

The methods under investigation are anaerobic bacteriological denitrification in deep ponds and packed columns, algae growth and harvesting in shallow ponds, and desalination.

SUPPORTED BY California State Government
U.S. Dept. of Interior - Bu. Reclamation
U.S. Dept. of Interior - F. Water Pol. Ctl
U.S. Dept. of Interior - Off. Saline Water

4.0033, GROUND WATER RECHARGE AND MANAGEMENT IN CALIFORNIA

P. NIXON, U.S. Dept. of Agriculture, *Fresno, California* 93726

Objective: To develop and evaluate improved facilities, methods, principles, and design criteria required for efficiently recharging underground water reservoirs.

Plan of Work: Continue study of water movement through soil down to the water table as it relates to storage rates, buildup and dissipation of ground water mounds, impeding layers within the profile, clogging by turbid water at the soil surface and permeability changes due to the interaction of salts in the percolating water and the exchange complex of soil layers. Quality of ground water resulting from recharge by both natural and artificial means will be studied. Work will be carried on in field plots and infiltrometers as well as in the laboratory.

SUPPORTED BY U.S. Dept. of Agriculture

4.0034, FLOOD AND SEDIMENT REDUCTION IN STEEP UNSTABLE BRUSHLANDS OF THE SOUTHWEST

R.M. RICE, U.S. Dept. of Agriculture, Pac. Sw. For. & Rg. Expt. Sta., *Glendora, California*

Object: To evaluate flood peaks and debris production in relation to meteorologic, geologic, edaphic and vegative conditions, and to develop and evaluate land treatments for controlling erosion and floods, particularly following fire in steep, unstable brushlands.

Plan of Work: The project staff is investing two overall problems: flood hydrology and erosion control measures. In flood hydrology, the studies include (1) inventories of hydrologic conditions in southern California; (2) investigation of variables pertinent to floods and erosion; and (3) hydrologic analyses of data from stable chaparral watersheds. The erosion control measures being evaluated are (1) wetting agents for reduction of post-fire erosion; (2) durable land treatments installed prior to and after a large fire; and (3) side slope erosion rates.

SUPPORTED BY U.S. Dept. of Agriculture

4.0035, ANALYSIS OF WATER CHEMISTRY

A.W. FAST, State Dept. of Fish & Game, *Los Angeles, California*

Objectives: To determine the effects of artificial destratification on the basic chemical and physical limnology of the lake by comparing observed changes in the lake with records of chemical and physical data collected during our investigations.

Procedure: Water samples will be collected from three depth intervals at one station monthly for complete chemical analysis. Water samples will be collected at 1- and 2-meter intervals, 2 to 4 times monthly, to determine dissolved oxygen, total alkalinity, turbidity, pH, and conductivity. Water samples will be collected at 2-meter intervals, 3 or 4 times yearly, to determine concentrations of phosphorus, manganese, and iron. Water samples will be collected at 2-meter intervals monthly to determine chlorine demand. Mud samples will be collected at 2-meter intervals monthly to determine chlorine demand. Mud samples will be collected from five depths, 3 or 4 times yearly, to determine complete oxygen demand and total nitrogen. Three mud samples will be collected from each 2-meter depth interval at three locations yearly to determine particle size and organic vs. inorganic fractions. Temperatures will be measured with a resistance thermometer from each 0.5-meter depth from these locations weekly. All water samples will be collected using standard techniques and equipment. Mud samples will be collected with an Ekman dredge or a small coring device. Chemical records compiled by the City of San Diego and Helix Irrigation District will be used to draw a base line for comparing observed changes due to destratification. Records will also serve as criteria for evaluating changes caused by water volume fluctuations. Comparisons will be made between the pre-aeration and aeration period.

Electronic data processing programs are being written to analyze the data.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
California State Government

4.0036, COOPERATIVE WATERSHED MANAGEMENT ON BRUSHLANDS OF CALIFORNIA

W.E. STEINER, Univ. of California, Water Resources Center, *Los Angeles - U.C.L.A., California* 90024

The University, from its Davis campus, on a matching fund basis, does research for the Department of Water Resources for the ultimate purpose of discovering best watershed management practices on typical brushlands of the State.

This year, evaluation of past experimental conversion of brushland to grassland, and of the effect of conversion on water yield, time distribution, and quality, will continue. Continued data collection is expected to confirm and further refine relationships discovered in the past between rainfall, rainfall patterns, and runoff, and between storm rainfall and surface and subsurface components of flow during and after storm periods. Prediction equations and graphs, and their necessary parameters will be further developed. Economic analyses of costs and benefits will continue, and possibly preliminary figures published. Studies will continue of the rates and sources of sediment, particularly where increased sediment production appears to be a corollary of increased water yield, and alleviation measures will be tried.

SUPPORTED BY California State Government
University of California

4.0037, SAN GORGONIO PASS GROUND-WATER STUDIES, CALIFORNIA

R.M. BLOYD, U.S. Dept. of Interior, Water Resources Division, *Menlo Park, California*

This research is part of the program of water resources investigations conducted by the U.S. Geological Survey in cooperation with State and local agencies in California.

Purpose: To determine the geologic and ground-water hydrologic features, feasibility of artificial recharge, and storage of water in the ground-water basins or storage units within the San Gorgonio Pass Water Agency area.

Methods: Available ground-water levels, well logs, well depths and yields, specific capacities, pumpage figures, chemical analysis, streamflow measurements, data on streamflow, and evaporation data will be collected. The pattern of ground-water movement will be shown by water-level contour maps. Gravity and magnetometer surveys will be made to assist in determining the location of ground-water barriers. These surveys may be supplemented by seismic surveys to define ground- water barriers, the extent of the ground-water basins, the thickness of the aquifers and the basin profile at the San Gorgonio River narrows.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
California State Government

4.0038, FLOOD FLOWS AND SEDIMENT YIELD OF COLMA CREEK BASIN, CALIFORNIA

G. PORTERFIELD, U.S. Dept. of Interior, Water Resources Division, *Menlo Park, California*

This research is part of the program of water resources investigations conducted by the U.S. Geological survey in cooperation with State and local agencies in California.

Purpose : To determine the water and sediment yield of Colma Creek basin and evaluate the effect of current urbanization on the future yield of the basin.

Methods: Data will be obtained at two locations in the basin on a continuous basis and periodic observations of sediment and water discharge will be made at various other locations in the basin. These locations were selected on the basis of drainage area, and of the current and potential development in each area. The first location, that of the present gage on Colma Creek, is located downstream of the major urbaniztion and construction projects. The second location, that of Spruce Branch, is located downstream of an area where urbanization and basis erosion controls are nearly complete. Data thus obtained by standard procedures will be correlated with the various geologic, hydrologic, and physical factors influencing runoff and erosion.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
California State Government

4.0039, FLOODS FROM SMALL DRAINAGE AREAS

W.E. STEINER, U.S. Dept. of Interior, Water Resources Division, *Menlo Park, California*

The U. S. Geological Survey conducts this cooperative program, also contributed to by the U. S. Forest Service and the California Division of Highways, to determine flood magnitude and frequency data from representative small (10 square miles or less) drainage basins in California. About 270 crest stage gages have been installed on statistically representative small drainage basins. Thirty continuous recorders are moved from basin to basin, as correlations are established, so that eventually there will be sufficient data to define the magnitude and frequency of these floods on a regional basis for the entire State.

SUPPORTED BY California State Government
U.S. Dept. of Interior - Geological Survey

4.0040, TOLERANCE AND PHYSIOLOGICAL REACTIONS OF PLANTS TO SALINITY AND RELATED FACTORS

C.A. BOWER, U.S. Dept. of Agriculture, ***Riverside, California***

Objective: Determine the salt, specific ion, and exchangeable sodium tolerances of economic plants and the underlying physiological and biochemical mechanisms of growth inhibition by these factors.

Plan of Work: Use greenhouse cultures, outdoor sand tanks, and field plots to grow crops and ornamental plants under controlled salinity conditions, to determine tolerance to total salinity, specific ions, and exchangeable sodium as related to mineral nutrition, climatic factors, and foliar absorption of salt. Analyze experimental plants for salt accumulation and investigate mechanisms of salt absorption and translocation. Determine water status and water use by salt affected plants in relation to salt tolerance. Determine change in metabolic rates and pathways in salt-affected plants, and salt effects on content and properties of enzymes. Investigate methods for improving salt tolerance of crops by correcting chemical lesions, applying protective chemicals, modifying growing conditions, and selecting more tolerant varieties.

SUPPORTED BY U.S. Dept. of Agriculture

4.0041, LEACHING REQUIREMENT AND SALINITY STUDIES WITH BEARING ORANGE TREES

F.T. BINGHAM, Univ. of California, School of Agriculture, *Riverside, California* 92502

Bearing orange trees are being irrigated with salinized waters to observe the effects of soil salinity on fruit production. The objective is to develop appropriate irrigation management procedures for waters differing in salinity and alkali hazards.

The experiment consists of 4-tree plots, replicated 5-fold for each of the four irrigation waters. Irrigation is by basin flooding, applications being timed according to soil suction with treatments being initiated July 1965. Soil salinity levels are followed continuously. Plant tissue analysis, soil, analysis, and various soil physical properties will be related to tree performance, including fruit production characteristics.

SUPPORTED BY University of California

4.0042, CURRENT FISH AND WILDLIFE PESTICIDE PROBLEMS

E.G. HUNT, State Dept. of Fish & Game, *Sacramento, California*

Objectives: To evaluate those fish and wildlife pesticide problems and relationships that are currently of greatest concern to the Department. Concern is based on potential hazard to wild animas of certain experimental programs. The investigations are aimed primarily at (1) developing information regarding the hazard of these chemicals under field conditions, and (2) developing a guide for establishing adequate safeguards for fish and wildlife. Special attention will be given to the hazards to game and nongame species created by the use of mercurial seed dressings, aerial application of 1080 treated rodent baits and Endrin treated conifer and brush seeds, organic phosphates in cotton culture, and polychlorinated biphenyls (PCB) in eggs of raptors and water-associated birds.

Procedures: (a) Evaluate the hazard of mercurial seed dressings to birds. A survey will be made to determine the amounts of the different mercurials being used in California. Caged pheasants will be fed grain treated with alkyl mercury and another type of mercury fungicide to determine the effect on the test animals and the amount and type of mercury accumulated in tissues. Pheasants will be collected in areas where alkyl mercury and other mercury seed dressings have been used extensivley over a period of years. The birds will be examined for gross pathology and tissues analyzed for mercury content. (b) Evaluate the effects on nontarget wildlife of the aerial application of 1080 grain baits, Diphacin, and Endrin treated conifer and brush seeds in both field and forest rodent control programs. (c) Field evaluations will be made regarding the effects on game and nongame wildlife resulting from the application of insecticides in cotton fields. (e) Eggs of raptors and water-associated birds will be collected and analyzed for polychlorinated biphenyls.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
California State Government

4.0043, HYDROLOGIC ANALYSIS OF GROUNDWATER BASINS BY DIGITAL COMPUTER SIMULATION

C.F. MEYER, General Electric Company, *Santa Barbara, California*

This project has a dual purpose: (1) to improve certain of the techniques used in devising a mathematical model of a groundwater basin, and (2) to provide technical assistance and consultation to other investigators, who are conducting separate but related research.

Mathematical techniques will be developed to permit water-elevation and other historical records to be used to deduce the effective values of storage factor, S, and transmissibility, T, in an aquifer. These techniques will be incorporated into a sample computer program, provided by the California Department of Water Resources, by means of which groundwater flow in an aquifer can be simulated and water levels computed. An evaluation will be made of the sensitivity of the techniques for deducing S and T to possible inaccuracies in estimating water production and recharge.

Technical support and consultation from the TEMPO staff and its consultant, David K. Todd, will make available the results of this work and other experience to the High Plains Underground Water Conservation District and to Texas Technological College, of Lubbock, Texas, who will investigate the application of mathematical modeling and computer simulation to the Ogallala aquifer and its management.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

4.0044, ROCK CREEK PARK CLARIFICATION PROJECT

H.F. SCHAEFER, Dow Chemical Company, *Walnut Creek, California* 94598

The objective of this project is to demonstrate the feasibility of and determine operating costs for in-stream treatment with polyelectrolytes for the removal of suspended solids and other contaminants.

A site will be selected on upper Rock Creek within the District of Columbia. Polyelectrolyte solutions will be sprayed into the stream at a rate proportional to the streamflow rate. The coagulated solids will settle a certain distance downstream in a temporary settling basin created by an inflateable dam. Water leaving the basin will be chlorinated for further disinfection.

Various parametric studies will be conducted, including investigation of different polyelectrolyte types, different dosing rates, and sludge recycle.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

4.0045, LITERATURE REVIEW ON FLOODED GREEN TIMBER AREAS

R.E. CHANDLER, Canadian Wildlife Service, *Ottawa - Ontario, Canada*

To review the existing literature on flooded green timber areas to assess their possible value to waterfowl in Ontario and to suggest possible methods for the management of such areas for maximum waterfowl utilization. These methods will be implemented in management plans for any such areas acquired in Ontario.

SUPPORTED BY Canadian Government

4.0046, MARSH EVALUATION AND ACQUISTION - ONTARIO

D.G. DENNIS, Canadian Wildlife Service, *Ottawa - Ontario, Canada*

To provide a three stage report on the quality waterfowl areas throughout Southern Ontario, directed towards the maintenance and development of suitable waterfowl habitat. The primary phase will be a preliminary list of wetland units showing location, acreages, descriptions, cost estimates and on acquisition priority rating. The second phase will be submitting acquisition proposals for each area. Following acquisition, an ecological study and management plan will be prepared for each unit. This project was begun in 1967 and will continue for an undetermined period.

SUPPORTED BY Canadian Government

4.0047, STUDY OF THE DISTRIBUTION OF FOUR ASSOCIATIONS OF AQUATIC PLANTS IN THE VICINITY OF MONTREAL

J. LAMOUREUX, Canadian Wildlife Service, *Ottawa - Ontario, Canada*

To study the relationship of four associations of aquatic plants, namely Scirpetum, Saggitarietum, Typhaetum and Pontederietum, with depth of water. To assess their general relative position on a transect line running from pasture to water. To compare data obtained in different kinds of marshes, i.e., islands (6), bays (2), bog lakes (1). To describe the distribution of these associations in the vicinity of Montreal.

SUPPORTED BY Canadian Government

4.0048, AN ECOLOGICAL STUDY OF ILES-DE-LA-PAIX, LAKE ST. LOUIS, QUEBEC

M. LAPERLE, Canadian Wildlife Service, *Ottawa - Ontario, Canada*

To study the ecological relationships between the habitat and waterfowl using a group of alluvial islands in Lake St. Louis, Quebec. This study will be conducted over a period of two years and has begun in April 1968.

SUPPORTED BY Canadian Government

4.0049, MARSH EVALUATION AND ACQUISITION, QUEBEC

M. LAPERLE, Canadian Wildlife Service, *Ottawa - Ontario, Canada*

To provide a three-phase report on quality wetland areas in the province of Quebec, directed toward maintenance and development of adequate waterfowl habitat. The initial phase consisted of a preliminary list of wetlands showing their location, acreage, description, cost estimates and an acquisition priority rating. A separate acquisition proposal is then made for each area. Following acquisition, an ecological study and management plan will be prepared for each unit. This project was begun in 1966 and will continue on an undetermined period.

SUPPORTED BY Canadian Government

4.0050, AN ECOLOGICAL STUDY OF LAKE ST. PETER, QUEBEC

W.T. MUNRO, Canadian Wildlife Service, *Ottawa - Ontario, Canada*

To study the relationships between water level aquatic plants and insects, and duck production on Lake St. Peter, Quebec. This study, with the emphasis to be placed on the black duck, was begun in April, 1968.

SUPPORTED BY Canadian Government

4.0051, WATERFOWL HABITAT INVESTIGATIONS - OTTAWA RIVER

W.T. MUNRO, Canadian Wildlife Service, *Ottawa - Ontario, Canada*

To study the effects of flooding on waterfowl habitat on the Ottawa River. The water level of the Ottawa River at the study area near Thurso, Quebec, was raised after a hydro-electric dam was erected at Carillon, in 1963. Vegetation and waterfowl breeding surveys were to be carried out before, during, and after the flooding of the river to determine the relationship between the pre-flood and post-flood vegetation complex and waterfowl use.

SUPPORTED BY Canadian Government

4.0052, MARSH EVALUATION AND ACQUISITION - MARITIMES

A.D. SMITH, Canadian Wildlife Service, *Ottawa - Ontario, Canada*

To provide a three phase report on quality wetland areas throughout the Maritimes, directed toward maintenance and development of adequate waterfowl habitat. The initial phase will be a preliminary list of marsh units showing location, acreages, descriptions, cost estimates and an acquisition priority rating. According to priorities acquisition proposals will then be submitted for each area. Following acquisition, an ecological study and management plan will be prepared for each unit.

SUPPORTED BY Canadian Government

4.0053, REHABILITATION, SCOTSBURN MARSH, NOVA SCOTIA, CANADA

G.H. WATSON, Canadian Wildlife Service, *Ottawa - Ontario, Canada*

To design a waterholding structure for this marsh. To experiment with waterlevels in order to obtain optimum habitat conditions for waterfowl and furbearers. To encourage growth of desirable aquatic plants through waterlevel fluctuation; plowing, discing, and fertilizing. To increase the quality of habitat through construction of nesting islands, and excavating of areas which cannot be adequately flooded.

This project involves land acquisition, and therefore the starting date is uncertain. It is hoped that it will commence in 1968, and that certain investigations will continue for an indefinite period.

SUPPORTED BY Canadian Government

4.0054, MUSQUODOBOIT - METERING BASINS NOVA SCOTIA, CANADA

G.H. WATSON, Canadian Wildlife Service, *Ottawa - Ontario, Canada*

To evaluate the ecological effect of change in the water levels and related causes in small lakes, bogs, and marshes in the Musquodoboit watershed. The first stage, observation of vegetation before water- retaining structures are built, is to take place in September 1967. Each following year a vegetation survey is to be made. In addition, use by wildlife will be observed. It is hoped to carry out experiments with fluctuating water levels to reach an optimum stage of aquatic vegetation for waterfowl and furbearers.

SUPPORTED BY Canadian Government

4.0055, IMPROVEMENT OF HIGH ALTITUDE (7600) VEGETABLE CROPS

F.D. MOORE, Colorado State University, Agricultural Experiment Sta., *Center, Colorado*

1. Determine nutritional requirements of San Luis Valley vegetable crops as related to irrigation practices with regard to an increase in crop yield and quality. 2. Relate environmental phenomena peculiar to high altitude growing area to production of vegetable crops. 3. To test vegetable crop varieties, strains, and breeding lines for their commercial production value in the San Luis Valley. 4. To test chemical herbicides and determine correct rates for their use on vegetable crops grown in the San Luis Valley. 5. To determine irrigation practices which will best conserve water with no limitation to vegetable crop production. 6. To retard senescence of highly perishable vegetables.

A major portion of the study will involve the determination of the optimum fertilization of head lettuce with regard to irrigation practices. Soil and tissue analyses will be made as well as measurements on yield and quality after vacuum pre-cooling and the transit and marketing period. Effect of solar UV radiation and high intensity solar radiation (in the visible range) on vegetable crops will be studied. Varieties will be evaluated with regard to market preference, San Luis Valley growing conditions, and quality during the transit and marketing period. Rates and methods of application of standard herbicides as well as experimental chemicals will be tested. An attempt will be made to prolong the marketable condition of head lettuce and cauliflower through the use of anti-senescence compounds. Enzyme and respiration studies will be used to supplement information gained from the senescence and radiation studies.

SUPPORTED BY Colorado State Government

4.0056, WATER APPLICATION AND USE ON A RANGE WATERSPREADER

F.A. BRANSON, U.S. Dept. of Interior, Water Resources Division, *Denver, Colorado*

The objective of this project is to determine quantities and frequency of flows onto the spreader and the quantities of water stored and lost from the soil during the growing season. To determine changes in vegetation and soils due to waterspreading.

The spreader site was precalibrated in terms of kinds and quantities of plants present for three years before the waterspreader was constructed. One year of soil moisture records on the spreader and control areas were obtained before water was applied to the spreader.

Water applied to the spreader is measured by means of a water stage recorder which determines the duration of flow through a pipe onto the spreader and by means of a rain gate. Use of water on the spreader is determined by means of periodic soil moisture samplings.

Plant measurements are being made by the Montana Agricultural Experiment station. The measurements include line transects and yield determinations. Twelve species were seeded on the spreader to test adaptability.

Soil samples for physical and chemical measurements were taken before water spreading and will be obtained again during the final year of study.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

4.0057, RADIOISOTOPE WATER FLOW MEASUREMENT IN HIGH-HEAD TURBINES AND PUMPS

R.L. HANSEN, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225 (AT(49-11)2758)

Radioisotope methods and instrumented systems developed by the Denver Office, Bureau of Reclamation, Department of the Interior, for open channel water flow measurements are adaptable in part to the problem of accurately determining the rate of water flow through high-head turbines and pumps -a measurement which cannot be as accurately made by conventional methods. Research is being conducted to determine the minimum mixing length required to obtain adequate mixing. Techniques and equipment for injection of radioisotopes are being developed. A program of field testing is being

SUPPORTED BY U.S. Atomic Energy Commission

4.0058, RESEARCH AND BASIC DATA ON THERMAL POLLUTION

G.E. HARBECK, U.S. Dept. of Interior, Geological Survey, *Denver, Colorado*

This work, initiated in FY'69, involves research into some of the theoretical aspects of heat transfer and dissipation when heated water is discharged to rivers. Of primary interest will be the relationships among the eddy-transfer coefficients, or diffusivities, of heat, momentum, and water vapor when the atmospheric lapse rate is non adiabatic.

In addition to the research, certain basic data will be collected and published that will be immediately helpful to both plant designers and researchers. The data would include flow, measurements of temperature profiles, and velocity distribution under controlled conditions on 10 to 12 streams representing a wide range of flow conditions and a variety of climatic and weather conditions. In addition, various pertinent meteorological parameters would be measured; air temperature, humidity, and wind speed.

SUPPORTED BY U.S. Atomic Energy Commission

4.0059, GROUNDWATER ANALYSIS BY DIGITAL COMPUTER APPLICATION DEVELOPMENT

H.R. MCDONALD, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

This study will develop procedures for the analysis of groundwater aquifer systems covering areas up to 25,000 square miles by use of digital computer applications. Present methods, using electric analogs are satisfactory for areas up to 2,500 square miles but become unmanageable for areas of larger magnitude. Extensive areal study of declining water tables, forecasting aquifer depletions, and relating this source of water supply to potential Reclamation project demands are primary objectives of this new research activity.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

4.0060, SURFACE WATER MANAGEMENT

R.E. DANIELSON, Colorado State University, Natural Resources Center, *Fort Collins, Colorado* 80521

The objectives of this research are: 1. to study the relative importance of various range conditions in Alpine areas to soil movement and water contamination; 2. to examine the dichotomy between flood hydrographs from 'forested' and 'agricultural' watersheds; 3. to develop soil treatments and systems of land preparation that will promote maximum use by the crop of rain where it falls, in marginal regions; and 4. to study the role of seepage and the mechanics of bank development in alluvial channels and its significance in the design of conveyance systems and control of rivers.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

4.0061, GROUND WATER RECHARGE AS AFFECTED BY SURFACE VEGETATION AND MANAGEMENT

R.E. DANIELSON, Colorado State University, School of Agriculture, *Fort Collins, Colorado* 80521

Contributions to groundwater of range and cultivated lands will be determined in eastern Colorado. Plant species and microrelief and texture of the soil will be evaluated as factors modifying this contribution.

Surface treatments such as: contour ridging, basin listing, herbicided to reduce or eliminate transpiration, surface mulches, altering surface texture, snow fences, and chemicals to increase infiltration and retard evaporation will be evaluated as to their effect on increasing recharge.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Colorado State University
Colorado State Government

4.0062, GROUND WATER TABLE FLUCTUATIONS

H.R. DUKE, Colorado State University, Agricultural Experiment Sta., *Fort Collins, Colorado* 80521

A. Establish an observation well network. B. Arrange periodic measurements of ground water table elevations at selected observation wells. C. Compile power consumption records for pumping plants. D. Develop procedures for processing data by machine methods. E. Periodic publication of basic data and interpretation of analysis.

Description of Work: Water table elevations in each observation well are measured each spring and fall. Basic information is analyzed and published periodically.

SUPPORTED BY Colorado State Government

4.0063, LOW GRADIENT BORDER CHECK IRRIGATION

N.A. EVANS, Colorado State University, Agricultural Experiment Sta., *Fort Collins, Colorado* 80521

OBJECTIVES: To determine the operating characteristics of border check irrigation systems with very low gradients in order to improve water management practices.

DESCRIPTION: Border checks with land gradients in the range of 0 to 0.1 percent will be studied to determine optimum rate and volume of water application as a function of crop and soil characteristics.

SUPPORTED BY Colorado State Government

4.0064, DRAINAGE FACILITIES, METHODS, AND DESIGN CRITERIA FOR PROTECTION AND IMPROVEMENT OF AGRICULTURAL CROPS AND SOILS IN THE NORTHERN PLAINS

H.R. HAISE, Colorado State University, School of Engineering, *Fort Collins, Colorado* 80521

Object: To develop theoretical and rational equations describing flow of water to surface and subsurface drains utilizing laboratory and field approaches for the development and evaluation of new methods and facilities for improvement and protection of agricultural crops and soils and the disposal or reuse of drainage water.

Plan of Work: Cooperative investigations will be conducted in the laboratory and field. Field evaluations of newly developed systems and practices will be made at specific sites under exacting engineering controls. The evaluation of new facilities for drainage will be made in various regions involving different soil and climatic conditions. New methods of drainage will be developed for special problem areas. Basic drainage formulas for computing drain spacing and depth of drains developed in the laboratory will be evaluated in the field for accuracy and suitability for use by drainage engineers. Data obtained from this project will provide additional design criteria based on recent developments in drainage techniques that have been evaluated in field studies.

SUPPORTED BY U.S. Dept. of Agriculture

4.0065, TURF RESEARCH

W. MACKSAM, Colorado State University, Agricultural Experiment Sta. , *Fort Collins, Colorado* 80521

Objectives: (1) Irrigation-rates, frequency, methods, costs. (2) Varieties. (3) Pests-weeds, diseases. (4) Plant nutrition, etc.

Procedures: Establishment of plots under sprinkler irrigation, comparing grass clipping heights, fertilizers and herbicide application.

SUPPORTED BY Colorado State Government

4.0066, SEDIMENTATION AND CONTAMINANT CRITERIA FOR WATER RESOURCES PLANNING AND MANAGEMENT

H.W. SHEN, Colorado State University, School of Engineering, *Fort Collins, Colorado* 80521

To study the effect of vegetation on flow rate, sediment yield and dispersion of pollutant in watershed.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Colorado State University

4.0067, GROUND WATER RESOURCES

D.K. SUNADA, Colorado State University, School of Engineering, *Fort Collins, Colorado* 80521

Objectives: A) Analyze and develop techniques for efficient development and management of ground water aquifers. B) Evaluate the feasibility and usefulness of such techniques in maximizing the use of Colorado's water resources. C) Investigate the applicability of management and development techniques deemed feasible to the various ground water situations in Colorado and other areas. D) Train young engineers and scientists in the latest advancements for analysis and management of ground water resources through the graduate research program. E) Serve as advisors to the Colorado Ground Water Commission, Colorado Water Conservation Board, State Engineers Office, and other State and local water agencies on ground water problems.

Work Proposed: Refinement of modeling techniques which have been developed recently will be pursued and will include considerations for water quality. The measurement of water levels in the observation well network will provide the necessary data for construction and verification of particular models as well as provide information now needed prior to management decisions.

SUPPORTED BY Colorado State Government
Colorado State University

4.0068, INFLUENCE OF ACCUMULATED SEDIMENTS UPON WATER VELOCITY OF MICROHABITATS OCCUPIED BY TROUTS

R.E. VINCENT, Colorado State University, State Coop. Fishery Unit, *Fort Collins, Colorado* 80521

Water velocities will be recorded near the bottom and sides of a stream. After severe turbidity and settling of bottom sediments, water velocities will be taken in the same cross section. The difference between the before and after water velocities can be paired with the velocity requirements of salmonids to give an indication of the influence of sediments upon microhabitats of trout.

The work will be conducted upon the upper Dolores and Rio Grande Rivers in southern Colorado.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Colorado State University

4.0069, INFLUENCE OF SEDIMENTATION UPON THE PRODUCTION OF GAME FISHES

R.E. VINCENT, Colorado State University, State Coop. Fishery Unit, *Fort Collins, Colorado* 80521

A pre-treatment population inventory was made of all species of fishes in Blue Water Creek in 1963. Sections of the watershed were then treated to reduce the amount of sediment in the watershed. Post treatment inventory will then be made of all fish species with emphasis upon species composition, numbers and age class, standing crop and productivity. Fish population information can be correlated with the changes in sediment discharge and attendent changes in water temperatures, food organisms, etc.

The project is being conducted in Blue Water Creek in south-central Montana.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
U.S. Dept. of Interior - F. Water Pol. Ctl
Montana State Government
Colorado State University

4.0070, COVER AS A LIMITING FACTOR IN TROUT PRODUCTION

R.E. VINCENT, Colorado State University, State Coop. Fishery Unit, *Fort Collins, Colorado* 80521

A one mile section of study stream was surveyed and divided into 100 ft sections of a general, uniform type. Measurements that determined the uniformity were mean current velocity, velocity distribution, total cover, amount of cover, and water depth. Fish population is being censused in each section by electrofishing so that number and weight of fish present can be related to the physical features of the stream. Fish cover will be manipulated to demonstrate further the effects of cover and population density.

Project is being conducted on Dale Creek, northern Colorado.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Colorado State University

4.0071, STORM RUNOFF AND FLOODS AS RELATED TO INTEGRATED CLIMATIC AND WATERSHED CHARACTERISTICS

D.A. WOOLHISER, Colorado State University, School of Engineering, *Fort Collins, Colorado* 80521

Object: To identify and integrate climatic and watershed factors influencing storm flows and floods from watersheds; develop procedures to estimate such flows from ungaged watersheds; to develop working tools to synthesize flood hydrographs, and methods to estimate the effects of changed use and conservation treatment of land on such flows; to study precipitation characteristics; methods to estimate the effects of pervious stream channels and valley alluviums and combining or joining hydrographs of storm runoff and flow from small to increasingly large watersheds as flood waves travel downstream.

Plan of Work: The work is currently in progress on agricultural watersheds in the vicinity of Hastings, Nebraska; Newell and Cottonwood, South Dakota; and Ft. Collins Colorado. Some of the factors required for the analysis and which are measured or otherwise documented for the study are: rates and duration of streamflow; precipitation patterns; antecedent moisture; season, soils; land use; conservation and watershed management practices; ground water elevations; riparian vegetation; geology; gradients and hydraulic roughness of stream channels; and the size, shape and other geomorphic attributes of the watersheds.

SUPPORTED BY U.S. Dept. of Agriculture

4.0072, FACTORS INFLUENCING THE STABILITY AND REGIME OF CHANNELS IN AGRICULTURAL WATERSHEDS

D.A. WOOLHISER, Colorado State University, Agricultural Experiment Sta., *Fort Collins, Colorado* 80521

Object: To establish fundamental principles and develop planning and design criteria on (1) stability of natural and artificial channels; (2) influence of altered flow and sediment regime on channel deformation; (3) deposition patterns above sediment detention and water storage structures; and (4) geomorphic influences in waterway physiography.

Plan of Work: Laboratory and field studies will be made of (a) numerous channels with measurement or identification of all factors contributing to the existing conditions; (b) effect of imposing water and sediment control on the natural regime; (c) topographic maps, aerial photographs, and historic records of channel shapes, geometrics, and waterway systems, and (d) coordination of laboratory and field investigations. Factors to be measured or identified include channel shapes and meander, hydraulic characteristics, water and sediment conveyance, vegetation aspects, physical and chemical characteristics of channel periphery materials, rates of aggradation and degradation, geomorphic parameters, climatic events and land use influences. New and improved instrumentation and techniques to measure and identify channel stability features will be developed. Findings will be analyzed and interpreted to provide information necessary to establish guides and criteria for planning, design, and maintenance of agricultural watershed programs.

SUPPORTED BY U.S. Dept. of Agriculture

4.0073, MATHEMATICAL MODELING OF SMALL WATERSHED FLOODS

V. YAVJEVICH, Colorado State University, School of Engineering, *Fort Collins, Colorado* 80521

The objective is the characterization of the response of small watersheds to rainfall in terms of methematical relations among the physical parameters of the watershed. These relations will then be used to predict the runoff hydrographs for floods from small watershed.

Work will include: (1) Statistical correlation of watershed parameters with runoff; (2) Investigation of models developed from concepts of physical processes at work in runoff; (3) Coordination with a related project involving a one-acre experimental facility for rainfall-runoff experiments. Data from natural flood events will be added to the existing Small Watershed Data File.

SUPPORTED BY Colorado State Government

4.0074, MANAGEMENT OF FOREST GAME RANGES IN THE CENTRAL ROCKY MOUNTAINS, AND IMPROVEMENT OF FISH HABITAT BY MANIPULATION OF STREAMSIDE VEGETATION

D.R. SMITH, U.S. Dept. of Agriculture, Rocky Mtn. For. & Rg. Ex. Sta., *Fort Collins, Colorado*

Object: To determine (1) what constitutes high-quality habitat for important game species and desirable streamside vegetation for trout waters; (2) how habitat and streamside vegetation is modified by other land uses and range and watershed improvement practices, and (3) methods of habitat improvement for the particular vegetation types and physiography of the region.

Plan of Work: Studies will be made of (1) environmental characteristics in terms of soil, elevation, aspect, vegetation type, etc.; effects of fire, logging, and livestock grazing; quantity, quality, and use of plants present; and of the current status of streamside vegetation and effects of land use; (2) the effect, on wildlife habitat values of chemical and mechanical plant control used for range improvement; and effects of phytocides and mechanical treatments in terms of physical and chemical changes of plants affecting habitat quality for particular game species; (3) the possible use of soil and plant amendments to improve nutritional quality and palatability of abundant low-quality species, to improve composition of the vegetation, and to attract game animals from deteriorated ranges; and (4) ecology of browse species with first attention on true mountain mahogany. Range, site, reproduction, longevity, and production and palatability of the forage will be determined.

SUPPORTED BY U.S. Dept. of Agriculture

4.0075, POTENTIAL FISHERY FOR RIVER HERRINGS IN CONNECTICUT RIVER

W.A. LUND, State Board of Fish. & Game, *Hartford, Connecticut*

During 1966, basic information will be gathered on the time and duration of the run of each species of Alosa (with the exception of Alosa sapidissima) which enters the Connecticut River. Physical data will be gathered and temperature will be constantly monitored near the mouth of the river. The entering adults will be sampled with gill nets and lengths, weights and sex will be recorded. Scale samples will be taken for age determination. This sampling will continue periodically during the entire run. The techniques worked out and the basic data gathered at this time will be used to plan a more intensive study to be conducted in 1967 and 1968.

A survey will be made to ascertain the major spawning areas of each species. This area will be sampled with gill nets, seines and plankton nets to determine the species present and if spawning has occurred. Physical and chemical data will also be collected at this time.

This preliminary survey augmented by information gathered on the other sub-projects shown enable us to design an intensive survey which will be carried out in 1967 and 1969.

The laboratory facilities of the University of Connecticut, Marine Research Laboratory will be utilized for this sub-project.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.
Connecticut State Government

4.0076, RESEARCH AND TRAINING PROGRAM DEALING WITH THE PROBLEMS AND POTENTIALITIES OF THE FOUR MAJOR RESERVOIR PROJECTS CURRENTLY UNDER WAY IN AFRICA

G.F. WHITE, Natl. Academy of Sciences, *Washington, District of Columbia*

The great artificial lakes being created by dams--Nasser in the United Arab Republic, Kariba on the borders of Zambia and Rhodesia, Kainji in Nigeria, and Volta in Ghana -- will eventually cover a combined surface of more than 7,000 square miles, bringing changes which will radically affect the economy and culture of the regions. At the outset, more than 250,000 people will have to be resettled to permit flooding of the areas; subsequently the introduction of hydroelectric power, the elaboration of irrigation and fisheries projects, and the development of transportation can be expected to transform the physical environment and alter the mode of life of whole populations.

SUPPORTED BY Rockefeller Foundation

4.0077, ECONOMIC ANALYSIS OF WATER USE IN IRRIGATION IN THE NORTHERN PLAINS

G.A. PAVELIS, U.S. Dept. of Agriculture, *Washington, District of Columbia*

Objectives: To analyze crop response to irrigation water under alternative managerial practices and soil conditions.

Approach: The analysis will be confined to small grains, legumes, sugar beets and potatoes, the crops best suited for irrigation in North Dakota. The managerial practices will be selected to include different levels of fertilization and alternative systems of farming and other managerial inputs consistent with irrigation farming. Primary data will be collected from irrigation farmers and the North Dakota State University Branch Irrigation Station. Additional data relevant to this study will be obtained from research planned by the Soils Department, North Dakota State University to measure response to irrigation water as affected by timing and amount of water per application.

SUPPORTED BY U.S. Dept. of Agriculture

4.0078, EFFECTS OF HEATED WATER IN A TIDAL ESTUARY

R.L. CORY, U.S. Dept. of Interior, Water Resources Division, *Washington, District of Columbia*

The Patuxent River is one of the few rivers entering Chesapeake Bay that presently is more or less free from cultural influences. In the near future rapid change is expected to result from urbanization in the upper basin and operation of a large generating plant at Chalk Point, which will significantly alter the temperature of the water in that vicinity. At times the heated water released into the estuary will be equal to or greater than the fresh water inflow.

The objective of this project is to understand the effects of such release in the physical, chemical, and biological character of a tidal river by studying the yearly and seasonal attachment, rates of growth and mortality of attached organisms, and associated physical factors, including salinity. Interrelations between the environment and aquatic biota will be determined for the normal hydrologic condition and the heated condition over a period of about two years for each.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

4.0079, WATER TABLE CONTROL IN ORGANIC SOILS

F.H. THOMAS, Univ. of Florida, Agricultural Experiment Sta. , *Belle Glade, Florida*

Objective: (1) To determine the effectiveness of lined and unlined mole drains as part of a water table control system for shallow organic soils and (2) To make preliminary evaluations of crop response to different water table depths in shallow organic soils.

Description: Three water tables will be maintained on 9 plots on Everglades peaty muck soil in a 3 x 3 Latin Square design. Sub plot treatments will consist of unmoled (check), conventional moling and plastic-lined mole drains. Water stage recorders established in the center of each sub-plot and in the 3 ditches surrounding the main plots will give the relation of water levels in the ditches to water tables in the plots. Piezometer tubes installed at strategic locations will furnish data to characterize the slope of the water table. Effectiveness of mole treatments will be determined by their ability to maintain the desired water table. Crops will be planted with rows crossing all moling treatments.

SUPPORTED BY Florida State Government

4.0080, EVALUATION OF CONSUMPTIVE WATER USE, SOIL-WATER STORAGE, AND THE INTERRELATION OF THREE COMPONENTS OF THE WATER BUDGET

W.H. SPEIR, Univ. of Florida, Agricultural Experiment Sta. , *Gainesville, Florida* 32601

Data is collected from evaporation pans, evapotranspirometers, and land tanks located at Plantation Field Laboratory and the Everglades Experiment Station. Rainfall, runoff, groundwater levels, standard pan evaporation, and artesian pressure data are collected from four experimental watersheds in south and central Florida Flatwoods ranging in size from 4,000 to 63,000 acres.

These data are analyzed and correlated in order to: determine the effect of plant density, water table level, and climatic factors on evapotranspiration and apply these findings to agricultural watersheds; evaluate open water evaporation and the effect of climatic conditions on these water losses; derive methods for computing changes in soil moisture and ground water storage on a watershed basis; derive and test methods for estimating evapotranspiration from small agricultural watersheds; and, evaluate contribution of artesian and pumped irrigation to basin storage.

SUPPORTED BY Florida State Government

4.0081, DESIGN, INSTALLATION, AND MAINTENANCE OF SURFACE AND SUBSURFACE DRAINAGE SYSTEMS WITH OR WITHOUT LANDFORMING AND CONDITIONING

J.R. CARREKER, U.S. Dept. of Agriculture, *Athens, Georgia*

Object: To improve surface drainage systems on farms which will permit high level crop production and more effective use of modern farm machinery; to determine the factors which control design of surface water conveyance systems and develop ways to stabilize such facilities; and to study design features and the feasibility of using lower cost materials for subsurface drains; and develop methods of maintaining subsurface drainage systems in good condition.

Plan of Work: Drainage and water control system design will be related to soil properties and drainage needs. Drainage systems and related tillage management will be developed to provide necessary surface add profile and water control and permit effective use of modern farm machinery. Data will be obtained on the rate of water movement over, into, and through the soil, and on the other soil properties that affect the management of water. Study will be made of the effect of length and gradient of the row, and the rates and amount of runoff, together with data on row erosion, in order to reorganize drainage patterns in the sugar cane production areas, to improve drainage and workability of the land, and to increase the percentage of land in useful crops. The overall use of lower cost materials for drains will be tested. The need for and required design features for subsurface systems will be studied in the laboratory and field.

SUPPORTED BY U.S. Dept. of Agriculture

4.0082, THE ARTESIAN SYSTEM IN GEORGIA STRATIGRAPHY AND HYDROLOGY OF THE OCALA

R.E. CARVER, Univ. of Georgia, Graduate School, *Athens, Georgia* 30602

The Ocala limestone is a principal source of water for the south Georgia region whose continued development depends upon the intelligent use of water supplies from this aquifer. The hydrologic and recharge characteristics of the Ocala are not well understood; hence the long range productivity of the reservoir cannot be predicted.

The major objectives of the research are to determine: (1) the lithology and distribution of the Ocala and correlative units, (2) the hydrologic and recharge characteristics of the Ocala and correlative units, and (3) the effects of long term use (last 50 years) on the piezometric surface.

Procedure: All known data regarding the geology, water and well records of the Ocala limestone aquifer will be compiled. In addition, palynological, petrological, lithostratigraphical and biostratigraphical studies of the Ocala limestone from well samples and also from the entire outcrop area within the state of Georgia will yield new data on the three dimensional stratigraphy of this aquifer in both the surface and the subsurface. This knowledge will lay the groundwork for further studies on ascertaining where and how the Ocala derives its recharge and where and how the water moves through the Ocala. These additional data will ultimately enable the pinpointing of sources of pollutants.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Georgia

4.0083, FACTORS AFFECTING WATER YIELDS FROM SMALL WATERSHEDS IN GEORGIA

C. COBB, Univ. of Georgia, Agricultural Experiment Sta. , *Athens, Georgia* 30602

Objective: To correlate rates and yields of runoff to watershed characteristics and climatic conditions.

Description: Watersheds representative of physiographic and climatic conditions will be selected and studied. Initially, two watersheds of approximately 100 and 1000 acres with representative Piedmont conditions near Watkinsville, Ga., will be studied. Each watershed will be characterized as to soils, geology, topography, land use, conservation practices, and management. Base flows, peak rates, and total yields of runoff will be measured. Precipitation will be measured. Precipitation and runoff characteristics will be interpreted in terms of causative factors including soil moisture properties, watershed characteristics, climatic conditions, and management. Punch card arrangement of data, computer programs, and statistical treatment will be coordinated with other contributing projects to Regional Project S-53.

SUPPORTED BY U.S. Dept. of Agriculture
Georgia State Government

4.0084, A SURVEY OF THE SEASONALLY-INUNDATED MARGINS OF LAKE VOLTA (GHANA)

P.M. AHN, Univ. of Ghana, *Accra, Ghana*

General - Assessment of the extent and quality of agricultural land seasonally flooded, location of promising agricultural areas, detailed soil survey and related investigations leading to their practical development; duration approximately two years commencing mid-1968.

Pre-field work: collection of background information; study of topography from maps and aerial photographs.

Reconaissance: rapid reconaissance of the area, by plane, boat and on foot, to allow preliminary classification of the lakeside areas as to priority for further, more detailed, investigation.

Detailed study: investigation of soils, topography, irrigation and drainage structures, social and economic factors (including transport and markets) affecting practical development.

The scheme involves close cooperation between the departments of Agronomy, Botany, Economics and Geography of the University, and also between the university personnel and the UNDP/FAO Volta Lake project. It is also hoped to involve up to 12 undergraduates of the University of Ghana in the field work in each of the two years of survey.

SUPPORTED BY Rockefeller Foundation

4.0085, FLOODS IN THE WAIAHOLE-WAIKANE AREA, OAHU, HAWAII

R. LEE, U.S. Dept. of Interior, Water Resources Division, *Honolulu, Hawaii*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Hawaii.

Purpose: To provide flood data for use by State and county officials in planning zoning measures to protect Oahu residents from flood hazards.

Methods: Records of peak discharges from a regular gaging station on Waiahole Stream and from gaging stations of longer duration on nearby streams will be used to determine the magnitude-frequency relation of floods in Waiahole Valley. Field surveys of inundated areas from past floods will be made and transferred to an enlarged topographic map (scale 1:12,000) to delineate the inundated areas. The field survey will be guided by historical data and information obtained from long-time residents of the area.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Hawaii State Government

4.0086, FLOODS IN PUNALUU-HAUULA AREA, OAHU, HAWAII

T.M. USHIJIMA, U.S. Dept. of Interior, Water Resources Division, *Honolulu, Hawaii*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Hawaii.

Purpose: To provide flood data for use by State and county officials in planning zoning measures to protect Oahu residents from flood hazards.

Methods: Records of peak discharges from a regular gaging station on Punaluu Stream and from gaging stations on nearby streams will be used to determine the magnitude and frequency of floods on Punaluu Valley. Field surveys will be guided by historical flood data and information obtained from long time residents of the area.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Hawaii State Government

4.0087, EROSION AND RUNOFF CONTROL PRACTICES AND SYSTEMS TO CONSERVE SOIL AND WATER RESOURCES IN THE PACIFIC NORTHWEST

M.E. JENSEN, U.S. Dept. of Agriculture, *Kimberly, Idaho*

Object: To develop improved erosion and runoff control practices and systems applicable to the climatic, soil, topographic, and cropping conditions of the Pacific Northwest.

Plan of Work: Studies are made of various crop sequences and management practices, as related to magnitude and severity of runoff and soil loss. Tillage systems, including stubble mulching, subsoiling, vertical mulching, minimum tillage, and deep profile modification methods are evaluated as to runoff and erosion control benefits. Other studies are concerned with adaptation and adjustment of farm equipment to better serve the needs of erosion control, and with practices to supplement natural resistance to wind and water erosion such as contour farming, row design, terracing, benching, and other methods with the view of developing adapted, effective and economical control measures. Studies are also made of engineering aspects of various types of terracing and benching systems, to collect excess runoff and deliver it from the field or to impound it for infiltration on leveled areas. Various types of terrace outlets and waterway designs are evaluated, including lining materials and permanent structures for managing the runoff water.

SUPPORTED BY U.S. Dept. of Agriculture

4.0088, FACTORS INFLUENCING THE FLOW OF SUB-SOIL WATER IN THE IMMEDIATE PROXIMITY OF AND INTO DRAINAGE FACILITIES

G.L. COREY, Univ. of Idaho, Agricultural Experiment Sta. , *Moscow, Idaho* 83843

Object: To analyze and describe the sub-soil surface flow of water and those factors which effect it in the immediate vicinity of the drain facility for the preparation of improved criteria and procedures for design, installation and operation of drains.

Procedure: A drainage nomograph will be developed using the criteria of similtude developed under this project by the Colorado Station. Model soil columns will be allowed to drain under the influence of gravity. Scaled outflow will be plotted against scaled time for a wide range of homogeneous soil textures. Various column lengths will be used so that one can arrive at the drainage outflow-time relationship for any homogeneous soil material of any practical thickness.

SUPPORTED BY U.S. Dept. of Agriculture
Idaho State Government

4.0089, SOIL AND WATER REQUIREMENTS FOR BLACK WALNUT AND OTHER HARDWOODS

W.H. CARMEAN, Southern Illinois University, U.S.D.A. Forest Service, *Carbondale, Illinois* 62901

Object: To provide the basic knowledge on soils and water required for the culture of black walnut and other high value hardwoods used for timber and related products.

Plan of work: Primary emphasis will be placed on obtaining the basic soils knowledge for effectively culturing walnut and other hardwoods in plantations. Guides and site curves will be developed for predicting the soils and sites where immature trees will grow quickly and produce quality logs. Controlled soil moisture and drainage studies will be made to determine moisture requirements of hardwoods. Ways will be sought to maintain or improve soil structure and other physical and chemical properties with particular emphasis on cultivation. Site information for all important upland oaks will be analyzed and improved oak site index curves will be made. (2 pmy per yr.)

SUPPORTED BY U.S. Dept. of Agriculture

4.0090, THE RELOCATION OF INDUSTRY AND THE LOCATION OF NEW INDUSTRY AS AFFECTED BY THE AVAILABILITY OF WATER SITES

A.E. PRELL, Southern Illinois University, Graduate School, *Carbondale, Illinois* 62903

The purpose is to investigate the resons for the location of industry on the Mississippi River since 1945. The principal emphasis is to be on whether or not the availability of water played a role in the choice of the industrial site. Further, the study will investigate what types of industries find water sites essential and/or important enough to affect the location decision. Finally, the study will attempt to determine what barriors exist to the use of waterways and water sites for new industry on the Mississippi River.

SUPPORTED BY Southern Illinois University

4.0091, LAWRENCE AVENUE UNDERFLOW SYSTEM

M. PIKARSKY, Chicago Dept. of Public Works, *Chicago, Illinois*

The project is to construct a machine bored tunnel of 16,600 lineal feet of 12-foot tunnel and 9,300 lineal feet of 17-foot at a depth of 200-250 feet in the Niagaran limestone stratum for storage of excess combined sewage from a 3,620 acre urban area. Included are necessary inlet shafts, outlet shafts, vents, pumpage and new conventional trunk sewers.

The facility will eliminate approximately 48 - 52 yearly overflow events. The stored excess sewage will be pumped to an interceptor for treatment at the Northside Treatment Plant during low flow periods.

The proposed project will demonstrate the use and economics of utilizing large scale underground facilities for temporary storage of excess volumes of combined sewage produced during periods of rainfall. No City in the Nation is currently using such a system, which would have application in highly developed urban areas where space for surface storage is uneconomical.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Chicago City Government - Illinois

4.0092, DOMESTIC WATER USE IN EAST AFRICA

G.F. WHITE, Univ. of Chicago, Graduate School, *Chicago, Illinois* 60637

An appraisal of volume of domestic water use, its monetary and other direct costs, its other social costs, and the factors affecting use and the choice among alternate sources. Use, social cost, and the decision-making process were examined in 31 sites in Kenya, Tanzania, and Uganda selected for diversity in environment. Both piped and unpiped sources were studied.

SUPPORTED BY Rockefeller Foundation

4.0093, FLOOD INUNDATION MAPPING, NORTHEASTERN ILLINOIS

A.W. NOEHRE, U.S. Dept. of Interior, Water Resources Division, *Oak Park, Illinois*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Illinois and the Northeastern Illinois Planning Commission.

Purpose - To prepare inundation maps for the Northeastern Illinois Metropolitan area, covering 62 7 1/2-minute quadrangles.

Methods - Records will be obtained from an extensive crest-stage gage network, of which 69 sites will be rated for discharge in the 19 quadrangles remaining to be mapped. These records and previously established data collection points will be used to define flood profiles, inundation boundaries, and flood-frequency relationships. Inundation maps will be superimposed on topographic quadrangles and published as Hydrologic Atlases.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Illinois State Government

4.0094, ECOLOGY OF THE FISHES OF THE KASKASKIA RIVER

R.W. LARIMORE, State Dept. of Conserv. , *Springfield, Illinois*

Objectives: Biologists of the Illinois Natural History Survey have studied the fishes of the Kaskaskia River during the past half century. Intensive investigations were carried out in 1928, again in 1960 and each year to the present. This long background of field work gives us information on the distribution of the fishes and an opportunity to evaluate changes that have occurred. Our field studies were intensified in 1965, at which time water was impounded in the new reservoir at Carlyle. A second impoundment is to be completed in 1969 at Shelbyville. The objectives now are (1) to continue getting the information on the habitat requirements and life history of river fishes, (2) to investigate the biology of reservoir fish populations, and (3) to determine the relationships between river and reservoir populations.

Procedures: Diurnal and seasonal changes in food habits of the more common fishes will be carried out and related to the benthic and drifting organisms. Reproduction of most of the species will be investigated both by examining individual fish and determining year class strength. From this we will understand what factors influence success of reproduction of sport fishes. Population changes and growth rates of various species will be followed by taking frequent collections, either seining or electrofishing, and by taking large late summer collections in the main river as well as in coves of the new reservoirs.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Illinois State Government

4.0095, TEMPERATURE PROSPECTING FOR SHALLOW GLACIAL AND ALLUVIAL AQUIFERS

K. CARTWRIGHT, State Geol. Survey, *Urbana, Illinois*

A thermistor probe for measuring shallow soil temperatures has been developed and is being tested as a means of prospecting for shallow sand and gravel aquifers. The theory is that shallow sand and gravel aquifers act as heat sources or sinks that produce temperature anomalies near the surface. Thermal surveys have been conducted over eight shallow sand and gravel aquifers known from test drilling and electrical earth resistivity surveying. A paper outlining the basic theory and citing a field example was published in Water Resources Research in April 1968.

SUPPORTED BY Illinois State Government

4.0096, GROUND-WATER GEOLOGY OF DEKALB AND BOONE COUNTIES, ILLINOIS

J.P. KEMPTON, State Geol. Survey, *Urbana, Illino.*

Collection of subsurface records, studies of physical characteristics, surficial mapping, air photo interpretation and geophysical surveys have provided a basis for interpreting the stratigraphy of the glacial deposits. Important sand and gravel aquifers with high ground-water potential have been delineated in the course of this work. Aquifers in the bedrock are sources of large groundwater supplies but their characteristics are less variable and have been better known than those of the glacial drift.

SUPPORTED BY Illinois State Government

4.0097, CLIMATOLOGY OF HAIL

S.A. CHANGNON, State Water Survey, *Urbana, Illinois*

Continuing investigations are being made of factors influencing hailstorms in Illinois. Recent studies include: correlation between areal distribution of hail in summer and distribution patterns of related climatological factors; climatological relations of hail days and thunderstorm days; detailed analyses and descriptions of hail cells in hailstorms from field surveys of severe storms; investigations of extensive, severe hailstorms in Illinois including antecedent weather conditions and extent of such storms to the west in Iowa and Missouri.

New studies involve techniques to assess hail suppression programs. Included are radar-hail detection studies, hailgage development, types of data for use in measuring suppression effects, and statistical design of projects.

SUPPORTED BY Illinois State Government

4.0098, DEVELOPMENT OF COST CRITERIA FOR WATER SUPPLY

J.H. DAWES, State Water Survey, *Urbana, Illinois*

An effort is being made to develop cost data criteria to be applied in comparisons of alternative water resources developments. These criteria will be extracted from actual cost data collected from federal, state, municipal, and private agencies. The study encompasses impoundments, well supplies, and transmission facilities. Although the study is being made for Illinois, the purpose and format of its results should be of general interest.

Completed as of July 1968 were the following technical letters: No. 7, Water Transmission Costs; No. 8, Cost of Reservoirs in Illinois; No. 9, Cost of Pumping Water; No. 10, Costs of Wells and Pumps; and No. 11, Costs of Water Treatment in Illinois.

Cost studies are continuing for the development of working tools in our water resources development model that involves the capture, storage, treatment, distribution, reconditioning and recovery of water supplies.

SUPPORTED BY Illinois State Government

4.0099, PIT METHOD OF ARTIFICIAL GROUND-WATER RECHARGE

R.L. EVANS, State Water Survey, *Urbana, Illinois*

A successful pit method of artifical recharge using Illinois River water was developed for heavily-used ground-water sources at Peoria; infiltration rates reached as high as 175 feet per day and water temperatures were maintained at desirable levels. Pits currently operated by city as needed and contribute substantially to maintaining the water table in that area. Research to evaluate effects of artificial recharge is continuing; includes observation for introduction of possible contaminants, and the effect of artificial recharge on clogging tendencies in the aquifer soils.

SUPPORTED BY Illinois State Government

4.0100, EVAPORATION RETARDATION, PONDS OR SMALL LAKES

W.J. ROBERTS, State Water Survey, *Urbana, Illinois*

After earlier field studies on small lakes and farm ponds in Illinois which showed usefulness of monomolecular chemical film in retarding evaporation, research was aimed at efficient and economical method of application of film. Although the usefulness of monomolecular chemical films for retarding evaporation from water bodies has been proven in many world-wide tests, the cost of such a film cannot be justified except in special cases.

Tests carried on cooperatively with Southern Illinois University and the Procter and Gamble Company during 1967 and 1968 indicate that solid barriers in various forms can be used over large surfaces where wind is a big factor in impairing the efficiency of the chemical monolayer. While water savings using barriers becomes quite high, it is necessary to balance such savings with the oxygen demand of aquatic life under the barrier.

Solutions are being tested to determine the ratio of water area covered by solid barriers to peripheral areas covered by chemical films. The project involves economic studies to determine the life of plastic and other barriers, and their ability to withstand exposure to storms.

SUPPORTED BY Illinois State Government

4.0101, TRACER STUDIES - URBAN RUNOFF

M.L. TERSTRIEP, State Water Survey, *Urbana, Illinois*

In conjunction with other urban runoff studies, a program has been initiated to use tracers in determining travel times during relatively high flows within a small urban watershed (Boneyard Creek in Champaign-Urbana, Illinois). To determine the travel time from a given point in the basin to the stream gage, a fluorescent dye (Rhodamine B) is released at the point of interest, and the concentration measured downstream at the gage. The time lapse between the release and the peak concentration downstream is considered to be the travel time. Measurements are made during winter as well as warm- season rains.

SUPPORTED BY Illinois State Government

4.0102, DEVELOPMENT OF A MATHEMATICAL MODEL FOR THE SIMULATION OF FLAT-LAND WATERSHED HYDRAULICS

H.P. JOHNSON, Iowa State University, School of Agriculture, *Ames, Iowa* 50010

The primary objectives of the proposed research project are: (1) to develop a mathematical model to simulate the flow of water from an area which is characterized by shallow surface depressions and artificial (man-made) drainage facilities, (2) to use the model to investigate the effect of the degree of drainage on watershed outlet flows and (3) to use the model to investigate the economics of agricultural drainage.

There are regions in our country where the flow of water from large areas is greatly facilitated by artificial drainage and where the drainage facilities are constantly being improved. The movement of water through and from these areas is not fully understood. A method or procedure should be developed which will provide a more complete knowledge of flat-land hydrology. A mathematical model will achieve this objective. Such a model will be of value to water resources planners and engineers. The mathematical model will be developed on a digital computer.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Iowa State University

4.0103, FIELD INVESTIGATIONS OF SUBSURFACE AND SURFACE DRAINAGE

H.P. JOHNSON, Iowa State University, Agricultural Experiment Sta., *Ames, Iowa* 50010

Objectives: 1. Determine effects of tile spacing and crop management on corn and soybean yields 2. Obtain drawdown and tile discharge data from present installations 3. Obtain hydraulic conductivity and pore space characteristices of soils which are drained 4. Determine design criteria for tile joints 5. Determine probability of drainage need based on climate, plant and soil characteristics

Description: 1. Yields of corn and beans will be obtained on Davis County and Clarion-Webster Experimental Farm where tile spacing and surface drainage experiments are installed 2. Drawdown, tile discharge and water table level data will be taken at Ankeny Station, private farm near Bloomfield, Davis Co. Farm, Ag.E.-Agron. Farm, Kanawha Farm, Howard Co. Farm and Carrington-Clyde Farm 3. Field and lab. measurements of hydraulic conductivity and pore space characteristics of several soils in Ia. where drainage is a problem are planned 4. laboratory study of the hydraulics of flow at tile joints is planned to determine whether tile can be installed on steep grades 5. The determination of frequency of given water levels for given tile depth and spacing, soil properties and rainfall is planned.

SUPPORTED BY U.S. Dept. of Agriculture
Iowa State Government

4.0104, HYDROLOGIC CHARACTERIZATION OF SMALL WATERSHEDS

H.P. JOHNSON, Iowa State University, Agricultural Experiment Sta., *Ames, Iowa* 50010

Objective: The objective of the project is to investigate the use of mathematical, electrical and hydraulic models to study hydrologic phenomena of watersheds.

Description of Work Proposed: The work will be conducted in two steps, namely, (1) develop parameters for quantitatively describing watersheds, and (2) quantitatively describe watersheds which have been gaged and relate parameters describing the watershed to surface runoff and, if possible water yield. For step 1 physiographic information such as contour maps, stream cross section, profiles and aerial photos of small watersheds in several physiographic areas will be collected. From these watersheds parameters as area and drainage density will be defined. The interdependence of variables will be determined. In step 2 gaged watersheds will be studied. All known flow characterizing variables as mean annual discharge, unit graph, rainfall, peak flows and low flows will be defined. The relationship of watershed parameters and flow characterizing parameters will be studied.

SUPPORTED BY U.S. Dept. of Agriculture
Iowa State Government

4.0105, IRRIGATION INVESTIGATION IN IOWA

H.P. JOHNSON, Iowa State University, Agricultural Experiment Sta., *Ames, Iowa* 50010

The research carried on under this project has covered the problems of the determination of the optimum levels of water application and soil and plant management needed for maximum returns from field crops. Associated with this work has been the study of moisture use by corn.

The results to date have identified the ranges of optimum conditions necessary for maximum production of corn under irrigated conditions in Iowa.

The experiments have been conducted in the field on both sandy and heavy soils. The data collected represent crop responses during years of varied climatological conditions.

SUPPORTED BY Iowa State Government

4.0106, TECHNOLOGY AND ECONOMICS OF CONSERVATION

P. ROSENBERRY, Iowa State University, Agricultural Experiment Sta., *Ames, Iowa* 50010

Objectives: To determine and evaluate the economic aspects of current and developing technology of water management. This will include evaluating the effectiveness of alternative terrace systems and other land treatment measures in managing the flow of surface water to: 1. More effectively utilize precipitation to crop production through control of runoff; 2. reduce soil fertility losses from sheet erosion; 3. control gully growth; and 4. reduce downstream sediment and flood damages. Associated effects to be analyzed include the maintenance or improvement of soil productivity, pollution abatement, efficiency of machinery use and the land area removed from production as a result of the water management measures adopted.

Approach: The first step is a comparative cost study of alternative types of terraces applied in the North Central Region. The analyses considers slope, soils and methods of construction. The large, parallel, grassed-backslope terraces will receive particular attention. Following studies will evaluate the effectiveness of representative terrace systems and other measures in producing various on-site benefits.

SUPPORTED BY U.S. Dept. of Agriculture

4.0107, AN EVALUATION OF SOME MARSH MANAGEMENT TECHNIQUES

M.W. WELLER, Iowa State University, School of Agriculture, *Ames, Iowa* 50010

To evaluate the success of some common marsh management techniques, long-term studies of nesting waterfowl populations and vegetation are being conducted on three areas. On the Ruthven Game Management Area, an evaluation is being made of the waterfowl use of potholes made by blasting over 20 years ago. The longevity of the potholes and their influence on vegetation is being appraised. Their permanent vegetation and bird-use is being measured, and bird-use is being compared with that on natural water areas. On the Spring Run Game Management Area, a preliminary study was made of the nesting duck population, nest-site selection, and the relationship of nests to water areas and to cultivated fields. A portion of the study area is being grazed lightly to compare grazed versus ungrazed areas. Vegetative data also are being recorded to evaluate the impact of grazing on the density and species composition of upland herbs and grasses.

At the Elk Creek Marsh near Lake Mills, Iowa, a series of impoundments is being built to create three deep, permanent marshes along a stream fringed with sedge meadows and seasonally inundated marshes. The development of vegetation and waterfowl populations is being recorded and water levels are being manipulated to produce maximal vegetation suitable for duck nesting and feeding as well as for hunter- use. Muskrat activities and populations also are being measured.

SUPPORTED BY Iowa State University
Iowa State Government

4.0108, EVALUATION OF HABITAT AND REPRODUCTIVE FACTORS WHICH INFLUENCE POPULATIONS OF NESTING WATERFOWL

M.W. WELLER, State Conservation Commission, *Des Moines, Iowa*

Objectives: To measure vegetation changes; develop techniques for reestablishment where plants have been eliminated by water levels and muskrats; evaluate waterfowl use of habitat and measure environmental relationships and reproductive behavior which influences waterfowl use; evaluate role of artificially created marshes; and to appraise grazing effects on waterfowl nesting.

Procedures: Elk Creek Marsh: Changes in vegetation will be recorded by transects data on units, will be re-run only during periods of dramatic changes. Cover maps, photographs and water depths will be recorded. Use of nesting cover will be studied. Dramatic increase will be made in water levels providing a means of measuring the value of flooded emergent vegetation in attracting potential nesting ducks in the spring. Growth of muskrat populations will be appraised by spring territory and mid-winter house counts.

Ruthven Area: Vegetation of key marsh areas will be cover mapped in spring and in winter. Waterfowl populations will be appraised. Populations of blue-winged teal will be nest trapped and marked for study. General observations on success and design of marsh draw-down experiments, artificial pot-holes and other habitat techniques.

Spring Run: Waterfowl populations will be appraised by spring- pair counts intensive nest-searching, and brood-counts. Vegetation in nine selected 5-acre quadrants will be measured by sampling marsh and upland portions of each. Species composition and density will be appraised. Newly fenced portion will be surveyed to appraise plant use and damage by cattle. One-half of marsh area will be grazed lightly and pair-use and nesting success will be related to grazing.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Iowa State Government

4.0109, REMOVAL OF SUSPENDED MATTER AND TURBIDITY FROM WATER BY FLOCCULATION WITH POLYELECTROLYTE COAGULANTS AND COAGULATION ACIDS

M. REBHUN, Technion, *Haifa, Israel*

Object: To determine the electrokinetic properties of suspended particles, principally clays of the montmorillonite, illite and kaolinite groups; the reactions occurring when suspended in saline waters and the flocculation effects of additive coagulant materials such as electrolytes, polymers and metallic compounds. The study will seek to develop knowledge needed to design field methods to remove suspended material from flood waters to be used for ground water recharge.

Plan of Work: Laboratory study will be made to determine settling characteristics of suspended matter in natural flood water and changes brought about by adding polyelectrolytes and other flocculants or flocculant aids. Electrochemical and other properties of the suspended material will be determined and changes noted as flocculants of known characteristics are added. This will include determination of changes in the zeta potential of the suspended materials. The retention of the suspended materials in waters of various salt concentrations and sodium-absorption ratios will be studied. The microscope electrophoresis will be used to measure the electrophoretic mobility of the particles. With information from these basic studies of characteristics and related mechanisms of reaction, field application studies will be developed and carried out.

4. WATER QUANTITY MANAGEMENT AND CONTROL

SUPPORTED BY U.S. Dept. of Agriculture

4.0110, OPTIMUM UTILIZATION OF SURFACE AND SUBSURFACE WATER FACILITIES

J. BEAR, Technion Res. & Develop. Fdn., *Haifa, Israel*

Object: To develop criteria, techniques, and procedures for optimum utilization of aquifers as elements for storage and exploitation of water in water resources systems.

Plan of Work: After a literature survey of the applicable operations research techniques, mathematical models of increasing complexity will be set up for analysis. Included will be models of a single aquifer, a coastal aquifer, systems consisting of a number of aquifers, and a complex system utilizing both ground and surface waters. Techniques for analysis of these models will be developed, evaluated, and applied toward the solution of some specific problems in water resource development and ground water management. The results of the project will be formulated in terms suitable for engineering practice.

SUPPORTED BY U.S. Dept. of Agriculture
Kansas State University

4.0111, DRYLAND SOIL MANAGEMENT

W.W. HARRIS, Kansas State University, Agricultural Experiment Sta., *Colby, Kansas*

Objectives: Objectives of this project are broad. They are: (1) Maximum moisture conservation and utilization, (2) soil protection from wind and water erosion, and (3) optimum crop production.

Description of work proposed: A series of short and intermediate length experiments will be used so that changes in machinery and equipment can be included in overall testing. Evaluation of currently available equipment and its effect on the above-named objectives will be made. Moisture utilization and optimum crop production will be investigated in a series of date of planting, rate of planting, row width studies, and fertility tests. Weather records will be used in evaluating results.

SUPPORTED BY Kansas State Government

4.0112, MANAGEMENT OF SOILS IN DRYLAND REGIONS

C. THOMPSON, Kansas State University, Agricultural Experiment Sta., *Fort Hays, Kansas*

Concentration of runoff water from contributing area onto leveled or bench terrace areas to determine the feasibility of such a system of water conservation. A series of 9 runoff areas located on an approximate 2% slope and contributing runoff water to 6 leveled plots through 3 flumes for measurement purposes have been established. Rotation of fallow, wheat, sorghum is used on contributing area plots and a continuous cropping of grain sorghum is used on the leveled areas.

SUPPORTED BY Kansas State Government

4.0113, SOIL MANAGEMENT UNDER DRYLAND CONDITIONS

D.L. ROBINSON, Kansas State University, Agricultural Experiment Sta., *Garden City, Kansas*

To determine the effect of tillage methods and other soil management techniques on yield and quality of crops, wind and water erosion, conservation of soil and water resources, and efficiency of water storage and utilization. Work includes (1) comparisons of various types of farming equipment for seedbed preparation, planting, and cultivation, (2) crop rotations, (3) use of fertilizers, (4) dates and rates of planting, and (5) tests with soil surfactants and other transpiration and evaporation reducing agents.

SUPPORTED BY Kansas State Government

4.0114, SOIL MANAGEMENT INVESTIGATIONS ON IRRIGATED LAND

R.J. SWENSON, Kansas State University, Agricultural Experiment Sta., *Garden City, Kansas*

The objectives are to study the problems of crop rotations, fertilizer requirements, methods of irrigation, water requirements, consumptive use of water, soil management methods, comparison of tillage implements, efficiency of water use, time and frequency of irrigation, rates of seeding, effects of fertilizer on quality, and the correlation of laboratory analyses of the soil with actual field response to fertilizer and other management practices.

A wide range of tests are conducted to gain the above objectives.

SUPPORTED BY Kansas State Government

4.0115, STORAGE OF FRESH WATER IN UNDERGROUND RESERVOIRS CONTAINING SALINE WATER

D.W. GREEN, Univ. of Kansas, School of Engineering, *Lawrence, Kansas* 66045

It is proposed to study the utilization of underground reservoirs, which contain salt water, as storage zones for fresh water. Fresh water would be directly injected into a formation through wells, the injected water displacing brine away from the wells and forming a zone of potable water.

In the initial work, the storage process will be mathematically modeled. The model will consist of differential equations which describe water flow in a porous medium. It is to be an analogue of the storage reservoir, including injection-production wells, reservoir boundaries, and salt-water and fresh-water zones. The movement of the fresh-water bank will be 'tracked' as it displaces the saline water and the degree of mixing of the two phases at the interface will be calculated. Guided by the results of the modeling, an economic analysis will be made.

Based on the calculations an experimental program will be designed in which such variables as water injectivity characteristics and displacement efficiences are examined. Field tests will be conducted in which water is first injected into a formation and then produced, the water being analyzed at set production intervals. Analysis of the field tests will be a final factor in determining the feasibility of undertaking a full-scale storage program.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Kansas

4.0116, RECHARGE OF GROUND WATER IN RIVER VALLEYS OF EASTERN AND CENTRAL KANSAS, AND THE HIGH PLAINS

H.V. BECK, Kansas State University, Agricultural Experiment Sta., *Manhattan, Kansas* 66504

Objectives: 1) To determine the amount of recharge that is taking place in river valleys and the High Plains. 2) To determine the magnitude of withdrawal from water in reservoirs above that amount that is recharged. 3) to determine the methods of increasing natural recharge. 4) To determine the feasibility of artificial recharge.

Procedure: River valleys in Central and Eastern Kansas where ground water surveys have been made would be reinventoried to determine decline of water table. Information on precipitation, pumping, and other uses would be used to calculate the magnitude of natural recharge. Materials surveys would be made to determine the relation between magnitude of recharge and rate.

SUPPORTED BY Kansas State Government

4.0117, EFFECTS OF TUTTLE CREEK RESERVOIR ON GROUND WATER LEVELS BELOW THE DAM

H.V. BECK, Kansas State University, Agricultural Experiment Sta., *Manhattan, Kansas* 66504

Objectives: To determine 1) the change in water levels in wells below the dam since water was impounded, 2) the fluctuations of water levels in comparison to those in wells above the mouth of Blue River in Kansas River Valley, and 3) from the above, if the water in the reservoir does contribute to more stable water table conditions.

Procedure: A system of observation wells would be established in the Kansas and Blue River Valleys and periodically measured. The present levels would be compared with the water table map presented in a M.S. thesis in 1959. This comparison would indicate the magnitude of lowering of the water table in the past five years. Records of pumping this spring and summer, along with records of lake level should indicate the effect of the reservoir on the water table.

SUPPORTED BY Kansas State Government

4.0118, POLLUTION FROM ANIMAL FEEDLOTS

G.H. LARSON, Kansas State University, School of Engineering, *Manhattan, Kansas* 66504

State Health Department personnel have concluded that runoff from concentrated animal feeding areas is the source of a new and serious kind of stream pollution. High nitrate and nitrite content in ground waters also have been reported unofficially near concentrated animal feeding areas.

Two experimental feedlots have been constructed. Each is intended for beef animals. Management is typical of that followed by commercial beef cattle feedlots. One feedlot is paved. The other is paved only at the feedbunks and the waterer. Lots are equipped to simulate rainfall and to measure and sample runoff.

Rainfall intensities of 0.30 to 2.6 inches per hour have been simulated for durations up to three hours for the lower intensities. Runoff from both simulated and natural rainfall are collected. Runoff versus precipitation rates and time are recorded. Analyses of five general groups are made on runoff samples. They are: bacteriological, organic matter, nitrogen forms, suspended solids, and miscellaneous chemicals. Solid samples from the feedlot surface are collected in an effort to relate runoff quality to surface condition.

Studies under different conditions of management and of precipitation will continue. Hydrologic factors relating to detention, treatment, and release of polluted runoff will be investigated. Chemical, physical, and biological changes of the runoff during detention will be studied. Consideration will be given to means of control such as the possibility of filtering runoff through the soil profile and spreading detained runoff on agricultural land.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

4.0119, TILLAGE STUDIES

M.C. LUNDQUIST, Kansas State University, Agricultural Experiment Sta., *Manhattan, Kansas* 66504

Objectives: To determine the effect of deep tillage, with and without inversion, on soil characteristics and on plant growth; to determine the effect of tillage on soil erodibility.

Description of work: Soils which present unfavorable conditions (either in the surface or subsoil) for plant growth will be manipulated in an attempt to improve the ease of moisture, air, and root, penetration. The effect of manipulation will be measured by physical means (infiltration rate, porosity, penetrability, bulk density, etc.) and by plant growth and development. The eeffect of various methods of tillage on soil erodibility will be measured by physical methods and by actual wind and rainfall tests.

SUPPORTED BY Kansas State Government

4.0120, REDUCTION IN DAMAGES TO FORESTS BY IMPROVING MINING AND REHABILITATION PROCEDURES

G. DAVIS, Berea College, Undergraduate School, *Berea, Kentucky* 40403

Object: To develop practical methods to reduce watershed damage and water pollution and to restore the wildlife, recreation, range, and timber resources after mining in the rugged forested watersheds of the Appalachian coal fields.

Plan of work: The project staff has been assigned seven major elements that will be attacked as dictated by problem urgency and by manpower skills. They are (1) develop more efficient and less damaging coal-haul roads; (2) develop better methods of excavating, placing, and storing overburden; (3) study mechanics of rock-soil mixtures; (4) develop better methods to identify and rate pyritic materials; (5) study spoil-bank chemistry; (6) study hydrologic processes associated with strip mining; and (7) develop techniques to stabilize disturbed surfaces using vegetation.

SUPPORTED BY U.S. Dept. of Agriculture

4.0121, SUBIRRIGATION

H.J. BRAUD, Louisiana State University, Agricultural Experiment Sta., *Baton Rouge, Louisiana* 70803

The study involves the development of subirrigation systems using small diameter polyethylene plastic pipe.

Objectives: 1. To develop prediction equations for rate of discharge from orifices in an elastic wall pipe. This will be studied from laboratory calibrations. 2. To study the effect of orifice type on root encroachment and sediment accumulation in subirrigation lines. Field studies are in progress. 3. To determine the effect of hydrostatic pressure on the water distribution pattern in several soil types. Subirrigation systems will be installed in several Louisiana soils. 4. To develop subirrigation methods for vegetable production. The performance of subirrigation systems for field and greenhouse use is being investigated.

SUPPORTED BY Louisiana State Government

4.0122, EFFECT OF FORMATION DIP ON THE MOVEMENT OF FRESH WATER STORED IN SALINE AQUIFERS

O.K. KIMBLER, Louisiana State University, School of Engineering, *Baton Rouge, Louisiana* 70803

A previous research project, 'Fresh Water Storage in Saline Aquifers', has indicated that under reasonably favorable conditions it would be technically feasible to employ saline aquifers as fresh water storage reservoirs. These results were limited, however, to horizontal aquifers. The proposed work would investigate the influence of aquifer dip on the configuration and migration of fresh water bubbles during injection, storage, and production. Large physical flow models (8 ft diameter) and mathematical models will be employed. These results will be incorporated into a computational technique which will be used for preliminary economic studies of possible field application of such storage techniques.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Louisiana State University

4.0123, UREA TRANSFORMATIONS AND RETENTION IN FLOODED SOILS

W.H. PATRICK, Louisiana State University, School of Agriculture, *Baton Rouge, Louisiana* 70803

Rates of hydrolysis, losses and recovery of nitrogen from applied urea are under investigation, in relation to properties of well-drained and flooded soils.

SUPPORTED BY U.S. Tennessee Valley Auth.

4.0124, PHOSPHATE TRANSFORMATION IN WATERLOGGED SOILS

W.H. PATRICK, Louisiana State University, School of Agriculture, *Baton Rouge, Louisiana* 70803

Phosphate transformations in soils are being studied mainly from the standpoint of rice nutrition.

SUPPORTED BY U.S. Tennessee Valley Auth.

4.0125, PLANKTON STUDIES

K.E. LANTZ, State Wildlife & Fish Comm., *New Orleans, Louisiana*

Objectives: 1. To determine what kinds and quantities of plankton are present in the four lakes prior to and following fluctuations in water levels. 2. To correlate changes in plankton productivity with chemical changes prior to and following fluctuations in water levels.

Procedure: For three months prior to and three months following water fluctuations in the four lakes, a series of monthly samples will be taken in each lake. Counts and weights will be made of net plankton collected from 20 liter samples with a No. 20 Wisconsin plankton net. Nanno plankton gravimentric

analyses will be conducted from one liter water samples passed through the Wisconsin net.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Louisiana State Government

4.0126, BOTTOM FAUNA STUDIES

K.E. LANTZ*, State Wildlife & Fish Comm., *New Orleans, Louisiana

Objectives: 1. To identify, count, weigh and measure the volume of bottom organisms in the four lakes prior to and following water fluctuations. 2. To correlate changes in counts, weights, and volumes of bottom organisms with physical, chemical and biological changes which occur during water level fluctuations in the four lakes.

Procedure: A series of bottom samples will be taken monthly from the littoral and open water areas with a Petersen dredge during the three months prior to fluctuation and monthly for three months following fluctuation. The samples will be washed and screened and contents preserved in formalin for later identification, counting, weighing and measurement of volumes of various benthic groups.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Louisiana State Government

4.0127, AQUATIC VEGETATION STUDIES

K.E. LANTZ*, State Wildlife & Fish Comm., *New Orleans, Louisiana

Objectives: 1. To map and identify the submerged plants in the four lakes. 2. To measure the dry weight of submerged vegetation in the lakes prior to and following periods of water level fluctuation. 3. To measure the nutrient levels of the submerged vegetation prior to and following water level fluctuation.

Procedure: Aerial and field observation will be used to identify and map the submerged vegetation in each lake. A series of vegetation samples will be taken prior to and following water fluctuation to measure dry weight of vegetation produced. This data will assist in detecting increases or decreases in vegetation as a result of fluctuation.

A series of vegetation samples will also be collected prior to and following fluctuation to measure nutrient levels of the submerged plants. Measurements of phosphorous, nitrogen, potassium, magnesium, sodium, manganese, iron, copper, and ash will be analyzed. These analyses will be conducted by the Auburn University Fishing Laboratory utilizing a Beckman atomic absorption spectrophotometer, Coleman flame photometer, and Bausch and Lomb Spectronic 20 colorimeter.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Louisiana State Government

4.0128, WATERFOWL STUDY-EVALUATION OF PHYSICAL CHANGES IN MARSH PONDS ON THE WISNER AND BILOXI DEVELOPMENT

R.E. MURRY*, State Wildlife & Fish Comm., *New Orleans, Louisiana

Objectives: 1. Record number, type and location of structures and dikes on the study areas and determine acreage influenced by the improvements. 2. Determine total cost of improvements and cost per developed acre for the Wisner and Biloxi areas. 3. Investigate physical and vegetative changes in marsh ponds from improvements erected on the area.

Procedures: 1. Obtain information on number type, and location of structures, and dikes, and the acreage developed, from existing records. 2. Obtain cost figures from records and vouchers in the accounting section. 3. Estimate physical changes in marsh ponds resulting from developments by comparing water depth, salinity and turbidity on the study area with similiar data from control areas. 4. Vegetative changes resulting from developments in marsh ponds will be estimated by one or more of the following techniques. A comparison will be made with similar data from control areas. a. Aerial photographs b. Sample field plots c. Line transects d. Ocular estimates

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Louisiana State Government

4.0129, STREAM RESTORATION AND CONTROLLED FLOWS

***R.P. AUCLAIR*, State Inland Fish & Game Dept., *Augusta, Maine* 04330**

Objectives: To evaluate the effects of stream restoration and controlled water flows in the drainage.

Procedure: Some of the tributaries to Moosehead Lake have been used for log and pulpwood driving. This practice often results in a widened stream bed with a scarcity of pools and shelter. In some cases the banks are cleared to mineral soil for hundreds of yards to pile pulp prior to the drive. Recent policy changes to improve relations with the public have resulted in the use of company equipment to restore damaged streams. Restoration work was completed on one tributary stream recently and evaluation work will be included under this project. A water control dam with ample storage is included in the headwaters of this stream making it ideally suited for salmon and brook trout production. Restoration work is contemplated for other tributaries.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Maine State Government

4.0130, SEDIMENTATION AND HYDROLOGY-ROCK CREEK AND ANACOSTIA RIVER BASINS, MARYLAND

W.J. DAVIS*, U.S. Dept. of Interior, Water Resources Division, *Baltimore - Towson, Maryland

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with State and local agencies in the State of Maryland.

Purpose: To systematically appraise various erosion-reducing measures applied to land undergoing urbanization. To determine the effects of urban development on the hydrologic regime in the Northwest Branch Anacostia River basin.

Methods: A report will be prepared which shows the amounts of sediment released before, during, and after active urban land development in relation to upstream land use (quantity of land stripped of vegetation, etc.), erosion control measures instituted, and types of zoning. The report will include analysis of the sediment loads in relation to associated precipitation distribution and evaluation of any changes in streamflow characteristics (flood peak lag times etc.) and changes in channel geometry detected during and after urban development. The water level of an observation well with records which began in 1932 will be measured to evaluate changes in ground-water recharge resulting from urbanization.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Maryland State Government

4.0131, ANALYTICAL HYDROGRAPHY IN WATERSHED ENGINEERING

H.N. HOLTAN*, U.S. Dept. of Agriculture, *Beltsville, Maryland

Object: The purposes of this project are to evolve and test new concepts, theories and principles for understanding the hydrologic processes on agricultural watersheds; to test and adapt information from various sources for application to water control and related problems encountered in watershed engineering; to conduct special analyses involving ARS data from more than one SEC Branch that can be more adequately carried out at a central location; and to provide case assistance to field personnel detailed to the Laboratory for specific analyses as requested by the SWC Branches.

Plan of Work: Hydrologic, geologic, soils, agronomic, and other information pertaining to the hydrologic performance of agricultural watersheds are compiled, analyzed, and interpreted by specialists in various disciplines for the evolution of new concepts and procedures for predicting flood flows and dependable yields of water from upstream watersheds.

SUPPORTED BY U.S. Dept. of Agriculture

4.0132, DEVELOPMENT AND EVALUATION OF SURFACE AND SUBSURFACE DRAINAGE PRACTICES

J. LUNIN, U.S. Dept. of Agriculture, *Beltsville, Maryland*

Object: To develop for different land resource areas of the Northeast (a) methods and design criteria for interception drainage systems on wet, seepy, sloping lands, and (b) surface and subsurface design criteria for poorly drained flat areas of the Coastal Plains and Piedmont Valleys.

Plan of Work: In Vermont and New York attention is given to the problem of intercepting water on wet, seepy hillsides. Piezometers are being used to determine subsurface water movement and to evaluate criteria for the use of tile and interception drains as a means of drainage improvement in these areas. Hydraulic characteristics of soils and other physical factors affecting the drainability are also being investigated in order to develop the most effective methods of removing excess surface and subsurface water from these areas. In other areas the effect of soil management systems on soil-water relations is being investigated in conjunction with diversion and tile drainage systems. Field studies are being supplemented by laboratory investigations of basic principles including the drainage requirements of crops of importance to the area.

SUPPORTED BY U.S. Dept. of Agriculture

4.0133, WATERFOWL MANAGEMENT THROUGH WATER-LEVEL CONTROL

F.M. UHLER, U.S. Dept. of Interior, Patuxent Wlife. Res. Ctr. , *Laurel, Maryland*

With the rapid loss of high quality wetlands, more intensive management of our poor quality wetlands becomes necessary if we are to maintain our waterfowl populations. Through water-level control such low quality wetlands as swamps, bogs, semi-dry marshes, gravel pits, and sewage lagoons can be of significantly increased importance to waterfowl. A series of impoundments have been constructed at the Patuxent Wildlife Research Center near Laurel, Maryland, to experiment with various water-level management techniques. Studies are being conducted on: 1. Impoundments held at full pool level the entire year; impoundments subject to an annual summer drawdown; impoundments subject to a biennial summer drawdown. 2. Impoundments cleared of timber before flooding; impoundments not cleared before flooding. 3. Green- tree reservoirs consisting of impoundments that are dewatered during the growing season and flooded during late fall, winter, and early spring. 4. Impoundments that receive effluent from a domestic sewage treatment field. 5. An abandoned gravel pit.

The effects of these experiments are measured by: 1. Weekly readings of water-level gauges. 2. Weekly waterfowl censuses. 3. Monthly samples of water quality. 4. Measurements of changes in plant composition.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

4.0134, OPTIMUM UTILIZATION AND MANAGEMENT OF WATER IN FORMATIONS HYDROLOGICALLY-CONNECTED TO A STRETCH OF THE CONNECTICUT RIVER

W.S. MOTTS, Univ. of Massachusetts, Graduate School, *Amherst, Massachusetts* 01003

This study will recommend methods and procedures for the maximum development and beneficial use of aquifers that are hydrologically connected to the Connecticut River in southern Massachusetts with focus on the Springfield-Holyoke urban area. These underground reservoirs hitherto essentially ignored in regional water-resource development of southern Massachusetts may in the future be vital to the optimum growth of this part of the state. The study will include: (1) The location, characterization, and evaluation of aquifers containing potable water. The water-producing capacity and the safe yield of these aquifers will be determined. (2) Methods of artificial recharge will be proposed to recharge the developed aquifers so that the base flow of the Connecticut River can be sustained. (3) Studies will be made of the feasibility of diverting Connecticut River water into the aquifers by induced pumping. (4) Methods will be investigated of increasing Connecticut River base flow by artificial recharge. It may be feasible to effect artificial recharge of floodwaters of the Connecticut River and its tributaries during periods of flood flows.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Massachusetts

4.0135, INTERACTIONS OF URBAN ACTIVITY AND THE HYDROLOGICAL CYCLE

E. MILLER, Abt Associates, *Cambridge, Massachusetts*

The proposed research is to: 1. investigate the question of the costs and the benefits of investment in pollution abatement aimed at expanding water recreation facilities, 2. to examine the potentialities of new directions in urban design that are made possible by the availability of waterfront land for other than transportation-oriented activity, 3. to conduct a reconnaissance into the technology of water supply and its alternatives to predict developing patterns of feasibility and highlight important trade-off margins among competing techniques and 5. to examine the industrial, aesthetic, residential, commercial and recreational interaction of an urban festurial environment.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

4.0136, THE IMPACT OF THE NORTHEASTERN DROUGHT ON THE PLANNING AND PROVISION OF MUNICIPAL WATER SUPPLIES

R.W. KATES, Clark University, Graduate School, *Worcester, Massachusetts* 01610

Significance: The Northeastern United States has experienced a long and severe drought over the past four years; the dry weather may continue. The drought has been costly to both the agricultural and urban sectors of the region's economy, but at present little is known about the size and incidence of these losses. At the same time, the drought has brought the subject of water supply to the public's attention as never before, creating a crisis atmosphere in which such diverse suggested remedies as higher prices for water and largescale sea water desalting programs compete for the public's attention and support.

Specific Aims: Professor Kates has already identified 50 communities in Massachusetts as the sample for his study. These communities represent a broad spectrum of experience in terms of the severity of drought conditions, adequacy of the underlying physical supply system, measures instituted to cope with the drought, and sophistication of planning procedures used. The cooperation of the Corps of Engineers, the Public Health Service, Geological Survey and relevant state agencies has been promised. The first objective of the study is to identify the characteristics of planning procedures used in communities where the drought impact was particularly severe and to contrast them with procedures used in communities experiencing little or no restriction of service. This will involve extensive interviews with system managers and acquisition of data on the dollar costs involved in either obtaining emergency supplies or in restricting water use. A second step will be to determine whether the range of alternatives considered in planning additional supplies was widened or narrowed by the pressure of drought crisis. Not only alternative physical systems, but institutional arrangements which would provide for system inter-ties and collaboration among separate political units will be considered. A third step involves measuring the effectiveness of various taken to reduce water use, including increased prices to water users. Relating to this, the financial condition of the utilities will be investigated and any financial difficulties induced by the drought will be noted.

SUPPORTED BY Resources For The Future Incorporated

4.0137, APPLICATION OF SEISMIC SHEAR WAVE STUDIES TO THE INVESTIGATION OF AQUIFERS

H.F. BENNETT, Michigan State University, Graduate School, *East Lansing, Michigan* 48824

The general objective of this program is to evaluate the potential value of seismic shear waves in surface groundwater geophysical studies. Specifically, the generation and detection of seismic shear waves, by refraction methods, will be investigated under field conditions using asymmetrical charge distributions with respect to the receiver orientations. Laboratory velocity measurements of ultrasonic compressional and shear waves through simulated aquifers will permit the calculation of all the elastic moduli and Poisson's Ratio. These moduli will be correlated with the pertinent parameters of the material such as lithology, porosity, and water saturation. The empirical relationships determined in the laboratory will be compared with field data obtained in areas with good geologic control. It is suggested that the lithology and porosity of an aquifer can be determined from the measured compressional and shear wave velocities in the aquifer both above and below the water table.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Michigan State University

4.0138, SMALL AGRICULTURAL WATERSHED HYDROLOGY

E.H. KIDDER, Michigan State University, Agricultural Experiment Sta., *East Lansing, Michigan* 48824

Determine: rainfall distribution and intensity plus the frequency of recurrence of various intensities over the watersheds; relationship between rainfall and runoff; and quantity of sediment transported in runoff during major flow periods.

Description of Work: Recording raingages were placed at an approximate density of one per square mile on three small watersheds. Precipitation data are collected and analyzed from these gages. Continuous recording is made of the runoff from these watersheds. These flow data are reported as peak rates of flood flow and in inches of depth of runoff per month. Sediment content of the flood flow is obtained by sampling with a suspended load sampler.

SUPPORTED BY U.S. Dept. of Agriculture
Michigan State Government

4.0139, AN ATTEMPT TO DETECT HIGHLY DILUTED VIRUSES IN WATERS BY FLOCCULATION

W.N. MACK, Michigan State University, School of Veterinary Medicine, *East Lansing, Michigan* 48824

The proposed research work seeks a simple method by which a small amount of virus can be recovered from a large volume of water. Concentration of viruses from fluids can be accomplished by ultracentrifugation but this method is limited to special programs. The experimental program is to determine the amount of virus recovered by using a flocculant as compared to concentrating in the ultracentrifuge. Samples of sewage from different steps in the activated sludge system will be tested and compared. To determine the presence of virus, monkey kidney cell cultures will be seeded with the concentrated samples. No attempt will be made to identify the type of virus recovered. Special attention will be given to any relationship or trend between the reduction of biochemical oxygen demand and the amounts of virus recovered from the samples.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Michigan State University

4.0140, REVIEW AND ANALYSIS OF PRECIPITATION AND RUNOFF DATA FOR SELECTED WATERSHEDS IN MINNESOTA

C.E. BOWERS, Univ. of Minnesota, School of Engineering, *Minneapolis, Minnesota* 55455

The proposed research will involve analysis of precipitation and runoff data for selected watersheds in Minnesota, with the objective of evaluating some hydrologic characteristics such as basin wide infiltration rates, hydrograph characteristics, significant storms and floods, and evapo -transpiration, relative to the physical characteristics of the basins. Data will be obtained from U.S.G.S., U.S.W.B., and State publications. Data will be analyzed on a highspeed digital computer using an 'optimization program.' It is hoped that the study will contribute to a better understanding of the hydrology of the state particularly with reference to design criteria and flood routing procedures.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Minnesota

4.0141, VERTICAL MIGRATION OF MOISTURE IN THE SOIL INDUCED BY WINTER THERMAL GRADIENTS AND ITS INFLUENCE UPON SPRING WATER RESOURCES

D.G. BAKER, Univ. of Minnesota, School of Agriculture, *Saint Paul, Minnesota*

There is frequently an appreciable thermally induced migration of moisture within the soil over-winter from the lower warmer soil upward to the colder surface layers. As a result of the migration the upper portion of the soil increases in moisture content at the expense of the lower levels from which the moisture originated. A saturated zone at the surface may result. Thus spring meltwater and precipitation enter the soil slowly at best until the surface horizon moisture has returned to lower horizons from which it originated. The hydrologic importance of this is the fact that flood and surface soil erosion hazards are increased with early spring rains until the internal downward drainage has taken place.

The objective of this project is to determine the quantity of water involved in the migration, and if various soil management practices, which will alter the heat reservoir and surface insulation characteristics of the soil, will appreciably decrease the moisture movement. The measurements will be made in two plots which contain temperature sensors buried at various depths in the soil under different surface covers and treatments. Moisture measurements will be made regularly each week or as results dictate.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Minnesota

4.014, WATERSHED VALUES AS AFFECTED BY FOREST MANAGEMENT

D.P. DUNCAN, Univ. of Minnesota, Agricultural Experiment Sta. , *Saint Paul, Minnesota*

Objectives: (1) To study forest cover as related to frost penetration, snow distribution and melt, soil mositure, water infiltration and runoff. (2) To study soil erosion by water as related to forest cover condition and treatment. (3) To study bog hydrology as affected by vegetative cover.

Proposed work: Runoff collection equipment will be established on campus for the purpose of observing complications which may result in alternate freezing and thawing, particularly during the critical spring runoff period. The Whitewater installations will be modified and improved, field installations at Cloquet will be expanded, moisture and density measurements will be continued at all Cloquet stations, snow removal will be performed on the frost study plots, and laboratory studies will be performed in connection with the soil freezing studies.

SUPPORTED BY Minnesota State Government

4.0143, HYDROLOGIC CHARACTERIZATION OF SMALL WATERSHEDS

C.L. LARSON, Univ. of Minnesota, Agricultural Experiment Sta. , *Saint Paul, Minnesota*

Objective: The objective of the project is to investigate the use of mathematical, electrical, and physical models to study hydrologic phenomena of watersheds.

Description of work proposed: 1. To develop a comprehensive mathematical watershed model suitable for use in areas having freezing climates, such as the Upper Midwest. This would require translation and modification of the Stanford Watershed Model. 2. To use this model as a research tool to study the basic factors involved in surface runoff, and their relationships. This would be done by using the revised model on gaged streams, printing of intermediate data, and making studies with these data. 3. To develop a suitable technique for synthesizing peak runoff from rainfall data for ungaged small watersheds. This would be a major application of the relationships developed under Objective 02.

SUPPORTED BY U.S. Dept. of Agriculture
Minnesota State Government

4.0144, THE EFFECT OF POTHOLE DRAINAGE UPON GROUNDWATER RESOURCES

P.W. MANSON, Univ. of Minnesota, School of Agriculture, *Saint Paul, Minnesota*

The agricultural benefits of drainage are well established and the practice of agricultural drainage is considered to be one of the first and most important steps in a well-planned conservation program for wet soils. As a result of extensive surface and subsurface drainage operations, many low-depression or pothole areas are drained so that these potholes will no longer hold water for long periods of time. There is a great deal of controversy about the effects of this drainage on water resources. Opposing views are held as to the beneficial, detrimental or neutral effects of drainage on the hydrologic cycle. This research is aimed at determining if the drainage effects floods or runoff and the groundwater supply of deep wells.

Thirty-seven potholes, located in the 6 major geological environments of Minnesota, will be under general observation, and 4 potholes will be operated under very precise instrumentation. All research will be directed to determine the exact hydrology behavior of the water in the potholes and in the surrounding ground. The use of chemicals, radioisotopes, and other means of 'tagging' water will be used. A tensiometer procedure will be established to measure the flow in unsaturated media. Small channels will be constructed under a few typical potholes so as to be able to better observe the water movement around these potholes.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Minnesota

4.0145, MECHANISMS OF BIOLOGICAL PRODUCTION IN STREAMS

T.F. WATERS, Univ. of Minnesota, Agricultural Experiment Sta. , *Saint Paul, Minnesota*

Identify plant community which serves as the primary producer of organic matter in streams. Determine relation between organic production and such environmental factors as nutrient content, light, and temperature. Clarify nature of trophic chain whereby basic elements are converted to plant organic matter, to grazing animal organisms, and finally to the carnivorous trophic level (fish). Contribute to ecology of stream organisms acting as secondary producers and as fish food.

Description of Work: Evaluation of tentative methods of estimating the production rate of stream bottom organisms is continuing. Drift rates are being measured between pools and riffles over a 24-hour period of time once each month; such drift rates, along with standing crop samples, permit the computation of production rate on the riffles, and consumption in the pools, in all seasons of the year. In the second method, an exclosure is being used to measure production rate on two types of stream bottom during all seasons. Several procedural and equipment problems are under study to add precision and greater efficiency, and allow further statistical treatment.

SUPPORTED BY U.S. Dept. of Agriculture
Minnesota State Government

4.0146, IRRIGATION OF ROW CROPS

B.L. ARNOLD, Mississippi St. University, Agricultural Experiment Sta. , *Holly Springs, Mississippi*

Objectives: To find the response of cotton irrigation at different nitrogen levels; to find the response of corn to irrigation at different nitrogen levels and plant populations, and the influence of irrigation on ear size and ears per plant.

Description of work: The cotton test is a split-plot design of six replications, irrigation being the whole plot, and nitrogen rates the sub-plots. Rates of nitrogen are 60, 90, and 120 lbs. per acre; a base application of 0-80-80 is applied annually. Sub-plots are four rows wide, 60 feet long. The two center rows are harvested. The corn test is a 2 x 3 x 2 factorial. Irrigation is the whole plot, nitrogen rates the sub-plot, and stand the sub-sub-plot. Nitrogen rates are 120, 180, and 240 lbs. per acre; stands are 8,000 and 12,000 plants per acre. Sub-plots are four rows wide, 60 feet long; sub-sub-plots are 27.5 feet long. Irrigation of both crops is done by judgment of when the crops need water.

SUPPORTED BY Mississipi State Government

4.0147, WATER RESOURCES OF COPIAH COUNTY

T.N. SHOWS, State Geol. Survey, *Jackson, Mississippi*

The water resources investigation of Copiah County was started in the summer of 1967. Emphasis was placed on obtaining information on the aquifers within the County as all domestic and industrial supplies are from ground-reservoirs. Surface water data is needed to provide information to industries which might be users of surface reservoirs to supplement ground-water supplies. The Pearl River which forms the eastern boundary is large enough to provide water to industry, except that upstream pollution has limited the usefulness of this water.

The Survey will be able to provide answers to questions of quantity, quality and availability of ground and surface water in Copiah County. Some of the methods used in collecting ground-water information in Copiah County are: running aquifer performance tests, monitoring water level changes, collecting water samples for chemical analyses, drilling test holes to determine the presence and extent of aquifers, inventorying existing wells with emphasis on the large industrial and municipal wells, and running electrical logs.

Records of stream flow, including maximum and minimum flow, and chemical analyses of surface water are being compiled from available published and unpublished sources. Low flow data and partial chemical analyses are being collected on various streams in the County.

SUPPORTED BY Mississipi State Government

4.0148, CITY OF JACKSON, WATER RESOURCES STUDY, MISSISSIPPI

C.P. HUMPHREYS, U.S. Dept. of Interior, Water Resources Division, *Jackson, Mississippi*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Mississippi.

Purpose: To provide hydrologic data which will enable planners to design flood control measures, supplemental ground-water supplies for emergencies, and industrial water supplies.

Methods: Flood profiles and flood inundation maps for principal streams in the Jackson vicinity will be developed. Wells in the Jackson area will be monitored and significant changes in ground-water resources will be reported. Data on the color of water in the Sparta Sand and data for determining the potential of the Wilcox Group for industrial supplies will be collected. Site studies will be made where shallow ground seepage is a problem in city construction.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Mississippi State Government

4.0149, SMALL WATERSHED YIELDS

H.O. VAIGNEUR, Mississippi St. University, Agricultural Experiment Sta. , *State College, Mississippi* 39762

To correlate the rate and quantity of runoff with the hydrological characteristics of the watershed. To determine the relationship of water yields from shallow wells to the hydrological characteristics of the area.

DESCRIPTION OF WORK - Typical agricultural watershed of 8,000 acres will be used. Maps showing soil types, slopes, and land use will be developed. Instrumentation includes rainfall amount and intensity, stream gaging for runoff measurements. Interpretation of precipitation-runoff relationship will include correlation of runoff yields to watershed characteristics.

Shallow well studies are similar to surface water yields. Wells will be pumped and records of yields analyzed in relationship to rainfall characteristics and character of the aquifers. Recharge rates will be determined.

SUPPORTED BY U.S. Dept. of Agriculture
Mississippi State Government

4.0150, SOIL AND WATER CONSERVATION MANAGEMENT

R.P. BEASLEY, Univ. of Missouri, Agricultural Experiment Sta., *Columbia, Missouri* 65202

Improve design of terraces and terrace systems. Determine the effect of terraces on power, labor and machine costs in crop production and on crop yields. Investigate new designs of erosion control structures and terrace outlets with a view to improving them and reducing their cost. Develop a method by which the erodability of different soils can be evaluated. Investigate use of land grading as it may improve the farmability of terraced land, as it may effect the spacing between terraces and as it may improve the efficiency of operation of farm machinery.

DESCRIPTION OF WORK - Terraces to be constructed on varying soil and topographic conditions to determine the extent that farmability can be improved. Cost of construction by different methods to be determined. The critical tractive force for different soils to be determined by hydraulic tests. The electronic computer to be used to solve the hydraulic flow equation for terrace grades and cross section. Experimental seedings to be used to select grasses adapted to erosion control in terrace outlets. Models to be used to investigate new designs of erosion control structures.

SUPPORTED BY U.S. Dept. of Agriculture
Missouri State Government

4.0151, HYDROLOGY OF SMALL AGRICULTURAL WATERSHEDS

R.P. BEASLEY, Univ. of Missouri, Agricultural Experiment Sta., *Columbia, Missouri* 65202

Evaluate the effect of climate factors and watershed characteristics on the rate and amount of runoff from small watersheds. Evaluate the effect of terraces on the soil and water losses from small watersheds. Determine the proper relationship of watershed size, reservoir capacity and water use in the design of surface reservoirs.

Description of Work: Hydrologic investigations on the 212-acre Burge Branch to determine the effect of terraces on the hydrology of small watersheds will be continued in cooperation with the U. S. Geological Survey. Measurement of runoff into and evaporation and seepage from the 154-acre watershed at McCredie will be continued in cooperation with the Agricultural Research Service. Studies similar to those discussed above will be initiated on other major soil areas of the state as personnel and facilities become available.

SUPPORTED BY U.S. Dept. of Agriculture
Missouri State Government

4.0152, GEOCHEMISTRY AND ORIGIN OF SULFO-SALINE GROUND WATER, SALINE COUNTY, MISSOURI

A.B. CARPENTER, Univ. of Missouri, Water Resources Research Ctr., *Columbia, Missouri* 65202

The purpose of this investigation is to contribute to a better understanding of: 1. the extent of chemical equilibrium between high- sulfide saline ground water and its environment. 2. the factors which control the accumulation and chemical evolution of high-sulfide saline ground water. The area to be studied during the project is Saline County, Missouri.

The project will consist of: 1. preparation of a geologic reconnaissance map of Saline Co., Missouri. 2. determination of Na , K , Ca , Mg , Cl-, SO4--, HCO3-, pH, Eh, sulfide, and a preliminary investigation of Li , heavy metals, dissolved gases, and microorganisms in the sulfo-saline springs and wells in this area. 3. determination of the mineralogy, porosity and permeability of saline water producing strata. 4. preparation of hydrochemical facies maps. 5. calculation of selected ion activity products to determine the extent of chemical equilibrium between the water and its environment. 6. interpretation of the data to determine as quantitatively as possible the origin of this sulfo-saline water.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Missouri
Missouri State Government

4.0153, DRAINAGE OF AGRICULTURAL LANDS

C.F. CROMWELL, Univ. of Missouri, Agricultural Experiment Sta., *Columbia, Missouri* 65202

To study ground water conditions as they affect drainage needs. To determine drainage requirements of different crops. Determine effect of drainage on the physical condition of soils, the farmability of the drained area, and the growth and yield of crops. To study the different methods, develop engineering design data, and improve the techniques of drainage.

DESCRIPTION OF WORK - The effect of river stage on ground water table for land adjacent to levees will be studied at two Experiment Station farms. Laboratory studies of the effect of water table on movement of water into a soil profile will also be conducted.

The effect of surface ponding of water on growing plants will be evaluated on cotton in southeast Missouri. Corn and soybeans will be included if funds permit.

Comparisons will be made between well-drained and poorly drained plots as to timeliness of operations, farmability, etc.

The techniques for improving drainage such as land grading, ditching, and tiling will be evaluated.

SUPPORTED BY U.S. Dept. of Agriculture
Missouri State Government

4.0154, FERTILITY RUNOFF

E.M. KROTH, Univ. of Missouri, Agricultural Experiment Sta., *Columbia, Missouri* 65202

Objective - To determine the effect of soil fertility additions on runoff and erosion under different cropping systems.

Procedures - The project evaluates the effect of high and low fertility levels on runoff and erosion from continuously cropped corn plots with different tillage methods and from four year rotations of corn, wheat, meadow, meadow. A non-fertilized corn-oats rotation and fallow plots are included in the study. Also the effect of irrigation on two continuous corn treatments is studied.

SUPPORTED BY U.S. Dept. of Agriculture
Missouri State Government

4.0155, AVAILABILITY, DISTRIBUTION, QUANTITY AND QUALITY OF WATER RESOURCES IN CARBONATE KARST TERRAIN

J.C. MAXWELL, Univ. of Missouri, Water Resources Research Ctr., *Columbia, Missouri* 65202

The overall objective of this comprehensive, long-term investigation is to develop quantitative methods for determining the occurrence, movement, quantity, quality and availability of surface and subsurface water resources in a region of carbonate karst. Current studies are being conducted in an area of approximately 300 square miles in the Dry Fork Creek and Benton Creek watersheds southeast of Rolla, Missouri.

The specific objectives planned for July 1, 1967 to June 30, 1968 are (a) Continued collection of rainfall, runoff, and groundwater data to determine the effect of Karst terrain on the disposition of water; (b) Estimation of quantity of water stored in and flowing through bedrock of the area, using aquifer characteristics determined in a separate study; (c) Continued periodic characterization of surface and subsurface water quality in the area; intensive study of individual streams and related wells to ascertain effects of local accretions, losses and pollution. (d) Preliminary evaluation of availability of water by computation of a water budget which will be revised as additional data become available. (e) Examination of water quality data in relation to water budget data to identify direction, magnitude and effects of exchanges between surface and subsurface waters. (f) Tracer studies to enable confirmation of flow directions and velocities.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Missouri

4.0156, FOREST COVER

L.K. PAULSELL, Univ. of Missouri, Agricultural Experiment Sta. , *Columbia, Missouri* 65202

A. Study hydrologic processes of interception, infiltration, percolation, and detention-retention storage as related to living forest cover, non-living plant material on the soil surface, and plant residues incorporated in the soil body. Relate physical characteristics of Missouri forest soils to certain hydrologic processes. B. Test effects of forest land management on small watersheds.

Description of Work: Interception studies will be conducted using catch-troughs under a young oak canopy. Water levels will be determined in shallow well installations at University Forest. Infiltration rates will be determined for selected soil types under burning and grazing management. The effect of forest litter and soil organic matter will be determined. Fragipan effects on root development and water movement will be studied. Meteorological and runoff data will be collected from one watershed. Instrumentation of additional watersheds will be made as facilities permit.

SUPPORTED BY U.S. Dept. of Agriculture
Missouri State Government

4.0157, FLOOD INUNDATION MAPPING - JEFFERSON COUNTY, MISSOURI

J.E. BOWIE, U.S. Dept. of Interior, Water Resources Division, *Rolla, Missouri*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Missouri.

Purpose - To provide hydrologic data for planning roads and streets, use of flood plain areas, zoning ordinances on land use, and channel improvements.

Methods - Streamflow and other hydrologic data will be collected on various streams in the area to define hydrologic characteristics. Flood data are collected on a continuing basis to define flood frequencies, flood profiles, channel shapes and capabilities, flow characteristics and other factors needed to complete flood inundation maps on selected streams and give basic data for other hydrologic analyses.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Missouri State Government

4.0158, HYDROLOGY OF STREAMS, ST. LOUIS METROPOLITAN AREA

D.W. SPENCER, U.S. Dept. of Interior, Water Resources Division, *Rolla, Missouri*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with St. Louis Metropolitan Sewer District.

Purpose: To define hydrologic characteristics of the area. To prepare flood inundation maps and other analyses of runoff to aid municipal planners.

Methods: Reconnaissance of streams which the Metropolitan Sewer District plans to improve will be made to determine the number of data collecting sites needed for definition of the hydrologic characteristics of the area. Flood data will be collected at many sites on a continuing basis to define flood frequencies, flood profiles, channel shapes and capacities, flow characteristics and other factors needed to study the urban hydrology. Gaging stations, crest-stage gages and precipitation stations will be installed at a sufficient number of sites to furnish the data needed for the analysis outlined above.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Saint Louis City Government - Missouri

4.0159, RECLAMATION AND MANAGEMENT OF SOILS ON IRRIGABLE LAND (MONTANA)

C.C. BOWMAN, Montana State University, School of Engineering, *Bozeman, Montana* 59715

Study the interrelationships of N, P, & K fertility levels and irrigation regimes on the production of high quality malting barley on the Rebish and Helle Ranch of the East Bench Unit. Study crop response to eight fertilizer treatments and irrigation at four stages of plant growth to determine optimum use of water.

Salt Removal. Studies will be continued at the Huntley Branch Station and at off-station demonstrations on the effectiveness of reclamation of saline soils. Selected problem soils of Montana will be studied in the field. The removal of salts and improvement of soil properties will be monitored. The influnce of clay type, salt status of the soil and salt status of the soil on salt and water movement is being studied.

Agricultural Engineering. Installation of operational automated irrigation demonstrations at Bozeman, Dillon and Huntley.

Development of a mathematical model predicting water movement and determining the effect of errors in the estimation of the variables on the predictive value of the velocity equation.

Continue evaluation of oval form border dykes on the yeld of various crops.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

4.0160, METHODS OF CONTROLLING CLUBMOSS (SELAGINELLA DENSA RYDB) AND REDEVELOPING THE PRODUCTIVE CAPACITY OF RANGES FOLLOWING CLUBMOSS CONTROL

M.J. BURRIS, Montana State University, Agricultural Experiment Sta. , *Bozeman, Montana* 59715

Objectives of the study are: (1) To determine through laboratory studies the responses of clubmoss to environmental factors of temperature light, and water realtionships affecting, establishment, maintenance, and reproduction. (2) To determine through field studies, the adaptability of ecotypic selections of nature species and techniques for their establishment on clubmoss infested ranges through mechanical and/or chemical removal of clubmoss and other competitive vegetation as well as effects of additions of plant nutrients.

Procedures include lab, greenhouse, and field methodology to provide knowledge of: (1) Infiltration, percolation, and runoff on clubmoss ranges; (2) Rooting depth, effects of variable moisture supply on spore formation and germination; influence of light intensity on clubmoss; (3) Methods and species for planting on clubmoss-infested ranges; (4) Vegetational components of undisturbed clubmoss ranges by means of transects and clipping plots; (5) Soil moisture, soil temperature, bulk density and nitrogen determination of soil, light intensity, evaporation, from soil surface, air movement, and precipitation; (6) Herbicides and their carriers for clubmoss control.

SUPPORTED BY U.S. Dept. of Interior - Bu. Land Mgmt.
U.S. Dept. of Agriculture

4.0161, INTERAGENCY FRAIL LANDS STUDY - MONTANA IV. WATER QUANTITY MANAGEMENT

F.H. SIDDOWAY, U.S. Dept. of Agriculture, *Sidney, Montana* 59270

Frail lands are lands that are highly susceptible to accelerated erosion by either wind or water. They are characterized, usually, by steep slopes, highly erodible soils and soil materials, and poor vegetative cover. The frail lands in this study are rangelands in the Pierre Shale plains and Badlands resource area comprised of (a) Solodized-Solonetz soils, (b) Raw Shale soils, and (c) Solonchak soils.

Objectives: To evaluate the effects of conservation practices (primarily contour furrowing) on vegetative response and surface runoff on frail lands and to provide information which may be used as guidelines for making management decisions on the frail land resource areas.

Procedures: Three sites will be selected, each of which will be characteristic of one of the main soil or topographic features of the frail lands. Within each site, six homogeneous watersheds of 2-3 acres each will be selected and instrumented to obtain climatic data, surface runoff yield, soil moisture, etc. Other watershed characteristics will be inventoried by detailed soil and vegetation surveys; following which, nine watersheds will be mechanically treated by contour furrowing. Effects of furrowing, and, runoff relationships taking into account hydrologic characteristics such as cover type and density, land use, soil type, ground litter, bulk density of surface soil, and changes in soil moisture.

SUPPORTED BY U.S. Dept. of Interior - Bu. Land Mgmt.
U.S. Dept. of Agriculture

4.0162, UTILIZATION OF THE STORAGE POTENTIAL OF RIVER VALLEY AQUIFERS (ABBREV)

R.R. MARLETTE, Univ. of Nebraska, School of Engineering, *Lincoln, Nebraska* 68508

The Water Resources Research Category of this project would be IV. Water Quantity Management and Control, Groundwater Management. The first work would augment the meager water quality data available in the lower Platte River basin with a systematic sampling and analysis of the physical, chemical and biological features of these rivers' water. The aim would be to determine the important characteristics and develop simplified testing procedures for using river water to recharge valley aquifers.

The seasonal quality of the Elkhorn, Loup and Platte rivers will be analyzed to determine the treatment, if any, that may be required in order to use these waters to recharge through infiltration basins located near production wells. The sampling will take place within a fifty mile radius of Lincoln, Nebraska. Some of the analysis will be done in the field, but most of this work will be performed in the Sanitary Laboratory of the Civil Engineering Department.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Nebraska

4.0163, ENGINEERING AND AGRONOMIC STUDIES ASSOCIATED WITH LAND SHAPING, ETC.

H.D. WITTMUSS, Univ. of Nebraska, Agricultural Experiment Sta., *Lincoln, Nebraska* 68508

Evaluate land shaping practices in regard to conservation of moisture, and amount and stability of crop production in western Nebraska. Develop effective agronomic and engineering practices for use in farming conservation bench systems.

Description of work: A 15 acre field in western Nebraska was shaped into conservation benches and level benches to conserve moisture and eliminate runoff and erosion. Some of the contributing areas have been covered with galvanized roofing material in order to divert extra water on to the level benches.

The land is to be cropped annually in an area where summer fallow is a common practice.

A study was made of construction procedures on bench system with the objective of keeping the cost in line with other types of construction. The best known fertility practices were followed in an attempt to bring the cut areas into high production as soon as possible.

Several different crops are being grown on the benches to determine the potential effect of water control on crop production.

A record is being made of the soil moisture. This will be used to determine the system of water control which will give the highest use-efficiency of rainfall.

SUPPORTED BY U.S. Dept. of Agriculture
Nebraska State Government

4.0164, DRAINAGE SYSTEMS FOR THE GREAT BASIN

L.S. WILLARDSON, U.S. Dept. of Agriculture, *Reno, Nevada*

Objective: Determine flow rates from artesian wells and feasibility of drainage of artesian basins with wells and surface drains. Develop basic drainage design.

Plan of Work: Obtain additional data on causes of drainage problem in Fallon, Nevada study area by correlating groundwater contour maps, soil stratification and flow net patterns with conductivity measurements, water application per season, etc. Complete survey work and process data on study of drainage by pumping from wells in an artesian aquifer.

SUPPORTED BY U.S. Dept. of Agriculture

4.0165, DRAINAGE DESIGN FOR IRRIGATION AGRICULTURE

C.T. BOURNS, Univ. of Nevada, Agricultural Experiment Sta., *Reno, Nevada* 89507

Objectives: 1. To determine the characteristics of flow of drainage relief (up) wells and gravity drains located over-lying an artesian aquifer, and, in particular, the phenonmona of flow in the immediate proximity of the well or drain. 2. To determine the interaction effects of drainage (up) wells and open ditches used conjunctively. 3. To determine the feasibility of this type drainage. 4. To develop design criteria for drainage facilities where high water tables are produced by artesian pressures and irrigation.

Work Proposed: To study in the field and the laboratory the characteristics of and factors influencing flow into an open drain and drainage relief (up) wells on land overlying an artesian aquifer using meters to measure flow from the wells, Parshall flumes to measure flow in the ditch, and piezometers to measure pressures in the ground water and the artesian aquifer. Data and parameters developed from the field study will be utilized in appropriate model studies in the laboratory to further study pertinent parameters and theoretical variations in natural conditions influencing flow into these drainage facilities.

SUPPORTED BY U.S. Dept. of Agriculture
Nevada State Government

4.0166, MOUNTAIN MEADOW RESTORATION

R.E. ECKERT, Univ. of Nevada, School of Agriculture, *Reno, Nevada* 89507

Objectives of the study are: (l) To impose various restoration practices on experimental meadows. (2) To measure the effects of restoration practices on meadow condition and forage production. (3) To determine effects of restoration on wildlife and livestock. (4) To evaluate restoration proctices in terms of water, soil and vegetation conservation and improvement and livestock and wildlife production. (5) To determine which restoration practices can be best recommended for similar meadows in similar condition.

Procedures to fulfill objectives include: (1) Construction of 'gully plugs' to raise the water table and their effect on depth and fluctuation of the water table as it influences native vegetation. (2) Source of ground water and hydrostatic pressure of water table. (3) Siltation of reservoirs to determine quantity of sediment carried and life of the reservoir behind the 'gully plug'. (4) Measurement of streamflow. (5) Mapping of vegetative sites and evaluate improvement practices such as protection, fertilization, weed control, seeding improved species, and combinations of these practices. (6) Determination of soil characteristics and climatic factor will permit application of best practices to similar meadows.

SUPPORTED BY U.S. Dept. of Interior - Bu. Land Mgmt.

4.0167, EVAPOTRANSPIRATION PATTERNS OF FOREST AND BRUSH VEGETATION ON THE EAST SLOPE OF THE SIERRA NEVADA

R.O. GIFFORD, Univ. of Nevada, Agricultural Experiment Sta., *Reno, Nevada* 89507

Objectives: 1. To determine evapotransipration patterns of forest and brush vegetation on east slopes of the Sierra Nevada watersheds. 2. To evaluate and adapt procedures for estimating evapotranspiration from environmental measurements for use in mountain forest-brush areas. 3. To relate evapotranspiration patterns of various species to soil, plant and climatic factors.

Evapotranspiration rates of brush and tree communities will be measured by soil moisture depletion using the neutron probe technique. Environmental measurements are to be made to permit calculation of evapotranspiration by various methods. New methods of measurement will be considered and applied where possible. Root distribution of the species studied will be estimated from soil pits. Soil moisture depletion is to be related to root distribution as well as environmental measurements.

SUPPORTED BY U.S. Dept. of Agriculture

4.0168, CULTURAL PRACTICES ON EASTGATE BASIN

D. JAGER, Univ. of Nevada, School of Agriculture, *Reno, Nevada* 89507

This study was initiated July 1, 1965, with an anticipated completion in June, 1970. The main objectives of the study are to evaluate the effectiveness of various cultural practices in reducing sediment production and overland flow on frail lands and to obtain hydrologic data needed to interpret and project results. Two areas in the sagebrush type are being studied. Practices being tested include plowing, ripping, furrowing and spraying together with seeding of wheatgrasses. Runoff and sediment are collected and measured in 55- gallon drums. Other data being collected include rainfall, soil moisture, plant cover, bulk density, porosity and water storage capacity.

SUPPORTED BY U.S. Dept. of Interior - Bu. Land Mgmt.

4.0169, THE ECONOMICS OF WATER TRANSFER - AN APPRAISAL OF INSTITUTIONS

J.B. WYCKOFF, Univ. of Nevada, Agricultural Experiment Sta. , *Reno, Nevada* 89507

OBJECTIVES: 1. To appraise the legal-institutional-administrative devices and processes through which transfers of water between uses and users take place and 2. To assess the consequences of these devices and processes on the economic efficiency and equity of water use and 3. To suggest desirable modifications in these devices and processes that might enhance economic efficiency or equity in the use of water resources.

Nevada will collect all available data on the historical flows, diversions, and use of the water in its closed river systems. Historical changes, present patterns and possible use within existing institutions will be determined.

Normative models will be developed and examined to determine what the water use might be under conditions of maximum economic efficiency.

Finally, alternative changes in the existing institutional framework which could effect a conversion from the existing use pattern to one of maximum economic efficiency will be examined.

SUPPORTED BY U.S. Dept. of Agriculture
Nevada State Government

4.0170, THE INFLUENCE OF WETLANDS ON QUANTITY AND QUALITY OF STREAM FLOW

G.L. BYERS, Univ. of New Hampshire, School of Agriculture, *Durham, New Hampshire* 03824

Losses by evaporation, transpiration, or evapotranspiration diminish the available water supply by one half. The period of greatest water demand does not coincide with the greatest period of supply. Substantial amounts of water are lost from drainage basins with their wetlands and ponds tributary to the streams. Therefore, a better understanding of the hydrology of the wetlands and ponds could be a valuable contribution toward augmenting water supply during periods of low stream flow.

The meteorological data which are required for determining evaporation and evapotranspiration will be measured at a selected wetland site near the university campus. Humidity, air temperature, wind speed, and net radiaction will be measured from a tower at one elevation, above land surfaces. If necessary, ground-water levels and soil moisture will also be measured, and stream gaging performed. Chemical samples will be collected and some measurements made in the field. Eight chemical measurements and conductivity will be determined in the laboratory.

Solution of equations and statistical analysis of the data will be by computer programs.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of New Hampshire

4.0171, SOIL DRAINAGE

R.B. ALDERFER, Rutgers The State University, Agricultural Experiment Sta. , *New Brunswick, New Jersey* 08903

Objectives: 1. Measure levels of water saturation in different representative types of imperfectly to very poorly drained soils in New Jersey.

2. Measure the physical and chemical characteristics of these soils.

Procedure: Measurement of levels of water saturation will be made periodically (weekly) with piezometers, in representative imperfectly to poorly drained soils in N. J. Amount of accumulated rainfall will be measured each time piezometers are read. These data will be plotted regularly to provide a continuous record for each site. Physical and chemical properties of each soil horizon will be made at selected sites to determine whether any of these properties is related to or correlated with degree of wetness as influenced by water table level.

SUPPORTED BY U.S. Dept. of Agriculture
New Jersey State Government

4.0172, SURFACE AND GROUND WATER POTENTIALITIES OF THE MULLICA RIVER BASIN

M.L. GRANSTROM, Rutgers The State University, School of Engineering, *New Brunswick, New Jersey* 08903

The proposed research project involves a systems analysis study and an ecological field investigation of aqueduct water transfer from the Mullica River Basin (containing a large state water reserve) to several New Jersey cities. This study will determine the: 1) cities which will have future demands for Mullica River water 2) optimum conjunctive surface and ground water development 3) economic effects of water withdrawal on shellfish, other biota, recreation, and waste assimilation capacity of the river and estuary.

The systems analysis approach will involve applications of extremal mathematics, such as linear programming, or simulation and stochastic processes. Fish spawning and nursery grounds studies and plankton dredging surveys will determine the distribution of these biota with respect to the existing and projected hydrography of the river-estuary system. Dissolved oxygen, salinity, and other water quality parameters will also be measured for the mathematical model. Project results will be applicable to other river basins which have conjunctive surface and ground water potentialities which affect the estuarine ecology.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Rutgers The State University

4.0173, HYDROLOGY OF SUBURAN AREAS

K. NATHAN, Rutgers The State University, School of Agriculture, *New Brunswick, New Jersey* 08903

The objectives of the proposed study are: a. To determine the effect on the rainfall-runoff relationship on all watersheds in Central New Jersey as the land use changes from agriculture and forestry to suburban development. b. To study the impact of this change on local water resources. c. To determine the practices which will best contribute to proper conservation of existing water and soil resources in agricultural areas undergoing suburban development.

Rainfall will be measured by recording rain gauges with punched paper tape output. Runoff will be obtained by means of stage recorders with punched paper tape output. It is hoped that precise lag time relationships can be developed. Pertinent parameters of the watershed will be determined from available aerial photographs and contour maps. Surveillance on land use will be kept by inspection.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Rutgers The State University

4.0174, PERFORMANCE OF DRAINAGE SYSTEMS

K. NATHAN, Rutgers The State University, Agricultural Experiment Sta., *New Brunswick, New Jersey* 08903

Objectives: To obtain basic engineering data on the performance and effectiveness of existing tile and open ditch installations as a basis for rational design procedures for such systems.

Description of Work Proposed: The effectiveness of drainage systems will be evaluated in terms of water table drawdown. Observation wells will be used. Hydraulic conductivity of the soil will be established by visual evaluation, laboratory tests of core samples, and in situ determinations. Mosquito control ditches will be studied by determining stage, velocity, slope and other hydraulic variables. Sites representative of various major soil and geographic conditions will be selected. Ditches of various hydraulic characteristics will be selected or constructed.

SUPPORTED BY U.S. Dept. of Agriculture
New Jersey State Government

4.0175, WATERSHED REHABILITATION TO CONTROL EROSION AND SEDIMENTATION IN THE SOUTHWEST

E.F. ALDON, U.S. Dept. of Agriculture, Rocky Mtn. For. & Rg. Ex. Sta., *Alburquerque, New Mexico* 87101

Object: To develop methods for restoring plant cover and controlling erosion on Southwestern watersheds.

Plan of work: The project staff is continuing to select and evaluate various plants for erosion control and to investigate sediment movement on southwestern watersheds. They are initiating new studies on the hydrology of pinyon-juniper flood plains and factors affecting the stability and productivity of cretaceous soils. They are developing prefabricated check dams for gully stabilization.

SUPPORTED BY U.S. Dept. of Agriculture

4.0176, ECONOMICS OF WATER TRANSFER - APPRAISAL OF INSTITUTIONS

M.L. HANSON, New Mexico State University, Agricultural Experiment Sta., *Las Cruces - University Park, New Mexico* 88001

Objectives: 1. To appraise the legal-institutional-administrative devices and processes through which transfers of water between uses and users take place. 2. To assess the consequences of these devices and processes on the economic efficiency and equity of water use. 3. To suggest desirable modifications in these devices and processes that might enhance economic efficiency or equity in the use of water resources.

Description of Work Proposed: Compilation of statutory provisions for transferring water rights and examination of administrative procedures for effecting water transfers.

Assembly of input-output cost and demand data for water in various uses, primarily from secondary sources.

Determination of optimum water allocations under present and projected institutional arrangements and demand situations by use of efficiency criteria.

SUPPORTED BY U.S. Dept. of Agriculture
New Mexico State Government

4.0177, CHEMICAL CONTROL OF CREOSOTEBUSH AND MESQUITE

M.L. WILSON, New Mexico State University, Agricultural Experiment Sta., *Las Cruces - University Park, New Mexico* 88001

The overall objective is to develop methods for rehabilitating creosotebush and mesquite-infested sites to maximize watershed, wildlife, and forage values. This will be done by determining proper sequence of aerial spraying; proper herbicides, additives, and carriers; effect of brush control on vegetation response and soil stabilization in dune areas; most effective herbicidal treatment for brush control by spot treatment with granular herbicides; successful reseeding practices including optimum methods, rates, and dates for various sites, weedy vegetation reduction, insect and rodent control, managing seeded stands for maximum production, and adaptation of new grass introductions to arid semidesert conditions; and evaluation of vegetation types and sites as to suitability for various treatments.

Effectiveness of repeat sprayings at various intervals on mesquite control is being determined under grazed and ungrazed conditions. Combinations of dicamba, 2,4-D, and 2,4,5-T are being used.

Various herbicides are being screened for effectiveness in controlling mesquite and creosote-bush, and labelled herbicides are used to trace abosrption and translocation.

Vegetation response to mesquite control will be evaluated using line transects through duned areas. Such treatments will be replicated.

SUPPORTED BY U.S. Dept. of Interior - Bu. Land Mgmt.

4.0178, STREAM FLOW REGIMES ON A SEMIARID RANGELAND WATERSHED

R.B. HICKOK, U.S. Dept. of Agriculture, *Santa Rosa, New Mexico* 88435

Objective: Determine relations of storm flows to storm patterns, runoff source-area characteristics, and hydraulics of the stream channel system.

Plan of Work: Categorize storm patterns in relation to runoff- producing potential and relate to frequencies of occurrence, determine runoff response characteristics of land areas as affected by topography, geology, soils, vegetation, and cultural practices, and determine runoff transmission characteristics of the stream channel system components, to derive equations for prediction of runoff hydrographs for the watershed system.

SUPPORTED BY U.S. Dept. of Agriculture

4.0179, THE NANGARHAR CANAL PROJECT OF EASTERN AFGHANISTAN

C.H. EBERT, State University of New York, Graduate School, *Buffalo, New York* 14214

This investigation focuses on the impact of the Nangarhar Canal Project in the regional development of Eastern Afghanistan.

The Nangarhar Canal Project was launched in 1956 by an investigation of a Soviet Russian team which investigated the feasibility of a regional, agro-industrial plan based upon hydro electric power and irrigation development.

The investigator established working contacts with the Russian and Afghan personnel at the Jalalabad headquarters of the project and was permitted to engage in extensive field work within the project area. Of particular interest were new soil reclamation techniques aimed at overcoming unfavorable textural and structural soil characteristics, soil desalinization, and specialized land use planning.

The focal point of the investigation is the hydrology of the area, its soils, and climatic factors correlated with land use planning.

SUPPORTED BY State University of New York

4.0180, JORDANS EAST GHOR DEVELOPMENT PROJECT

J.J. HAUPERT, State University of New York, Graduate School, *Buffalo, New York* 14214

The East Ghor Canal and Agricultural Development Project was begun in the Jordan Valley in 1958 to convey water by a gravity system from the Yarmuk River southward for 45 miles to irrigate rich alluvial soils. Underdeveloped lands were planned for settlement by private peasant entrepreneurs planting corps best suited to existing soils and climatic conditions. Though the project was completed in 1966, continuing investigations by American, British, and Jordanian geographers and agronomists are expected to evaluate new methods of land use in the valley and the effect on the national economy of income from food exports, industrial crops, taxes, water charges, land reform techniques, etc.

SUPPORTED BY State University of New York

4.0181, AN EVALUATION OF THE REJUVENATION OF THE BUFFALO RIVER

R.A. SWEENEY, State University of New York, Graduate School, *Buffalo, New York* 14214

Some of the effects of the low flow augmentation project on the Buffalo River will be evaluated. At three (3) stations along the river's length water and sediment analyses will be conducted. The water will be measured according to Standard Methods for pH, conductivity, suspended and dissolved solids, alkalinity, chlorides, total PO4 phosphates and total nitrogen. Sediments will be examined for volatile solids, total iron, oils and greases, COD, total nitrogen and total PO4 phosphates. In addition, quantitative analyses of macrobenthos will be made.

The results of this survey will be contrasted to studies made on the Buffalo River prior to the initiation of the flow augmentation project.

SUPPORTED BY Allied Chemical Corporation

4.0182, DRAINAGE STUDIES OF NEW YORK SOILS

P.J. ZWERMAN, State University of New York, Agricultural Experiment Sta., *Ithaca, New York* 14850

Objects: 1. To study the soil-water relations in typical poorly drained soils. Many of the attempts that have been made to drain these soils have failed because the trouble was not properly diagnosed. 2. To devise the simple and cheap techniques for draining the various types of wet land encountered in this study. With bulldozers, mechanical ditchers, subsoil plows and other power equipment now commonly available, it may be possible to find economic solutions to this problem.

Procedure: The problem will be attacked by isolating the drainage problem locations by soil areas and land management systems. Experimental drainage systems together with modifications of the land management will be introduced in an attempt to find out what combination of drainage systems and land management is the most successful for the various drainage locations. Agronomy Department lands are to be used wherever possible. State owned and private lands will also be used for experimental locations.

SUPPORTED BY New York State Government

4.0183, ARTIFICIAL RECHARGE OF TREATED SEWAGE WATER AT BAY PARK, N.Y.

G.D. BENNETT, U.S. Dept. of Interior, Water Resources Division, *Mineola, New York* 11501

The objective is to evaluate the feasibility of and develop optimum methods for injecting water from highly treated sewage-plant effluent into deep artesian sand aquifers of the Magothy(?) Formation (upper Cretaceous) of Long Island. This formation, which is the principal source of the water supplies for Nassau and western Suffolk Counties, is being pumped intensively and locally is being invaded by salty water. Extensive artificial recharge through injection wells with reclaimed waste water may be needed for water conservation and to create fresh-water pressure ridges to retard sea water.

Water from sewage-plant effluent will be further treated to a potable quality and then injected under pressure through specially designed wells (with fiberglass casings) under various experimental conditions. Data on hydraulic and geochemical results of the injection will be collected using observation wells and special in-situ geochemical sensors.

This research is part of the program of water resources investigations being carried on in cooperation with the County of Nassau, N.Y.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Nassau County Government - New York

4.0184, ANALYSIS OF VEGETATIVE CHANGES RESULTING FROM WATER LEVEL CONTROL

O. FLORSCHUTZ, State Wildlife Resources Comm., *Raleigh, North Carolina*

Objective: To determine changes in vegetative types in diked and undiked marsh areas by transects and other methods.

Procedure: 1. Vegetative ecotones will be examined once a year, or more often if necessary, in order to obtain data on the growth or decrease of plant communities in the Gull Rock, Goose Creek, Pamlico Point and White Oak impounded areas. 2. Changes in vegetative composition will be recorded on maps of the areas.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
North Carolina State Government

4.0185, PEACH NITROGEN, PRUNING AND IRRIGATION STUDY

W.E. BALLINGER, Univ. of North Carolina, Agricultural Experiment Sta., *Raleigh, North Carolina* 27600

Objectives: To determine the effects of different levels of pruning, N, soil moisture, and their interactions on peach tree survival, growth and fruiting characteristics.

Description of work proposed: Two hundred and sixteen treated trees of the Redhaven and Elberta varieties were established in a split-split-split block designs at the N. C. Peach Experiment Station near Jackson Springs, N. C. in 1953 using three levels each of pruning and N. The two moisture levels used were normal rainfall and normal rainfall plus supplemental water. Measurements of tree growth and fruiting characteristics have been made since 1956 and will continue to be made until the decline of the planting. Longevity and probable causes of decline are to be studied.

SUPPORTED BY North Carolina State Government

4.0186, DEVELOPMENT OF CRITERIA FOR ADEQUATE DRAINAGE

G.J. KRIZ, Univ. of North Carolina, Agricultural Experiment Sta., *Raleigh, North Carolina* 27600

Evaluate relation between geometry of drainage systems, soil characteristics and soil moisture on a subsurface drained land. Study effect of water table behavior on plant growth. Develop appropriate methods of measuring variables pertinent to study of these objectives. Oltimately, devise rational method of designing drainage systems, taking account of weather uncertainties, crop needs and hydraulic behavior of soil-water complex.

Description of Work: Plants are to be grown at different moisture conditions obtained by maintaining different water table depths in tanks. Soil moisture conditions can be evaluated using neutron scattering, gamma densitometry and tensiometers. Soil aeration will be studied with the platinum electrode technique. Soil aeration will be studied with the platinum electrode technique.

Results are to be evaluated in terms of growth response and daily measurements of evapotransipration rates. Some tanks will be buried outdoors even with the soil surface; others are to be installed outdoors but will be protected from rain with movable shelters; others are to be inside in a growth chamber.

SUPPORTED BY U.S. Dept. of Agriculture
North Carolina State Government

4.0187, WATER SUPPLY FROM AGRICULTURAL WATERSHEDS AND UTILIZATION IN IRRIGATION

E.H. WISER, Univ. of North Carolina, Agricultural Experiment Sta., *Raleigh, North Carolina* 27600

(a) Develop methods for predicting water yields from small agricultural watersheds. (b) Obtain probability of occurrence of drought days and of days having excessive moisture. (c) Use approximate methods to solve moisture flow patterns in irrigation.

An analysis will be made of records of runoff, rainfall and other pertinent factors to develop methods of predicting probability of occurrence (1) soil moisture deficits, (2) days with moisture deficits, (3) soil moisture excesses, (4) runoff; and of predicting amounts of these deficits and excesses. These factors will be related to irrigation management. Machine techniques will be developed for studying flow patterns for water through unsaturated soil in order to evaluate water movement under irrigation and drainage.

SUPPORTED BY North Carolina State Government

4.0188, ECONOMICS OF WATER MANAGEMENT TECHNIQUES IN NORTH DAKOTA

W. MCMARTIN, North Dakota State University, Agricultural Experiment Sta., *Fargo, North Dakota* 58102

Objectives: To determine and evaluate the economic aspects of current and newly developing technology of water management applicable to both dryland and irrigated agriculture in the Northern Great Plains Region.

Approach: Specific techniques of irrigation and moisture conservation will be evaluated in terms of their effects on the relative efficiency that water and other resources are used in agricultural activities. Immediate attention is being devoted to a comparative economic analysis of recently developed irrigation techniques. Following this, an economic analysis of level bench terracing will be undertaken. Additional water management practices and techniques will be selected for study after completion of the first two analyses. Close cooperative working relationships will be established with ARS and State Experiment Station scientists to obtain experimental data required for the analyses. Additional data requirements will be met by personal interview surveys.

SUPPORTED BY U.S. Dept. of Agriculture

4.0189, THE USE OF GRAVITY SHAFTS FOR GROUND WATER RECHARGE, PHASE I OF A TWO PHASE STUDY

M.T. SKODJE, North Dakota State University, School of Engineering, *Fargo, North Dakota* 58102

It is proposed to study the advantages and efficiency of gravel- filled, gravity shafts for the recharge of a glacially deposited aquifer. One year of laboratory scale studies on gravity shaft models using variations in aggregates and water quality. The primary water characteristic being turbidity or suspended material. Two years of field investigation are to follow the laboratory studies.

The effect of variations in water quality and the methods of achieving improved water quality are to be investigated.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
North Dakota State University
North Dakota State Government

4.0190, WEATHER INFORMATION FOR AGRICULTURE

G.E. WILKINSON, North Dakota State University, Agricultural Experiment Sta., *Fargo, North Dakota* 58102

Objectives: To analyze and interpret weather data on a regional basis for application to agriculture and related industries.

Plan of Work: The North Dakota Station is emphasizing relationships between meteorological factors, properties and physiological characteristics of the soil with the loss of water through evapotranspiration. This is being accomplished through nutrient culture techniques and soil moisture sampling with an expectation this information can be correlated with weather data as it relates to agriculture.

SUPPORTED BY U.S. Dept. of Agriculture
North Dakota State Government

4.0191, IMPROVEMENT AND MODERNIZATION OF SURFACE AND SUBSURFACE DRAINAGE PRACTICES AND FACILITIES IN THE CORN BELT

R.C. REEVE, Ohio State University, Agricultural Experiment Sta. , *Columbus, Ohio* 43210

Object: To improve surface drainage systems on farms for high level crop production and effective use of modern farm machinery. To develop equipment and methods for installation of low cost subsurface drains and to determine the feasibility of their use.

Plan of Work: Studies will be conducted to determine effectiveness and design features of subsurface drainage systems. This involves field and laboratory measurements of hydraulic conductivities and piezometric pressures for determining tile depth and spacing with electrical analog procedures. Studies concerned with the feasibility of low cost drains include evaluations of various plastic and other materials and the development of methods of installation of these materials. Work includes development of grade control devices. Landforming and improved water management measures are being developed which will assure efficient farm drainage systems. Drainage systems and related tillage management procedures are developed to provide necessary surface and subsurface water control under various soil and cropping conditions.

SUPPORTED BY U.S. Dept. of Agriculture

4.0192, SURFACE AND SUBSURFACE DRAINAGE FOR SLOWLY PERMEABLE SOILS

G.O. SCHWAB, Ohio State University, Agricultural Experiment Sta., *Columbus, Ohio* 43210

Determine relative effect of no drainage, surface drainage alone, tile drainage alone, and combination of both surface and tile drainage on crop response, soil moisture conditions, and other soil physical characteristics. Determine tile outflow, surface runoff, and soil and plant nutrient loss data for improving design standards of drainage systems. Determine effect of time on backfill consolidation over tile. Determine effect of soil moisture level on the physiology of the plant under field conditions.

Description of Work: A field experiment was installed in 1958 in a heavy-textured lakebed soil to evaluate the effectiveness of surface and tile drainage. There are sixteen one-half acre plots which include four replicates of four treatments. To accelerate the collection of data the plots are irrigated once or twice each year to produce the desired degree of wetness. Tile and surface flow, water table depths, soil moisture, and oxygen diffusion rates are the principal measurements. Yields from corn and oats will be taken. Crops will be changed from year to year to obtain maximum results.

SUPPORTED BY U.S. Dept. of Agriculture
Ohio State Government

4.0193, METHODS AND EQUIPMENT FOR SUBSURFACE DRAINAGE

G.O. SCHWAB, Ohio State University, Agricultural Experiment Sta., *Columbus, Ohio* 43210

Develop and test new principles for controlling grade on trenching machines. Develop and test various types of materials and methods for improving subsurface drainage.

Description of Work: The first step in developing a grade control device will be to adapt the pendulum method now being developed in cooperation with the ARS. This device will be mounted on a trenching machine and field tests performed. Since such a device only assures that a grade is maintained, another method needs to be devised to establish a reference grade line. Infrared light or other devices will be investigated.

A continuation of field studies started under State Special 91, drain discharge and sediment outflow measurements form 1-inch plastic drains and from the fiber glass drains will be made for several years. The improvement of sediment and clogging of fiber glass around drains will be studied in cooperation with Hatch 230. Continued studies will be made on the effect of deviations from true grade for drains less than 2 inches in diameter. In cooperation with ARS the possibilities of zippering plastic drains less than 2 inches in diameter will be investigated.

SUPPORTED BY U.S. Dept. of Agriculture
Ohio State Government

4.0194, SOIL CHARACTERISTICS AFFECTING SUBSURFACE DRAINAGE

G.S. TAYLOR, Ohio State University, Agricultural Experiment Sta., *Columbus, Ohio* 43210

(1) Study effect of soil hydraulic conductivity, deep seepage, and drainable porosity on water removal by subsurface drainage systems. (2) Determine saturated hydraulic conductivity and drainable porosity of the Gray-Brown Podzolic, the humic Gley, and the Gray-Brown Podzolic Acid Brown soil groups. (3) Study by various laboratory techniques the effect of subsurface drainage systems on water removal for those soil profile conditions revealed through objective 2.

DESCRIPTION OF WORK - The effect of soil hydraulic conductivity (permeability) and drainable porosity on drainage are being evaluated by controlled laboratory experiments. These experiments utilize tank drainage models, an electrical resistance network, and an IBM 704 electronic computer. Monolith samples are being taken from field soils to evaluatle hydraulic conductivity and drainable porosity. This information is utilized in controlled laboratory studies to evaluate the effect of subsurface drainage systems on water removal from land.

SUPPORTED BY U.S. Dept. of Agriculture
Ohio State Government

4.0195, MILL CREEK VALLEY ANALOG MODEL STUDY, OHIO

R.E. FIDLER, U.S. Dept. of Interior, Water Resources Division, *Columbus, Ohio*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Ohio.

Purpose - To prepare an analog model of part of the Mill Creek Valley and study the effect of various plans to utilize injection wells to increase recharge to the aquifer presently in use.

Method - An inventory of ground-water pumpage will be made. Water levels will be measured periodically. Maps showing well locations, bedrock surface, historical and current water level contours, water- level change contours, and hydraulic properties, will be prepared.

The assembled data will be used to program an electric analog model which will be used to demonstrate the effects of various combinations of injection well systems and combinations of withdrawals.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Ohio State Government

4.0196, SPRINGFIELD AREA INFILTRATION STUDY, OHIO

S.E. NORRIS, U.S. Dept. of Interior, Water Resources Division, *Columbus, Ohio*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Ohio.

Purpose: To investigate variations in rates of induced recharge from streams to sand and gravel aquifers under natural conditions and to determine methods and techniques for artificially increasing the rate of recharge to sand and gravel deposits.

Methods: Measured loss in streamflow will be correlated with records of pumpage, evapotranspiration losses, and changes in storage in the aquifer. The unit rate of induced infiltration will be related to water temperature, sediment load, head in the stream, and other factors to find out what conditions mainly control infiltration rates. Pumping tests will be made to determine the transmissibility and storage properties of the aquifer to estimate the quantity of water represented by head changes in the aquifer. Water-level contour maps and change maps will be constructed for various conditions of flow and ground water levels to help define the conditions of infiltration.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Ohio State Government

4.0197, HYDROLOGIC CHARACTERIZATION OF SMALL WATERSHEDS

R.B. CURRY, Ohio Agric. Res. & Dev. Ctr., *Wooster, Ohio* 44691

Regional Objective: To investigate the use of mathematical, electrical, and hydraulic models to study hydrologic phenomena of watersheds.

Specific Objectives: 1. To investigate statistical models as a means of identifying and evaluating the pertinent variables in the runoff process. 2. To use these variables together with a mathematical model to predict behavior of a small watershed.

The behavior of small watersheds will be investigated to identify the pertinent variables using the statistical theory. These variables will be combined with the underlying physical and biological phenomena to develop a mathematical model which will permit statements to be made about probable watershed behavior. Data from existing watersheds and runoff plots will be used to test the validity of the model.

SUPPORTED BY U.S. Dept. of Agriculture
Ohio State Government

4.0198, SOLUBILITIES OF SILICATES IN SALINE WATERS

A.G. COLLINS, U.S. Dept. of Interior, Bureau of Mines, *Bartlesville, Oklahoma*

The objective of this research has been to obtain solubility data on silicates, in particular on silicates which form scale deposits on heat transfer surfaces during distillation of saline waters. The effect of such factors as temperature, pressure, pH, and dissolved gases is being investigated, and a hydrothermal apparatus has been specially constructed for the project. Solubilities of a few silicates have been determined in water, sodium chloride, magnesium chloride and sodium bicarbonate solutions.

The solubility experiments are continuing. The hydrothermal apparatus has been put in operation, and solubility measurements are being completed on the silicates of most concern in saline water technology.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

4.0199, PREPARATION AND ANALYSIS OF CLIMATOLOGICAL DATA IMPORTANT TO AGRICULTURE AND FORESTRY

W.P. LOWRY, Oregon State University, Agricultural Experiment Sta., *Corvallis, Oregon* 97331

Objectives: 1. To determine patterns and variability of climate. 2. To associate phenological response with climatic data. 3. To develop interpretations of phenological and climatic data for agricultural and other applications.

Description of Work Proposed: Oregon's participation will center on precipitation duration. Sequential relationships of weather events related to precipitation will be described for the Western Region. Experience tables of the lengths of wet and dry spells which have occurred at various stations and at various times will be computed and published rather quickly for immediate use. The theory of Markov processes will be utilized.

Oregon will also contribute to the proposed manual on synoptic climatology of various weather variables. The probability of occurrence of significant weather events associated with certain weather types will be assessed. This study has possibilities of being related to causes of air pollution.

SUPPORTED BY U.S. Dept. of Agriculture
Oregon State Government

4.0200, FACTORS INFLUENCING THE FLOW OF SUB-SOIL WATER IN THE IMMEDIATE PROXIMITY OF AND INTO DRAINAGE FACILITIES

J.W. WOLFE, Oregon State University, Agricultural Experiment Sta., *Corvallis, Oregon* 97331

Objectives: To analyze and describe the sub-surface flow of water and those factors which affect it in the immediate vicinity of the drain facility for the preparation of improved criteria and procedures for design, installation, and operation of drains.

Work Proposed: An attempt will be made to describe the flow of water in the close proximity to tile drains for the transient state by using the diffusion equation. Computer programming to solve this question, now complete in one dimension, will be continued by extending to two dimensions and by inserting appropriate boundary conditions at the drain and zone changes at the filter and at impeding soil layers.

Laboratory measurements of drydown in the soil will be made to confirm the computer results. Measurements of hydraulic conductivity and diffusivity will also be made in the laboratory. Field measurements using organic material for backfill or filter will be made as further confirmation of the theoretical solution.

SUPPORTED BY U.S. Dept. of Agriculture
Oregon State Government

4.0201, SOLAR POWERED EQUIPMENT FOR OPERATING A SMALL IRRIGATION PUMP.

M. ANWAR, Pakistan Atomic Energy Comm., *Lahore, Pakistan*

Object: To develop and design criteria and specifications for a 2-hp solar powered boiler and equipment using steam or other media for operating a small irrigation pump.

Plan of work: The following investigations will be conducted in the laboratory and in the field: A pilot system will be developed at the Atomic Energy Center, Lahore, West Pakistan consisting of a 400- sq. ft. parabolic reflector, a boiler and an engine or turbine powered irrigation pump. If time permits, consideration will be given to other fluid media that may be more efficient than steam at low temperatures. The mirror reflector will be installed on the roof of the Atomic Energy Center and the steam boiler, turbine and pump assembly so located that water can be pumped from the ground floor to the roof simulating the pumping from a well. This will allow observation and easy modification. Tests will not be made on an actual well until the unit is perfected. After perfection it will be placed in a well for field test. This can be done in the immediate vicinity or on the grounds of the Center as the water table is quite high.

SUPPORTED BY U.S. Dept. of Agriculture

4.0202, ORGANISMS WHICH ATTACK THE AQUATIC PLANT, EURASIAN WATERMILFOIL IN PAKISTAN

M.A. GHANI, Comm. Inst. of Biolog. Control, *Rawalpindi, Pakistan*

Object: To conduct explorations to discover insects, other plant- feeding organisms or plant diseases which attack Eurasian watermilfoil (Myriophyllum spicatum) to determine the degrees of host-plant specificity of any organisms that appear potentially useful for control of the plant; and to supply living specimens of potentially useful organisms to the U. S. upon request.

Plan of work: Arthropods and other organisms associated with watermilfoil will be studied in several locations in East and West Pakistan throughout the seasons of year when conditions are favorable. Samples of such organisms will be preserved and classified, and specimens supplied for study or deposit in the National Collections, if requested. Detailed observations will be made on any of the organisms which appear to be important control factors and which appear to be suitable for introduction into the United States. Studies regarding their life histories, ecological requirements and host specificity will be undertaken. The stage in which they may most readily be shipped to the United States will be determined.

SUPPORTED BY U.S. Dept. of Agriculture

4.0203, STUDY OF THE USE OF INERT GASES TO ELIMINATE ACID POLLUTION FROM ABANDONED DEEP MINES

D.R. MANEVAL, State Dept. of Mines & Min., *Harrisburg, Pennsylvania* 17120

An abandoned drift mine of approximately 200 acres will be sealed, and air blowing and monitoring equipment installed. The air leak rate from the mine will be determined by correlating variable air input rates to the changes in the barometric pressures and temperatures in the mine. Later inert gases will be forced in the mine to displace the air and reduce acid mine drainage formation.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Pennsylvania State Government

4.0204, EFFECT OF CONSERVATION PRACTICES ON HYDROLOGY AND SEDIMENTATION RATES

W.G. SHOPE, U.S. Dept. of Interior, Geological Survey, *Harrisburg, Pennsylvania*

This research is part of the program of water resources investigations conducted by the U.S. Geol. Survey in cooperation with the State of Pennsylvania.

The objective of this study is to evaluate the effects of changing land-use and agronomic practices on hydrology and sedimentation rates of two small watersheds in Pennsylvania. One watershed is undergoing land treatment at a moderate rate; therefore, a time control is being used. The other watershed is undergoing land treatment at an accelerated rate; therefore, an external control watershed is being used for comparison with the study area. Project started 1954 and will be completed 1968.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Pennsylvania State Government

4.0205, THE USE OF INERT GASES TO ELIMINATE POLLUTION FROM ABANDONED MINES

H.C. BRAMER, Cyrus William Rice & Company, *Pittsburgh, Pennsylvania* 15205 (14-12-98)

The objective of the project is to look at the following potential acid mine drainage control techniques and: 1) To determine the effect on the leaching of pyrites by water and on acid production in the following mine atmospheres (a) air (control), (b) pure nitrogen, (c) nitrogen plus CO2, (d) nitrogen plus NH3, (e) nitrogen plus CO2 plus NH3 and (f) nitrogen plus chlorine. (2) To determine the effect of pyrite partical size on the reduction of acid production with various gas atmospheres.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

4.0206, STORM RUNOFF AND FLOOD FLOWS IN RELATION TO CLIMATIC AND WATERSHED CHARACTERISTICS

E.T. ENGMAN, Penn. State University, U.S.D.A. Ne. Watersh. Res. Ct., *University Park, Pennsylvania* 16802

Object: To identify the climatic and watershed factors affecting the volume, time distribution, magnitude, and frequency of storm runoff and flood flows and to evaluate these factors quantitatively as a basis for predicting storm runoff and floodflows from complex ungaged agridultural watersheds of the Northeast.

Plan of Work: The work is currently concentrated on the Sleepers River Experimental Watershed near Danville, Vermont; the Northeast Watershed Research Center, University Park, Pennsylvania, and on other agricultural watersheds in Virginia. Some of the factors required for the analyses and which are measured or otherwise documented for the study are: rates and duration of streamflow; precipitation patterns; antecedent moisture; season; soils; land use; conservation and watershed management practices; ground water elevations; riparian vegetation; geology; gradients and hydraulic roughness of stream channels; and the size, shape and other geomorphic attributes of the watersheds.

SUPPORTED BY U.S. Dept. of Agriculture

4.0207, FACTORS AFFECTING WATER YIELDS FROM SMALL WATERSHEDS AND SHALLOW GROUND AQUIFERS

R.V. ROMERO, Univ. of Puerto Rico, Agricultural Experiment Sta., *Lajas, Puerto Rico*

1) Research work is proposed in order to correlate runoff rates and yields to water shed characteristic and climatic conditions.

Description of work: Topographic, soil and land capability maps will be made of the watershed area showing soil types, slopes, degree of erosion, drainage patterns, and ground surface configurations. Rain gages, HL flumes, and Bouyoucos resistance blocks will be installed in the area to measure rainfall, runoff rates, and soil water potential, respectively. Periodically, soil samples will be taken at different depths for soil moisture determinations. Isohyetal maps will be constructed for each storm and storm increments to determine the average rainfall in the watershed. Correlations will be made between runoff and soil moisture content, and between runoff and rainfall intensity.

SUPPORTED BY U.S. Dept. of Agriculture
Puerto Rico Government

4.0208, FACTORS AFFECTING WATER YIELDS FROM SMALL WATERSHEDS AND SHALLOW GROUND AQUIFERS

R. VAZQUEZ, Univ. of Puerto Rico, Agricultural Experiment Sta., *Lajas, Puerto Rico*

Research work is proposed in order to correlate runoff rates and yields to watershead characteristic and climatic conditions in Lajas, Puerto Rico. The amount of runoff available for storage from small watersheads will also be determined.

Topographic, soil, and land capability maps will be made of the watershead area showing soil types, slopes, degree of erosion, drainage patterms; and ground surface configurations. Rain gages, HL flames, and Bouyoucos resistance blocks will be installed in the areas to measure rainfall, runoff rates, and soil water potential, respectively. Periodically, soil samples will be taken at different depths for soil moisture determinations. The physical properties of the soils like field capacity, permanent wilting point, infiltration capacity, and water holding capacity will be determined. Isohyetal maps will be constructed for each storm increments to determine the average rainfall in the watershead. Correlations will be make bewtween runoff and soil moisture content, and between runoff and rainfall intensity.

SUPPORTED BY University of Puerto Rico
Puerto Rico Government

4.0209, DEVELOPMENT OF GROUND WATER CONTROL METHODS FOR THE HEAVY SOILS OF THE LAJAS VALLEY

R. VAZQUEZ, Univ. of Puerto Rico, Agricultural Experiment Sta., *Lajas, Puerto Rico*

Research work is being conducted in Lajas Valley, Puerto Rico in order to study the ground-water hydrology of the Valley and the effectiveness of different methods of draining various soil types in the drainage-problem areas.

To study the ground-water hydrology a Valley-wide net of piezometers and water-table observation wells was established. With these data, ground-water contour maps will be drawn showing the direction of the horizontal and vertical hydraulic gradients. Periodical analyses and interpretation of the data will be done to diagnose problems in the Valley.

Existing or new wells will be pumped to study their effectiveness in intercepting the waters moving down the side slopes. Deep interceptor drains will be installed in similar areas to check their effectivenss in the interception of these waters. Free flowing (relief) wells will be tested in areas with high artesian pressures. The effectivenss of shallow tile and/or plastic drains, and open drains will be studied in areas where the soil conditions does not permit another type of drainage.

Due to the nature of these studies they will be continued for a long time. The project will be reviewed and revised every five years or in a shorter period if it is necessary.

SUPPORTED BY University of Puerto Rico
Puerto Rico Government

4.0210, WATER REQUIREMENTS OF CROPS UNDER IRRIGATION IN LAJAS VALLEY, PUERTO RICO

R.R. VAZQUEZ, Univ. of Puerto Rico, Agricultural Experiment Sta., *Lajas, Puerto Rico*

Two experiments will be conducted to determine the amount of irrigation water required for evapotranspiration and deep percolation in Lajas Valley soils. The moisture distribution in the soil profile, its yearly fluctuations, and its relation with the water-table also will be studied.

For that purpose an experiment of 16 plots, 8 of them planted with sugarcane and 8 left bare covered with plastics was established. Two different irrigation treatments will be applied.

To supplement the field data another experiment will be established in the present installation of lysimeter tanks to study the evapotranspiration of sugarcane under 2 irrigation and 2 nitrogen fertility levels.

SUPPORTED BY U.S. Dept. of Agriculture
Puerto Rico Government

4.0211, THE INFLUENCE OF WATER AND CLIMATE ON THE YIELD AND SUCROSE CONTENT OF SUGARCANE

M. CAPIEL, Univ. of Puerto Rico, Agricultural Experiment Sta., *San Juan - Rio Piedras, Puerto Rico* 00931

An intensified use of weather data will be made to modify field management practices throughout supplemental irrigation and harvest dates so as to be working with weather rather than against it.

The essential objective of this project is to consider the influence of micro-climate on the yield and sucrose content of sugarcane as it interacts with water added to the plant as rainfall and supplemental irrigation. Water will be supplemented to the plant on the basis of evaporative demands which, for practical purposes under low advective energy, may be considered to be integrated by pan evaporation. The effect of 'cut out' irrigation before harvest on the yield and sucrose content of the cane will be analyzed in connection with the climatic factors.

This experiment will be repeated once every 2 months for three consecutive times. It is expected that these seasonal plantings will provide for micro-climatic differences near planting and harvest dates which may help to evaluate the role of water and climate on the yield and sucrose content of sugarcane.

SUPPORTED BY Puerto Rico Government
University of Puerto Rico

4.0212, SILVICULTURE OF COASTAL PLAIN TIMBER TYPES

O.G. LANGDON, U.S. Dept. of Agriculture, *Charleston, South Carolina*

Object: To develop methods for management of Coastal Plain timber including loblolly pine, wetland hardwoods, and baldcypress from knowledge of how they regenerate, grow and respond to environment.

Plan of work: Studies on natural regeneration of loblolly pine will include: (1) relation of seed production to age, site, and density of stands; (2) effects of logging on soil and tree growth; (3) tests of the seed- and seedling-in-place concepts in mature and pulpwood sized stands. Studies on seeding and planting of loblolly will include: (1) effect of root malformation on growth; (2) seedling establishment under varying soil texture, soil moisture, sowing depths, etc. Studies on yield and quality of loblolly will include: (1) relation of growth to age, site and density; (2) effect of climate on growth; (3) effect of stand density on log quality; and (4) effects of competition on young stands. Stand improvement studies on loblolly will include: effects of burning on hardwood control and site productivity. Studies on wetland species will include: (1) effect of water level and soil on tree survival and growth; (2) relation of swamp environment to growth; (3) species-site interrelationships; (4) species reactions to flooding; (5) effects of tree and stand traits on seed production; and (6) relation of cutting methods to natural regeneration.

4. WATER QUANTITY MANAGEMENT AND CONTROL

SUPPORTED BY U.S. Dept. of Agriculture

4.0213, SOIL, PLANT, AND METEOROLOGICAL FACTORS IN DRAINAGE EVALUATION AND DESIGN

J.T. LIGON, Clemson University, Agricultural Experiment Sta., *Clemson, South Carolina* 29631

Objectives: 1. To determine the frequency and duration of occurrences of prescribed drainage parameters on which crop response depends. 2. To determine the probability of being able to perform certain critical operations such as seedbed preparation, planting and harvesting of crops at optimum times. 3. To investigate techniques for more adequate evaluation of soil properties needed in the application of rational formulas to drainage system design.

A soil water balance will be used with soil, plant, and meteorological inputs to determine frequency and duration of drainage conditions unfavorable to plant development and agricultural operations. Limited field data will be taken to verify the models used. The four-well method for determining hydraulic conductivity will be investigated further along with other techniques for determining hydraulic conductivity and drainable porosity values useful in existing drainage design formulas.

SUPPORTED BY U.S. Dept. of Agriculture
South Carolina State Government

4.0214, WATER YIELDS FROM SHALLOW GROUND AQUIFERS

R.H. RAMSEY, Clemson University, Agricultural Experiment Sta., *Clemson, South Carolina* 29631

OBJECTIVES: 1. To investigate methods of determining average soil permeability to depths of 30 feet in small areas where extreme variations are encountered. 2. To determine the most feasible methods of obtaining shallow ground water for irrigation and to correlate yields with site and climatic conditions.

DESCRIPTION OF WORK PROPOSED: Methods of determining the average permeability in shallow water bearing strata within small areas (1/8 to 1/2 acre) will be investigated and tested in both laboratory models and in natural field conditions. Different methods of obtaining shallow ground water for irrigation and other uses will be investigated and evaluated. Extent of area from which shallow ground water can be obtained will be studied, and water withdrawal-recharge relationships will be studied for areas investigated.

SUPPORTED BY U.S. Dept. of Agriculture
South Carolina State Government

4.0215, VEGETATIVE SUCCESSION IN NEWLY CONTROLLED MARSHES

P.M. WILKINSON, State Wildlife Resources Dept., *Columbia, South Carolina*

Objectives: To determine plant succession in three newly developed 20 acre blocks of diked marsh in which all major conditions are nearly identical and in which the only variable will be water levels.

Procedure: Three 20 acre sections of formerly tidal marsh were recently diked. Each unit has a separate water control structure. A fourth unit, undiked, will serve as control. A schematic drawing of the layout is shown on reverse.

Unit 1 - Fill in spring. Maintain water at all seasons at 1'-2' depth above average ground level. Establish gage board. Surplus water will overflow at flash board. Permanent pool three years. Unit 2 - Maintain dry condition throughout spring and summer. Flood just prior to arrival of migrant waterfowl. Spring drawdown 1968 and repeat through 1969. Unit 3 - Spring drawdown to marsh ground level, keep bed wet. Flood just prior to average arrival of waterfowl.

Vegetation resulting in the three controlled compartments and in the uncontrolled check areas will be measured on established transects using the point contact method. Growth will be expressed both quantitatively and qualitatively. Transects will be run in September of each year and will continue for three successive years.

Subsidiary data to be collected include: 1. Biweekly salinity, all compartments and control. 2. Soil samples initial and quarterly (free analysis by Clemson University). 3. Hydrogen ion, potentiometer, biweekly.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
South Carolina State Government

4.0216, HYDROLOGICAL STUDIES OF THE SAVANNAH RIVER PLANT, SOUTH CAROLINA -GEOHYDROLOGY OF WASTE TANK FARMS

W.E. CLARK, U.S. Dept. of Interior, Water Resources Division, *Columbia, South Carolina*

Objective is to define in detail the geologic and hydrologic conditions in the vicinity of the tanks by drilling test holes, installing clusters of piezometers, and determining the permeability of the materials in the laboratory and from pumping tests. The validity of interpretations of flow conditions will be tested by constructing electric analog models and by digital computer analysis of the conceptual model. Tracer tests will also be designed to determine rates of flow.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

4.0217, DRAINAGE OF PROPOSED IRRIGATED SOILS IN OAHE UNIT

W.D. LEMBKE, South Dakota State University, Agricultural Experiment Sta., *Brookings, South Dakota* 57007

1. Determine the hydraulic conductivity of a soil using conventional methods and compare this with the hydraulic conductivity as determined from tile outflow. 2. Compare methods of predicting tile outflow with a falling water table and determine which is most applicable to Oahe Unit Soils. 3. Determine the drainage requirements of the soil with respect to the crops grown in this area.

Objectives one and two will be accomplished with field studies to observe actual flow from tile drains, with laboratory and field tests to measure hydraulic conductivity and by computing tile flow based on field and laboratory measurements.

Objective three will be accomplished by studying crop survival over a controlled water table.

SUPPORTED BY U.S. Dept. of Agriculture
South Dakota State Government

4.0218, IMPORTANCE OF TYPE 1 WETLAND COMMUNITIES TO WATERFOWL PRODUCTION

R.L. LINDER, State Dept. of Game Fish & Pks, *Pierre, South Dakota*

Objectives: 1. To evaluate breeding waterfowl use of habitat with high and low numbers of Type 1 wetlands. 2. To evaluate the roadside transect technique of censusing breeding waterfowl.

Procedures: 1. Two similar study areas of approximately 36 square miles will be selected. Each will have the same land-use type and contain comparable numbers of Types 3, 4 and 5 wetlands but differing numbers of Type 1 wetlands. 2. Two 20 mile transects will be set up in each of the study areas. 3. Frequent waterfowl counts will be made along each transect to determine waterfowl use of each wetland type and to obtain data for statistical analysis of the roadside transect technique. 4. Random sample plots will be selected throughout each area and intensive waterfowl counts made for comparison with roadside counts. 5. Surveys of land use, and changes cover types, vegetation phenology, water depths, area and perimeter, weather conditions, and human disturbance will be recorded. 6. After one year's data have been collected and analyzed, one additional study area of each type will be established for collection of data.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
South Dakota State Government

4.0219, FORAGE MANAGEMENT AND PRODUCTION IN THE TENNESSEE VALLEY

D.A. MAYS, U.S. Tennessee Valley Auth., *Knoxville, Tennessee*

Management methods for optimal production of forage plants in the Tennessee Valley are under study in field plots. This applied research includes the study of adaptable varieties, time of cutting, seeding rates, irrigation and fertilization.

SUPPORTED BY U.S. Tennessee Valley Auth.

4.0220, NORTH FORK CITICO CREEK WATERSHED RESEARCH

P.C. SPATH, U.S. Tennessee Valley Auth., *Knoxville, Tennessee*

Research established in 1960 cooperatively by TVA, U. S. Forest Service, and Tennessee State Game and Fish Commission in Cherokee National Forest to determine the effect of high-standard, multiple purpose forest management on watershed hydrology and stream biology. The well-managed, completely forested Appalachian Mountain watershed has an area of 7 square miles and ranges in elevation from 2000 to 5000 feet above sea level.

Hydrologic observations include precipitation, streamflow, air and water temperatures, relative humidity, and sediment. Forest, soil, and hydrologic condition surveys were made. Wildlife habitat surveys will be made and browse condition and trend or change in plant species composition observed. Stream biology investigations include sampling of bottom fauna, growth rate of wild rainbow trout, and determination of fish population.

The research involves two phases. The calibration phase involves the determination of the hydrologic characteristics of the watershed under existing conditions. The second phase, called the action phase, involves determining the changes in the hydrologic characteristics of the watershed caused by the construction of access roads to selected timber cutting areas and by the cutting and removal of timber in the selected areas. The calibration phase was completed in 1965. The action phase was begun in 1966 when construction was started on an access road to the first timber sales area. Construction of this access road was completed in 1967 and timber cutting began. A system of roads is being developed for timber harvesting operations and recreation.

SUPPORTED BY U.S. Tennessee Valley Auth.

4.0221, WHITE HOLLOW WATERSHED RESEARCH

P.C. SPATH, U.S. Tennessee Valley Auth., *Knoxville, Tennessee*

Research started in 1935 on a watershed of 1715 acres to determine cover improvement influences upon hydrologic characteristics of small watersheds under a land-management system devoted primarily to watershed protection purposes. The watershed is located in the White Hollow portion of the White Creek basin in the Norris Reservoir area. It lies in the Appalachian Valley and Ridge Province of upper East Tennessee. The study is being carried on by TVA's Divisions of Water Control Planning and Forestry Development in cooperation with the State of Tennessee Division of Forestry and Fish and Game Commission.

Hydrologic observations include precipitation, streamflow and sediment. Air and water temperatures and relative humidity observations added in 1964.

The watershed was originally two-thirds poorly managed forest; the remainder largely abandoned land with a small amount of cultivation on the ridge tops or flatter slopes. Extensive erosion control operations were carried on in 1934 and 1935. Forest management was established in 1934-1935; reforestation of open areas was accomplished in 1938-1942. Beginning in 1966 the study entered another phase with the initiation of a selective timber-cutting program. Harvesting of most of the pulpwood was accomplished by the end of 1966. Three game pasture plots were established and logging roads seeded. The study is continuing to observe the effect upon runoff and erosion of the slowly changing condition of the forest cover. Saw timber harvesting is still in progress.

Analyses show (a) no appreciable change in annual water yield or evapotranspiration, (b) a sharp reduction in summer season peak discharges, (c) a 25-percent reduction in winter peak discharges, and (d) a reduction of over 95 percent in sediment loads.

A comprehensive report has been published entitled, 'Forest Cover Improvement Influence Upon Hydrologic Characteristics of White Hollow Watershed 1935-1958.' A paper entitled, 'Effects of Forest Cover Upon Hydrologic Characteristics of a Small Watershed in the Limestone Region of East Tennessee,' prepared by Paul C. Sodemann and Jones E. Tysinger, was presented at the Symposium on Hydrology of Fractured Rocks at Belgrade, Yugoslavia, October 1965.

SUPPORTED BY U.S. Tennessee Valley Auth.

4.0222, BEECH RIVER WATERSHED PROJECT

P.C. SPATH, U.S. Tennessee Valley Auth., *Knoxville, Tennessee*

The Beech River watershed project established in 1953 is a demonstration of intensified development of land-water resources integrated with the development of other resources of the area comprising 193, 200 acres in Henderson and Decatur Counties in the western part of Tennessee. This project is being carried on in cooperation with the Beech River Watershed Development Authority and State of Tennessee.

Hydrologic measurements began in 1953, to ascertain the effects on the water resources of the watershed and its subdivisions resulting from changes in land cover, land-use management, and water management due to improvements in sound farming systems and the expansion and intensification of forestry programs. This included observations of precipitation, streamflow, both surface and ground water, and suspended sediment to serve as a base in evaluating the effects on hydrologic characteristics of changes in cover and land-use management.

The agricultural phase of the project is concerned with the improvement of land-use in sound farming systems.

The forestry phase is concerned with the expansion and intensification of forestry programs to increase both the resource base and the level of land resource utilization.

In December 1965 construction was completed of a multipurpose water control system for the Beech River watershed consisting of eight reservoirs and 80 miles of stream channel improvement. Hydrologic measurements are being continued to determine the hydraulic performance of the water control system, evaluate flood reductions, determine reservoir sedimentation and channel changes, and provide basic data for operation of the reservoirs.

SUPPORTED BY U.S. Tennessee Valley Auth.

4.0223, POND SEALING

J.I. SEWELL, Univ. of Tennessee, Agricultural Experiment Sta., *Knoxville, Tennessee* 37916

Objectives: 1. Determine, by laboratory tests, the effects of selected treatments on the hydraulic conductivity of major Tennessee soils. 2. Determine relationships between hydraulic head and thickness of soil blanket necessary to prevent blowouts. 3. Determine, by field tests, the effects of the sealing techniques found to be most promising through laboratory studies.

Description work proposed: The changes in hydraulic conductivity brought about by various chemical and mechanical (compaction and puddling) treatments will be evaluated by permeameter tests. The adsorbed cations, cation exchange capacity, and per cent silt and clay will be determined so that the basic aspects of permeability alteration can be evaluated. Cylinders having perforated bottoms simulating porous parent material will be used to study relationships between thickness of soil blankets and blowouts. Field tests of the most effective sealing techniques will be made at the Middle Tennessee Experiment Station and at least one other location.

SUPPORTED BY U.S. Dept. of Agriculture
Tennessee State Government

4.0224, FACTORS AFFECTING WATER YIELD FROM SMALL WATERSHEDS IN TENNESSEE

C.H. SHELTON, Univ. of Tennessee, Agricultural Experiment Sta., *Knoxville, Tennessee* 37916

The objectives of the project are (1) to determine water yield of watersheds under specific soil and vegetative conditions, and (2) to correlate runoff rates and water yield of watersheds with such engineering practices as terracing, water impoundment and tillage.

During the years 1963-1966 a total of ten watersheds were developed on land representative of four of the six physiographic provinces of the state. Watershed sizes range from 11.4 acres to

138 acres, with an average of 43 acres. Two of the watersheds are in woodland while eight are in pasture or cultivation. Watershed instrumentation includes rain gages, evaporation pans, pyrheliometer, hygrothermograph, access tubes for neutron soil moisture equipment, shallow ground water observation wells, and pre-calibrated stream gages with automatic float level recorders. Records are maintained relative to such items as topography, soils, and land-use practices.

Computer and statistical techniques have been developed for reduction and analysis of climatic and watershed data. Attempts are underway to numerically quantify parameters to facilitate computer analyses. To interpret data in terms of causative factors and to facilitate application of results to other areas, procedures of data collecting, processing, evaluating and reporting are coordinated with participating states and agencies in Regional Project S-52. As the element of time becomes sufficiently long to adequately sample the hydrologic response of the watersheds under various conditions, it is anticipated that findings will have their greatest application in determining criteria for (1) watershed management resulting in optimum time-distribution, predictability and efficient use of water supply, and (2) hydraulic design of water control structures.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Tennessee

4.0225, FACTORS AFFECTING WATER YIELDS FROM SMALL WATERSHEDS IN TENNESSEE

C.H. SHELTON, Univ. of Tennessee, Agricultural Experiment Sta., *Knoxville, Tennessee* 37916

Factors affecting water yields from small watersheds in Tennessee Objectives: 1. Determine water yield of watersheds under specific soil and vegetative conditions. 2. Correlate runoff rates and water yields of watersheds with such engineering practices as terracing, water impoundment, and tillage. Description of work proposed -- Initially, two watersheds having an area in the range of 10 to 300 acres and adaptable to necessary measurements and control for hydrologic studies will be selected. If additional pairs of watersheds can be found in areas representating different physiographic conditions, they will be developed later. The watersheds will be appropriately instrumented and uniform vegetative cover will be established. After having collected sufficient data to satisfy Objective (1) a series of suitable engineering practices for each watershed will be established and studied in sequence. The experiment will be so designed that the data may be statistically analyzed and be correlated with other participating states in S-24 with respect to such items as watershed characterization, principal measurements, and data processing.

SUPPORTED BY U.S. Dept. of Agriculture
Tennessee State Government

4.0226, WATERSHED EVALUATION

J.M. STUBBS, State Game & Fish Commission, *Nashville, Tennessee* 37203

OBJECTIVES: The major objective is to show what effects watershed impoundments, stream snagging, clearing, and channel excavation have on fish populations and water quality. The following data will be collected under each phase. (a) Complete population samples will be taken to evaluate the standing fish population. (b) Bottom fauna studies to evaluate benthic populations. (c) Temperature studies to measure the effects of the impoundments on stream temperatures. (d) General sport creel survey to measure fishing pressure and use. (e) A complete water chemistry study to analyze present water quality.

PROCEDURES: Three collecting stations are set up on Hurricane Creek and one of the major tributary streams (Little Hurricane Creek). Each station consists of at least a one-fourth mile sample section, and the fish population will be estimated by the mark-and-recovery method. The study will be carried out during the summer and fall months. Electro-fishing will be employed as the collecting method.

Quantitative and qualitative benthos samples will be taken at each of the four selected stations, and will be identified to family, and in some cases to Genus. The samples will be taken at least twice, once in the summer and once in the fall during the study period. Samples will be collected with a Surber sampler; identification will be carried out in the spring and winter months.

Three water temperature stations are set up on Hurricane Creek to measure the warming effects of the impoundments. The thermometers will be read and remain in the stream during the summer and fall months. Weather conditions the day before and condition of the water (turbid, clear, etc.) will be noted and recorded.

A complete water chemistry analysis will be collected on the stream at two stations. One sample will be collected in the fall and one in the spring.

A general sport creel survey will be taken by the local Game and Fish Officer. The purpose of a partial creel survey is to get a general idea of how many people are utilizing the creek for fishing purposes, species caught, and catch rate.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Tennessee State Government

4.0227, AN HISTORICAL APPRAISAL OF THE TENNESSEE VALLEY AUTHORITY'S FLOOD CONTROL PROJECT AND PROGRAM

W.H. DROZE, Univ. of Texas, Graduate School, *Arlington, Texas* 76010

This proposal entails the examination of flood literature, observation of flood prevention works, analysis of flood damage records, and the study of flood-proofing efforts for the purpose of determining the effectiveness of the Tennessee Valey Authority as a flood control agency. This study will include an analysis of the politics of flood controll planning and development, an assessment of the engineering scheme which was used to remake the river, an examination of the efforts to control water on the land, an economic judgment of the costs and benefits of the water control system, and a comparative appraisal of the political and economic feasibility of applying the valley-authority type of agency to flood problems on other rivers.

Historical methods will be used to obtain and analyze the data about the Tennessee Valley Authority's project and program. Private and public and published and unpublished documents will be studied to determine why and how the TVA's flood control system was developed. On-the-ground observations will be conducted during the rainfall season in the Valley for determining the effectiveness of the system. Documentary information and field observations will be checked for their accuracy. Assembled data will be organized and reported according to standard historical procedures.

SUPPORTED BY University of Texas

4.0228, WATER LOSS

C.D. STUTZENBAKER, State Parks & Wildlife Dept. , *Austin, Texas*

Procedures: Record weekly water levels in relation to rainfall and input-output flooding. Evaluate net water levels in relation to wind, temperature, humidity, water depth and vegetative condition to determine normal water loss factor for each compartment.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Texas State Government

4.0229, STABILIZATION STUDY OF FALCON RESERVOIR

J.M. TRAVIS, State Parks & Wildlife Dept. , *Austin, Texas*

P. P. S. Objective: To conduct a study of the effects of a stabilized water level on sport fishing, fish populations, and the physical, chemical, and biological properties of Falcon Reservoir.

Procedures: 1. Fish populations will be sampled bimonthly with experimental gill nets and seines. Nets will be set at 12 predetermined stations for a period of time ranging from 8-18 hours. Netting stations will be located in approximately the same positions as those used during a previous survey of Falcon Lake. Seine collections will be taken at four or five established stations. Data collected from specimens taken by net will include length, weight, and sexual development. Stomach contents will be examined for a set number of each species. Seining collections will be preserved and returned to the laboratory for identification.

2. An attempt will be made to observe, detect, and record any physical, chemical and biological conditions that could affect the ecology and fish population of the lake. Chemical analysis of the lake water will be run bimonthly at selected sites. Water analysis data will include dissolved oxygen, dissolved carbon dioxide, alkalinity, pH, air and water temperatures, chlorinity, and turbidity. Records will be kept of the water level in the lake and of any changes which occur. Past water level records will be obtained for reference.

3. A study will be made of creel census methods and the suitability of Falcon Lake for creel census work.

4. The relative abundance of game and rough fishes will be determined from data collected. Year class strengths will be approximated by length-frequency methods.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Texas State Government

4.0230, SYSTEMS SIMULATION FOR MANAGEMENT OF A TOTAL WATER RESOURCE

W.L. MEIER, State Water Development Board, *Austin, Texas* 78711

The objective of this year's research project will be the development of techniques useful in defining the least costly means of supplying municipal, industrial, irrigational, recreational, fish and wildlife, and secondary petroleum recovery water requirements for a selected portion of the proposed Texas Water System to the year 2020. A methodology will be sought to aid planners in decision-making regarding means of providing water at least cost to meet demands among the several source river basins and reservoirs, and along the route of conveyance to terminal storage within the constraints of prospective water sales contracts, alternative project feature sizing, and alternative sequences and timing of construction of project elements.

Specifically, this research will have as its goal the development of the following: (1) a transfer model for optimal allocation of water to meet specified demands to the year 2020 at minimum total cost within the prescribed legal, financial, contractual, and political constraints, (2) an optimal means of sizing, sequencing and timing of the addition of project elements, (3) simulation models for the system, and (4) a support Data Management System.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Texas State Government

4.0231, EVALUATION OF HYDROLOGIC EFFECTS OF URBANIZATION

W.H. ESPEY, Tracor Incorporated, *Austin, Texas* 78721

The objective of this research project is to evaluate and extend previous studies to determine the effects of urbanization on several small watersheds located in Houston, Texas. Equations have been derived which evaluate certain hydrologic characteristics under past rural or undeveloped conditions and predict these same characteristics under future urban conditions for a samll urban watershed at Austin, Texas. It is proposed to evaluate the applicability to other watersheds of these equations by comparison with historical data from twenty small gaged watersheds in Houston, Texas.

Unit hydrographs having a common time base will be derived for all twenty watersheds with the data used to derive the original equations, and by a multiple linear regression analysis generate modified equations having possibly broader application.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

4.0232, FLOOD INUNDATION MAPPING AND URBAN RUNOFF INV., DALLAS, TEXAS

G.R. DEMPSTER, U.S. Dept. of Interior, Water Resources Division, *Austin, Texas*

Purpose: To define in Five Mile, Cedar, and Coombs Creek watersheds which would be inundated by past floods of defined frequency. To collect basic hydrologic data on floods of greater-than-ordinary magnitude in these watersheds and White Rock, Barkman, and Joes watersheds. To determine the effects of urban development on flood flows and total runoff in the White Rock Creek area.

Methods: The three major objectives of this project are interrelated to the extent that all hydrologic data collected will be applicable to each objective. Hydrologic instruments and surveys associated with the long-range program will provide the necessary data to define areas inundated by specific floods and to evaluate the effects of urban development on runoff. The data, analyses and computation associated with the short-term phase of the project to provide interpretive information on areas which would be inundated by floods of selected frequency will be applicable to the other objectives and would be strengthened and substantiated by data collected on floods experienced in the watershed. The data collected on the partly urbanized White Rock Creek watershed will be integrated with that being collected on the adjoining but mostly urbanized Barkman Branch and Joes Creek watersheds and the completely urbanized Turtle Creek watershed for analysis.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Texas State Government

4.0233, HYDROLOGIC INVESTIGATIONS OF URBAN AREAS - HOUSTON, TEXAS

S.L. JOHNSON, U.S. Dept. of Interior, Water Resources Division, *Austin, Texas*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in Cooperation with State and local agencies in Texas.

Purpose: To determine the changes in magnitude of flood flow and runoff caused by urbanization at a selected number of stream-gaging sites within the Houston area.

Methods: A continuous record of rainfall and runoff will be obtained at 7 stations in the hydrologic data collection network. Flood-hydrograph partial-record stations will be maintained at 15 sites. In addition, 6 rain gages will be located in the area. The stations were selected to provide optimum sampling of flood discharge with respect to time, variations in rainfall through climatic cycles, size of area, and degree of urbanization of area.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Texas State Government

4.0234, URBAN HYDROLOGY STUDY - SAN ANTONIO, TEXAS

E.E. SCHROEDER, U.S. Dept. of Interior, Water Resources Division, *Austin, Texas*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Texas.

Purpose: To provide data for a logical approach to flood-zoning and flood-protection problems, and to analyze the effects of progressive urbanization on the runoff. Data will also be useful in design of storm sewers, culverts, and bridges.

Methods: An adequate sampling will be made of data with respect to flood discharge as affected by time, variations in rainfall through climatic cycles, size of area, and degree of urbanization of area. This sampling will be accomplished by installation of streamflow stations, crest-stage stations, and rain gages at appropriate locations. The instrumentation will be done on pairs of small drainage basins within the metropolitan area. One basin of a pair will be chosen to represent urbanized conditions; the other will represent the undeveloped conditions. In so far as possible, the pairs of basins will be chosen so that the other factors such as geology, topography, and size will be equal.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Texas State Government

4.0235, GEOLOGY OF THE PALUXY AND BRAZOS VALLEYS IN HOOD, SOMERVELL, AND ERATH COUNTIES, TEXAS

J.S. NAGLE, Univ. of Texas, Bureau of Economic Geology, *Austin, Texas* 78712

Research leading to preparation of the ground-water section of this study documents a history of water use, gives an evaluation of present status of ground water resources, and presents an estimate of reserves in the confined Trinity aquifers of the area. History of water withdrawal and use was gained from a literature survey. The area was historically famous for flowing artesian wells, described in detail by R. T. Hill in 1901. By 1934 (Fiedler, U. S. Geological Survey Water-Supply Paper) water levels had declined to the point that most wells had stopped flowing. Estimates of water use for 1901 to 1934 indicate at least as much water was wasted as was used. Continuing studies by the U. S. Geological Survey have provided data since 1934. Analysis of the stratigraphy of the Trinity sands enables one to determine which sands are isolated from recharge areas, and which are continuous to outcrop. From these data, as well as from pumpage and water level data, it was possible to estimate water reserves in isolated sands, and to estimate the maximum pumpage that could be maintained to develop a balance between recharge and withdrawal in areas of continuous aquifers. An areal geologic map will be included in the report.

SUPPORTED BY University of Texas

4.0236, DEVELOPMENT OF A CHEMICAL FALLOW SYSTEM OF FARMING

A.F. WIESE, Texas A & M University System, Agricultural Experiment Sta., *Bushland, Texas*

Objectives: 1. Determine the effect of chemical fallow during a wheat-sorghum-fallow rotation of runoff, soil losses, moisture storage, residue conservation, crop yields and other physical, microbiological and chemical properties of Pullman silty clay loam soil. 2. Determine factors which may enhance the effectiveness of herbicides on grass weeds under semi-arid conditions and evaluate new herbicides for controlling weeds in continuous sorghum, continuous wheat, wheat-fallow, and wheat-sorghum-fallow rotations. 3. Determine the effect of herbicidal treatment on the water use and weed growth.

Work Proposed: A long term experiment will be conducted to determine the effect of chemical fallow on soil moisture runoff, crop yield and various physical, chemical and microbiological properties of the soil. Studies will be conducted to locate herbicides for chemical fallow in various cropping systems. Studies will also be conducted to determine factors which will enhance the effectiveness of herbicide to grass weeds under semi-arid conditions.

SUPPORTED BY U.S. Dept. of Agriculture
Texas State Government

4.0237, FACILITIES AND PROCEDURES FOR CONSERVATION MANAGEMENT OF RUNOFF WATER FROM AGRICULTURAL LANDS IN THE SOUTHERN PLAINS

V.L. HAUSER, U.S. Dept. of Agriculture, *Bushland, Texas*

Object: To develop and evaluate new and improved facilities, procedures, systems, and design criteria for the efficient collection, conveyance and surface or subsurface storage of runoff water for beneficial use from both dry and irrigated lands.

Plan of Work: Engineering studies will be made of systems, structures, and procedures for conserving runoff water that accumulates in playa lakes or constructed reservoirs. The research will include, but not be limited to, the following: clarification of muddy lake water, detailed exploration of the soils and materials existing in, under and around playa lakes, reservoir construction to concentrate runoff water, construction of water-spreading systems, construction of simple and cheap recharge shafts or wells, study of rate and direction of movement of recharged ground water, and other approaches as recognized worthy of study. Engineering studies will be made of terraces and other structures built to manage runoff water for either storage in the soil or removing it from the field as the crop and soil condition may dictate. Systems studied will include: Zingg conservation bench and other water conservation type terraces, land leveling, water spreading, and waterways lined with vegetation or permanent lining materials.

Cooperation: Kansas, Oklahoma, and Texas Agricultural Experiment Stations; SCS; and soil and water conservation districts.

SUPPORTED BY U.S. Dept. of Agriculture

4.0238, IMPROVED DRAINAGE SYSTEMS DESIGN, MATERIALS, INSTALLATION TECHNIQUES & DRAINAGE REQUIREMENTS OF CROPS IN THE SOUTHERN PLAINS

V.L. HAUSER, U.S. Dept. of Agriculture, *Bushland, Texas*

Object: To develop basic equations describing water flow relationships in drainage systems; to develop and evaluate design procedures for surface and subsurface systems, singularly and in combination; to evaluate new tubing, bedding, and envelope materials, and installation techniques; to determine causes for decrease in effectiveness of installed drainage systems; and to determine drainage requirements of crops and soils in the Southern Plains.

Plan of Work: This work will be conducted in the laboratory under controlled conditions and in the field. These studies will seek to develop criteria and test new materials for farm drains and for filters and envelopes around drains. Field evaluations of old drainage systems will be made to determine the long-range effectiveness and durability of drain and filter materials. Model studies will be made to develop flow equations directly or to determine the accuracy of equations developed with computer techniques. Laboratory models, analog studies, and hydraulic tanks will be used to study special drainage problems that are difficult to evaluate under field conditions. High speed digital computers will be used to provide tabular material or basic nomograph data which can greatly simplify the design of drainage systems using improved flow equations that consider the heterogeneous conditions of most soil. Results of these studies should provide improved design criteria and formulae for computing drain spacing and depth. The development of new equipment and materials for tile drainage installations will be carried on cooperatively with drainage contractors and drainage material manufacturers.

Cooperation: Texas Agricultural Experiment Station; SCS; U. S. Bureau of Reclamation; soil conservation districts; State engineers; irrigation districts, and private agencies.

SUPPORTED BY U.S. Dept. of Agriculture

4.0239, EFFECT OF SURFACE IRRIGATION HYDRAULICS ON EFFICIENT APPLICATION OF WATER

L.J. GLASS, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

1. Determine the effect of irrigation stream size, slope and shape of irrigated surface, hydraulic roughness of irrigated surface and water intake characteristics of soil on system design for most efficient application of water by surface irrigation methods. 2. Correlate results into design procedures using hydraulic factors of surface irrigation flow as criteria for design.

DESCRIPTION OF WORK - The research will be conducted in two phases. One phase will include a laboratory investigation of the problem while the other will incorporate field work.

The laboratory work will include tests in a hydraulic flume to determine (1) the shape of the water surface profile of the advancing and receding free water surfaces; (2) the type of flow (laminar or turbulent) as related to conveyance surface roughness characteristics, fluid properties, and hydraulic aspects of flow such as depth of flow and channel shape; and (3) the cross-sectional shape of conveyance surface and its effect on flow.

The field work will be directed toward checking hypotheses considered logical and necessary from the laboratory phases of the study.

SUPPORTED BY U.S. Dept. of Agriculture
Texas State Government

4.0240, CONTAMINATION OF GROUND WATER FROM RADIOACTIVE PACKAGES IMPACTING ON LAND

M.C. SCHROEDER, Texas A & M University System, Graduate School, *College Station, Texas* 77843

The dispersal of radioactivity by the accidental impact on the land of an apparatus carrying radioactive materials will be in part into the ground. This then can be transported by runoff or percolating water to streams or to the ground-water body. The possible methods of transport are controlled by the distribution coefficient of the released radioisotopes for the earth materials and the transporting waters. The stability of the original radioactive compounds may also need to be determined. Measurements of distribution coefficients for various materials under several chemical conditions will be made. These and published measurements will be evaluated in terms of transport for a number of conditions of soil, precipitation, types of weathering, vadose-water percolation, aquifer materials, transporting waters and other pertinent conditions. Consideration must be given to the dependence of the distribution coefficient upon the concentration of the radioisotopes. This research under the supervision of Melvin C. Schroeder is an extension of similar studies he made for Lawrence Radiation Laboratory, Livermore, California. That study was concerned with the ground-water transport of radioactivity from the site of subsurface nuclear explosions.

SUPPORTED BY Sandia Corporation

4.0241, ECONOMIC ANALYSIS OF SMALL WATERSHED DEVELOPMENT IN TEXAS.

W.L. TROCK, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

1. To determine the economic impact of watershed development on farms, communities and towns in selected small watersheds in Texas. 2. To evaluate developments via cost-benefit analysis of completed projects. 3. To examine alternatives to present watershed developments.

Description of work proposed: A description of each watershed prior to development will be prepared. Then the structural works of the developments will be identified and the costs associated with these works determined. Other costs, as waiting costs, will also be identified and evaluated. The benefits realized from developments will be determined and cost-benefit analyses of the completed developments will be accomplished. Realized benefits of development will be compared with benefits estimated in the project plans as a check on planning methods and procedures. Finally, possible alternatives to the developments now complete will be evaluated via synthesis of developments which would incorporate these alternatives. Added information useful in planning will thus be produced.

SUPPORTED BY U.S. Dept. of Agriculture
Texas State Government

4.0242, A MODEL RELATING WATER QUALITY VEGETATIONAL STRUCTURE AND URBANIZATION IN THE SAN JACINTO RIVER BASIN

D.L. JAMESON, Univ. of Houston, Graduate School, *Houston, Texas* 77004

We propose to analyze the correlation between vegetational structure, amount and kind of land utilization urbanization and the chemical and biological measures of water quality in the San Jacinto River Basin, Texas. The initial parameters will be obtained from government documents, reports already available or currently obtained (weather and hydrographic stations). These measures are assumed to be available to any metropolitan region which should give the model structural generality. Principal component analysis will be used for data reduction. Canonical correlation analysis will be used to obtain a preliminary estimate of the significant parameters. Multiple discriminant analysis will be used to identify the significant variables correlated with specific water quality stations. The data from these analyses will be used to construct a model which will characterize the present situation. The parameters of this model will then be manipulated with simulation programs in computers to attempt to predict the course and nature of water quality changes during the continued expansion of urbanization in the vicinity of Houston, Texas.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Houston

4.0243, DEVELOPMENT OF SYSTEMS FOR GROUND WATER RECHARGE INTO THE OGALLALA FORMATION

M.J. DVORACEK, Texas Technological College, School of Agriculture, *Lubbock, Texas* 79409

The work proposed in this project is to develop systems for recharging underground formations. Several approaches - well, pit, basin, shaft, & trench recharge plus water spreading - will be investigated. Particular consideration will be given toward development of a filter or clarification system for removal of the high sediment load carried by waters used for recharge. Waters available for recharge are generally excess water such as surface runoff collecting in natural depressions (playas).

Investigation will include both field and laboratory installations of filter systems suitable for clarification of waters for both pit and well recharge. Pit, shaft, & trench recharge and water spreading will be primarily field evaluations of constructed recharge facilities. The establishment of design criteria for pits, shafts,& trenches and filters for clarification of water is the primary objective of the project.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Texas Technological College

4.0244, INTER-BASIN DIVERSION OF WATER - A TEXAS CASE STUDY

H.W. GRUBB, Texas Technological College, School of Agriculture, *Lubbock, Texas* 79409

Specific Aims and Expected Results: The study will seek to illuminate the issues involved in large-scale water diversions and improve the analytical methodology for dealing with them. The specific problems to be dealt with are as follows: (1) The evaluation of benefits from a new water supply which is large enough to affect substantially the overall economy of a region. (2) The development of appropriate pricing policies where more water will help rescue an agricultural area from decline due to depletion of water supplies. Under these circumstances the water users may not be able to afford to pay the full cost of the supply although the project as a whole may be justified because of the overall benefits to the region and the nation. Various techniques for financing projects under these conditions merit exploration. (3) The economic consequences of legal restrictions on water transfer. It is evident that the laws which protect the area of origin against transfers of water to other areas seriously limit the opportunity for making the most economic investments in water development. The study will endeavor to illustrate the significance of these costs by evaluating them in the Texas situation. (4) The optimal staging of diversion works. The study will consider alternative ways of staging the development so as to relate investment in increased supply to the demand outlook. For example, consideration would be given to the possibility of developing closer sources initially pending an increase in demand to justify the construction of larger facilities bringing water from greater distance to serve long-range future needs. It is anticipated that the study will produce a major monograph on the economics of interbasin diversions of water.

SUPPORTED BY Resources For The Future Incorporated

4.0245, EFFECT OF UNLINED TREATED SEWAGE STORAGE PONDS ON WATER QUALITY IN THE OGALLALA FORMATION

D.M. WELLS, Texas Technological College, Water Resources Center, *Lubbock, Texas* 79409

Treated effluent from approximately eighty municipalities located in the high plains of Texas is presently being stored in unlined ponds and used for irrigation of crops. This project is designed to determine the effect of such surface stored on groundwater quality in the underlying Ogallala formation.

A pond has recently been constructed for storing municipal effluent on the Texas Tech campus. Two wells will be drilled, cased, and equipped with electric pumps in the vicinity of this pond. One well will be located adjacent to the pond, and the other several hundred feet downstream. Samples will be collected weekly from these wells and from several other existing wells located in various distances around the pond. Weekly samples will also be collected from three or four points within the pond.

All samples collected will be analyzed for total nitrogen, total phosphorus, chlorides, and total dissolved solids. Changes in groundwater quality will be observed and quantitative estimates of the rate in which sewage percolates into the groundwater will be made by determining the rate and the extent of propagation of quality change from the test well adjacent to the storage pond.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Texas Technological College

4.0246, MATHEMATICAL MANAGEMENT MODEL UNCONFINED AQUIFER

D.M. WELLS, Texas Technological College, Water Resources Center, *Lubbock, Texas* 79409

This research will investigate the application of existing techniques to the development of a mathematical model describing the flow of water in the Ogallala (and similar) aquifers, and, as necessary, the development of new or improved methods for mathematical modeling of an aquifer, with the end objective of achieving a tool to be used in managing the operation of the aquifer.

Coding procedures for computerizing well data will be developed and an approach to calculating pumpage will be devised. This information will be related to existing maps depicting hydrologic conditions in the H.P.U.G.W.C.D. No. 1.

Mathematical modeling methods for the Ogallala aquifer will be developed, starting with existing modeling techniques, with development of new and improved methods as necessary. Technical assistance and consulting from General Electric, TEMPO, and their work in developing techniques for deducing values for storage factor and transmissibility, will be utilized.

The model developed will be tested, to some extent, on parts of the Ogallala aquifer.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Texas Technological College
Texas State Government

4.0247, DEVELOPMENT OF SYSTEMS FOR GROUND WATER RECHARGE INTO THE OGALLALA FORMATION

R.Z. WHEATON, Texas Technological College, School of Agriculture, *Lubbock, Texas* 79409

The work proposed in this project is to develop systems for recharging underground formations. Two (2) approaches--well recharge and pit or basin recharge--will be investigated. Particular consideration will be given to development of a filter for the clarification of waters carrying a high sediment load. Waters available for recharge are generally excess water such as surface runoff which has a characteristic high sediment load. These conditions are severe and any filter developed should function in other areas. Investigation will include both field and laboratory installations using various filter materials. Pit recharge studies will be primarily field evaluations of constructed pits, at least ten (10) foot in depth, with various side slopes. Pits are to be located in natural depressions, (playas) using primarily surface runoff water for recharge with sewage effluent as a secondary source. The establishment of design criteria for pits and filters for recharge wells is the primary objective of the project. The project was started in 1966 and anticipated completion date will be 5 years.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Texas Technological College

4.0248, RELATION OF CLIMATIC AND WATERSHED FACTORS TO STORM RUNOFF IN THE SOUTHERN PLAINS

R.W. BAIRD, U.S. Dept. of Agriculture, *Temple, Texas*

Object: To identify the climatic and watershed factors influencing the magnitude and frequency of storm flows from agricultural watersheds; to evaluate the factors quantitatively; and to develop procedures by which the magnitude and frequency of storm flows from ungaged watersheds may be estimated.

Plan of Work: The work is currently concentrated on a segment of the Washita River Watershed in the vicinity of Chickasha, Oklahoma; on small agricultural watersheds near Stillwater, Oklahoma; at the Blacklands Experimental Watershed, Riesel, Texas; and on Lowrey Draw at Sonora, Texas. Some of the factors required by the analyses and which are measured or otherwise documented for the study are: rates and duration of streamflow; precipitation patterns; antecedent moisture; season; soils; land use; conservation and watershed management practices; ground water elevations; riparian vegetation; geology; gradients and hydraulic roughness of stream channels; and the size, shape and other geomorphic attributes of the watersheds. The downstream effect on flow regimes associated with improvement works in upstream tributaries is a primary phase of the study on the Washita River Watershed.

SUPPORTED BY U.S. Dept. of Agriculture

4.0249, WATER YIELD IMPROVEMENT FROM SOIL TREATMENTS AND PLANT-COVER ALTERATIONS (ABBREV)

N.V. DEBYLE, U.S. Dept. of Agriculture, *Logan, Utah*

Object: To determine the vegetative characteristics and processes that influence effects of plant-cover alterations and soil treatments on water yield.

Plan of work: The project staff is inventorying the following resources of the Intermountain Region that affect water yield: precipitation zones, vegetative types, soil types, and available water supplies. They are determining the hydrologic processes and relationships between soils, plans, and water that are involved in water yield. This information will be applied to plot studies to provide preliminary information the effect of watershed treatments such as vegetative thinning, removal, and conversion to other types; prescribed burning; and methods of cutting. Finally, they will apply the most promising of these treatments to pilot watersheds for verification.

SUPPORTED BY U.S. Dept. of Agriculture

4.0250, WATERSHED PROTECTION & REHABILITATION TO REDUCE WATER RUNOFF

P.E. PACKER, U.S. Dept. of Agriculture, *Logan, Utah*

Object: To study the relation of soil, water and vegetation to water infiltration, flow, and erosion; flood and erosion hazard criteria and protection for high-elevation summer ranges; effects of various rehabilitation treatments and management practices on erosion and on flood potential; and methods to restore plant cover, soil stability, and infiltration on depleted watersheds.

Plan of work: The project staff is investigating storm patterns to determine maximum rainfall intensity and level of protection needed. They are identifying the soil and vegetational characteristics that affect infiltration, overland and subsurface flow, erosion, and those factors that limit plant cover on harsh sites. They are developing and evaluating (1) treatments to improve the limiting site factors and (2) engineering structures to prevent overland flow. Pilot watersheds have been calibrated to test rehabilitation measures and improved grazing practices.

SUPPORTED BY U.S. Dept. of Agriculture

4.0251, THE DRAINAGE OF IRRIGATED LANDS

A.A. BISHOP, Utah State University, Agricultural Experiment Sta., *Logan, Utah* 84321

Objectives: 1. To determine the influence of irrigation methods and practices on ground water levels and drainage requirements. 2. To develop methods for evaluating the natural sub-surface drainage potential of an irrigated area. 3. To determine the relation between the soil permeability, as measured by the auger hole method, and the rate of fall of the water table mound with different irrigation applications.

The work proposed consists of establishing a two dimensional, steady state, flow system in a natural soil and evaluating the natural drainage potential from measurements of the total flow, piezometric head, soil moisture tension, permeability, and water table conditions. Data for the non-steady flow condition will also be obtained.

SUPPORTED BY U.S. Dept. of Agriculture
Utah State Government

4.0252, HYDRAULICS OF SURFACE IRRIGATION

A.A. BISHOP, Utah State University, Agricultural Experiment Sta., *Logan, Utah* 84321

Objectives: To provide understanding of surface irrigation design through the investigation of the hydraulic characteristics of surface flow: 1. By further development of mathematical models describing the flow in terms of the many variables involved including appropriate testing under controlled conditions. 2. By laboratory experiments for the description and evaluation of component variables. 3. By field trials to test the validity of mathematical equations and laboratory relationships in 1 and 2 above.

Work Proposed: Refinement of the mathematical model which describes the advance of water over the soil surface will be continued. Simplification of certain assumptions employed in the development of the existing mathematical models for recession and improvement of models for application efficiency and distribution efficiency. Field trials will also be conducted to test the models proposed.

SUPPORTED BY U.S. Dept. of Agriculture
Utah State Government

4.0253, DESIGN OF OPEN CHANNELS TO PREVENT BANK FAILURE

A.A. BISHOP, Utah State University, Agricultural Experiment Sta., *Logan, Utah* 84321

Objective: To analyze and describe the sub-surface flow of water and those factors which affect it (such as the physical and chemical properties of air, water, soil and introduced materials) in the immediate vicinity of the drain facility (tile line, ditch, drain well, etc.) in order to prepare improved criteria and procedures for design, installation and operation of drains.

Work Proposed: A field plot adjacent to an open drain will be constructed such that the water table a short distance from the drain can be controlled at the desired level. Plastic liners will be placed in a trench around three sides of a short section of drain bank. Water introduced on one side of the plot would move toward the drain simulating field conditions. The flow patterns established and the height of the seepage face will be determined by piezometric measurements. The strength of the soil will be measured and used to predict failure conditions. The strength of the soil as influenced by the absorbed ions will also be studied.

SUPPORTED BY U.S. Dept. of Agriculture
Utah State Government

4.0254, DRAINAGE FARM SERVICE

A.A. BISHOP, Utah State University, Agricultural Experiment Sta., *Logan, Utah* 84321

Objectives: 1. To prepare land and provide general maintenance to land and equipment on the Cache Valley Drainage and Reclamation Farm. 2. To improve and maintain facilities for research on the Cache Valley Drainage and Reclamation Farm. 3. To provide funds for a portion of the general administrative expenses for the Cache Valley Drainage and Reclamation Farm.

Work Proposed: A coordinated plan of land use and development will be established for maximum use of the drainage farm facilities. Minor experimental facilities of a common nature will be provided for mutual use. Land not actually in experiments will be cultivated for income and appearance. The water handling facilities on the farm will be gradually improved with a view to developing a model demonstration system.

SUPPORTED BY Utah State Government

4.0255, FRAIL LANDS STUDIES NEAR CISCO, UTAH (ABBREV)

G.B. COLTHARP, Utah State University, Graduate School, *Logan, Utah* 84321

Objectives: (1) To determine the effects of gully plugs and contour furrows on cover, density, productivity, phenology, and vigor of seeded and native vegetation. (2) To determine the temperature micro-climate and soil salinity modifications produced by these soil surface treatments. (3) To determine the effects of gully plugs and contour furrows on the amount and distribution of soil moisture. (4) To evaluate the effectiveness of the treatments on erosion and sedimentation rates and amounts. (5) To make economic evaluations of gully plugs, contour furrows, and combinations of both in terms of vegetation response, soil moisture retention, surface runoff reduction, and erosion control.

SUPPORTED BY U.S. Dept. of Interior - Bu. Land Mgmt.

4.0256, THE ROLE OF VEGETATION AND SOIL IN WATERSHED YIELD

B.L. GROVER, Utah State University, Agricultural Experiment Sta., *Logan, Utah* 84321

Objectives and Description of Work - 1. To develop a water yield prediction equation based on probable precipitation, soil properties, plant characteristics, and expected evapotranspiration for a particular watershed unit. 2. To determine the water balance of specific watershed units to test the equation developed in Objective 1. This is to be done using data on climate and site characteristics obtained from sites selected for specific combinations of vegetation and soil types. 3. To determine the effects of site factors upon the dendrochronological record produced. It is proposed to develop a chronology for the Ephraim Canyon area from suitable cores and cross sections and compare these with climatic records of particular watersheds. 4. To determine recent changes in the extent of Gamble oak and aspen clones by use of ring dating of cross sections from selected 'trunks' from typical clones.

SUPPORTED BY Utah State Government

4.0257, ECOLOGICAL STUDIES OF MANIPULATED MARSHES AT DELTA, MANITOBA, CANADA

D. MOORE, Utah State University, State Coop. Wildlife Res. Unit, *Logan, Utah* 84321

This study is designed to quantitatively elucidate many of the ecological differences which may arise in marshes having different water depths. Waterfowl will utilize these different water depth marshes in varying degrees. On the basis of the measured ecological differences of these marshes, recommendations will be made for future water level management.

An area within the private marshes of J. P. Bell, approximately 200 acres in size, roughly triangular in shape, and five miles east of the Delta Station was chosen for the proposed study.

The study marsh is now divided, by dikes, into five adjoining units. Two of these units are 47 acres in size; three are 33 acres in size. All units are connected by culverts enabling water level manipulations to be executed independently of the water level fluctuations of the main marsh. Water depths of 0, 12, 18, 24 inches and an uncontrolled area outside will be used.

To determine the differences in emergent and submersed vegetation within the different, but constant, water depth impoundments and within a section of uncontrolled marsh the procedure will follow along two major lines of investigation: (1) the vegetation will be measured qualitatively and quantitatively employing recognized and standardized procedures and (2) ecological factors within the impoundments and the uncontrolled area which relate to the vegetation will be measured.

SUPPORTED BY Utah State University
Canadian Government

4.0258, COMPUTER SIMULATION OF URBAN HYDROLOGIC SYSTEMS

J.P. RILEY, Utah State University, Utah Ctr. For Water Resour., *Logan, Utah* 84321

This study represents a logical extension of the work performed under a previous project (B-016-Utah). Under the previous work urbanization factors were expressed as parameters that define a equivalent rural watershed in a lumped system. In this study the urbanization factors were accounted for by analyzing each unit of the watershed. It is anticipated that the results of this study will be useful in the design of drainage structures on an urban micro-watershed basis.

The study will include classification of the urban watershed into a number of homogenous subunits. One or two blocks from each subunit will then be analyzed in detail. An attempt will be made to apply the equations of gradually varied, unsteady flow in open channels to describe the mechanics of runoff. The computed total outflow hydrographs will be compared with both measured hydrographs and those obtained from other methods.

Simulation models will be tested and verified on the analog computer. Field data will be obtained from the Waller Creek watershed at Austin, Texas.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Utah State University

4.0259, MANIPULATION OF TREMBLING ASPEN AND GAMBEL OAK FOR INCREASED WATER YIELD

J.D. SCHULTZ, Utah State University, Agricultural Experiment Sta., *Logan, Utah* 84321

Objectives: 1. To determine effective means of obtaining prescribed degrees of eradication of trembling aspen and Gambel oak growing on soils varying in texture from silts to clays and from sands to loams. 2. To evaluate relative gross savings in water loss by eradicating trembling aspen and Gambel oak to different levels. 3. To evaluate patterns of vegetation manipulation in the aspen type on snow accumulation and snowmelt.

Procedures: 1. Seven eradication treatments, replicated twice on each of four sites in continuous stands of both aspen and oakbrush, will be applied as follows: clearcut, intermediate cuttings of 75, 50, and 25 percent basal area, metered poison injections of every tree on a plot, frustum-reservoir poison injections of plot trees, and no treatment. Sprouting to be used as criteria of success. 2. Neutron meter access tubes to be installed to six to ten feet deep on the same plots, representing four vegetation conditions at each site: untreated stand, clearcut stand, stand poisoned by frustum-reservoir method, and stand with 75 percent basal area removed. Soil moisture losses over growing seasons to be measured. 3. Snow courses to be located in aspen stands with clearcut patches and strips to provide data on accumulation and melt.

SUPPORTED BY U.S. Dept. of Agriculture

4.0260, ANALYSIS OF SMALL WATER MANAGEMENT STRUCTURES

G.V. SKOGERBOE, Utah State University, Utah Ctr. For Water Resour., *Logan, Utah* 84321

The Irrigation and Drainage Research Conference conducted at Utah State University in March 1964, delineated many of the research needs regarding 'Small, Low-Cost Hydraulic Structures for Conveyance and Distribution Systems.' In discussing possible means of having the recommended research accomplished, it was suggested that a considerable portion of the research material could be undertaken by graduate students, particularly at the Master of Science level. Because of the lack of time, only the general titles were listed for research to be conducted at this level. Much of the research suggested at the conference could be more readily accomplished if the topics were identified with specific details and separated into segments in order that an individual graduate student could investigate a single segment.

The specific needs for research regarding small water management structures will be prepared and described in a report for general distribution. Particular emphasis will be given to topics which could be accomplished as a thesis by a graduate student at the Master of Science level. The topics will be prepared in sufficient detail and with appropriate background information that the problem can be readily attacked.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Utah State University

4.0261, SUBCRITICAL FLOW AT OPEN CHANNEL STRUCTURES

G.V. SKOGERBOE, Utah State University, Utah Ctr. For Water Resour., *Logan, Utah* 84321

The research accomplished under the previous matching fund grant, 'Design and Calibration of Submerged Open Channel Flow Measurement Structures,' will be extended to include additional practical physical situations, and to seek more answers to certain basic open channel flow problems. The previous research project showed that the methods of subcritical flow analysis are applicable to any form of side constriction or floor constriction. Submerged flow at gate structures will be studied in the laboratory to evaluate the universality of the subcritical flow techniques for determining the discharge through any form of open channel constriction. In addition, the special case of zero constriction will be studied in the laboratory to determine if the methods of analysis are applicable for describing flow resistance in open channels under steady nonuniform flow conditions.

A large amount of data collected by previous investigators regarding the hydraulics of bridge constrictions will be evaluated using the techniques developed to date. The evaluation will include the hydraulic design of bridge constrictions and the collection of discharge measurements at bridge constrictions. The analytical tools developed to date will also be applied to developing hydraulic design criteria for open channel expansions.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Utah State University

4.0262, CROP AND SOIL MANAGEMENT OVER SHALLOW PLASTIC-LINED MOLE DRAINS

L.S. WILLARDSON, Utah State University, Agricultural Experiment Sta., *Logan, Utah* 84321

1. To evaluate the applicability of plastic-lined mole drains to the drainage problems of typical poorly drained shallow soils. 2. To evaluate the soil and crop management problems under shallow drainage conditions.

Plastic-lined mole drains with a 'zipper' type closure will be installed on the Drainage Farm of Utah State University. Spacings of 20, 40, and 80 ft. will be included. Placement will be at the maximum possible depth determined by soil permeability sampling. The drains will be approximately 600 feet long. Stainless steel wires will be inserted in the drains at the time of installation to enable evaluation of drain stability and root penetration. Cutler boxes for observation will be installed at the upstream end of the drain. Gypsum will be applied to replace the exchangeable sodium above the drain depth. Crops, perennial and annual, will be grown on the area and drain spacing effects on production evaluated. Forage crops will be grown during the period of soil reclamation and leaching. Periodic measurements of drain discharge will be made on the irrigation water and drain effluent.

SUPPORTED BY Utah State Government

4.0263, CONTROL OF INSECT VECTORS ON WATERFOWL MARSHES

D.M. REES, Univ. of Utah, Inst. of Environ. Biol. Res., *Salt Lake City, Utah* 84112

Research Objectives: 1. Determine by research conducted on selected study areas the most effective water management facilities and practices that can be used to abate mosquitoes, horseflies, deerflies and gnats that are produced on marsh areas bordering the Great Salt Lake. 2. Specifically attempt to reduce the amount of insecticides now used on this area for the control of mosquitoes and other insects by preventing the production of these pests and vectors by adequate water management procedures. 3. Include as an additional aspect of this water management program the development of the land and water for greater beneficial use for wildlife, natural and improved pastures, other suitable agricultural crops, recreational facilities, and other beneficial use. 4. If the results of this research program are successful on the study areas, establish and maintain demonstrations of these water management procedures.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

4.0264, SOIL-WATER-PLANT RELATION TO ARTIFICIAL DRAINAGE

R.J. BARTLETT, Univ. of Vermont, Agricultural Experiment Sta., *Burlington, Vermont* 05401

The objective of this project is to determine the effects of artificial drainage on (a) crop adaptation, (b) crop growth and yields, (c) available moisture in the soil, and (d) soil physical and chemical properties.

DESCRIPTION OF WORK: The project is intended to be cooperative with and complementary to an Agricultural Research Service project involving the investigation of different methods of interception drainage on sloping land. Consequently, considerable effort in the present project is being devoted to the physical and chemical characterization of the soil at the drainage site under study.

In addition, certain interrelationships between soil, water, and plants are being studied. Relative amounts of oxidized and reduced iron in the rhizospheres of forage plants are being measured in an effort to learn why crop plants differ in their abilities to tolerate poor drainage and aeration.

SUPPORTED BY U.S. Dept. of Agriculture
Vermont State Government

4.0265, WATER YIELDS FROM SMALL WATERSHEDS

J.H. LILLARD, Virginia Polytechnic Institute, Agricultural Experiment Sta., *Blacksburg*, *Virginia* 24061

Objectives: (1) To correlate runoff yields and rates to watershed characteristics and climatic conditions. (2) To develop procedures for estimating surface and subsurface contributions to runoff from parameters of climate and watershed characteristics. (3) To develop procedures and formulas to reliably estimate seasonal and annual water yields.

Description of Work: - Continuous rainfall and runoff records from 10 mixed cover and 4 small unit source watersheds will be measured. Each watershed will be carefully characterized through soil, geologic, topographic and land use surveys; and correlations established between the watersheds characteristics and runoff yields. Additional investigations of soil moisture properties, effects of watershed size, shape and topography, land use patterns, soil conservation practices and management will be undertaken; and high speed data processing techniques employed.

5 soil types.

SUPPORTED BY U.S. Dept. of Agriculture
Virginia State Government

4.0266, DRAINAGE REQUIREMENTS AND PRACTICES FOR CROP PRODUCTION

J.H. LILLARD, Virginia Polytechnic Institute, Agricultural Experiment Sta., *Blacksburg*, *Virginia* 24061

Objective: To determine the drainage efficiency and economic feasibility of applicable land forming procedures in the Coastal Plain and Piedmont Regions.

Work Proposed: Four field experiments are used. Two are located in Princess Anne County where corn and soybeans are the test crops. One is located in Culpeper County on a flat river bottom where corn is the test crop and the fourth one is in Franklin County where tobacco is the test crop. At each location large field plots are carefully formed to precise specifications required for the local soil, topography and crop requirements. Records of time and labor costs are carefully kept. Yields and quality of crops are measured. The effect of the forming operation on soil physical properties and on fertility is studied. The application of land forming principles to create optimum conditions for improved tobacco production management systems is also studied in the Franklin County experiment.

SUPPORTED BY Virginia State Government

4.0267, MOISTURE CONSERVATION PRINCIPLES AND PRACTICES IN THE PACIFIC NORTHWEST

J.D. MENZIES, U.S. Dept. of Agriculture, *Prosser*, *Washington*

Object: To assess and evaluate effects of climatic, vegetative, soil and management factors on evaporation and evapotranspiration and to develop soil and crop management practices to improve efficiency of water use.

Plan of Work: Basic soil and climatic factors involved in movement of water and heat in soils and their exchange between the soil and atmosphere are investigated. Factors such as pore size, soil density, soil stratification, moisture and energy gradients, as well as topography, vegetation and physical aspect are most pertinent to these studies. Effects of soil temperature on moisture movement are pertinent, and emphasis is placed on developing and testing mathematical relationships to describe moisture and heat flow phenomena. Field studies are made on moisture storage and utilization using a wide range of methods for controlling and directing runoff into storage for subsequent use, and for controlling evaporation through tillage, crop residue management and related procedures. The technique of adding soil moisture artifically is used when necessary to obtain more precise experimental control of the moisture variable. Specific studies are made relating various management practices to moisture storage at seeding time of various crops.

SUPPORTED BY U.S. Dept. of Agriculture

4.0268, HYDRAULICS OF SURFACE IRRIGATION

D.L. BASSETT, Washington State University, Agricultural Experiment Sta., *Pullman*, *Washington* 99163

Objectives: To provide fundamental surface irrigation design understanding through the investigation of the hydraulic characteristics of surface flow by further development of mathematical models describing the flow in terms of the many variables involved, including appropriate testing under controlled conditions.

Description of Work Proposed: At present the interrelationship among the variables of unsteady, non-uniform surface flow are not known in sufficient detail for system design. Mathematical analysis will be used to investigate these variables. Preliminary equations for the rate of advance will be refined and expressions for the rate of recession will be developed. These developments will be examined experimentally insofar as possible in existing laboratory facilities designed especially for the study of the variables involved. These expressions may then be combined to form a model of a complete irrigation, which can be made to define uniformity of water application and optimum conditions for system design.

SUPPORTED BY U.S. Dept. of Agriculture
Washington State Government

4.0269, THE ECONOMICS OF WATER TRANSFER - AN APPRAISAL OF INSTITUTIONS

C. DITWILER, Washington State University, Agricultural Experiment Sta., *Pullman*, *Washington* 99163

1. To identify the principal institutional and legal processes through which transfers of water between uses and users take place in the state of Washington. 2. To appraise the effect of this machinery on certain economic efficiency and equity aspects of water use transfer.

1. Review existing literature, administrative reports, and legal statutes which relate to the use and transfer of water to develop an inventory of the existing devices for water transfer. Although emphasis will be placed at the state level of government, county and local devices will be considered if they should differ. 2. The attributes of these legal and institutional structures, insofar as they affect the efficient transfer of the water resource, will be appraised by criteria derived from general economic principles underlying the efficient allocation and transfer of resources.

SUPPORTED BY U.S. Dept. of Agriculture
Washington State Government

4.0270, SIMULATION MODELING OF THERMAL EFFECTS ON SELECTED RIVER SYSTEMS

R.T. JASKE, Battelle Memorial Institute, *Richland*, *Washington* 99352

This program consists of the application of digital simulation program originally developed for the investigation and prediction of Columbia River water quality, primarily temperature, both above and below the Hanford plant, to perform water quality predictions associated with the erection of planning for nuclear electrical generating facilities in critical major river basin areas. These critical areas, or marketing regions would be selected by the Div. of RD&T in response to current licensing needs and other predictions.

Following successful completion of reports detailing trial simulations of the Deerfield and Illinois rivers, BNWL-628,and BNWL- 728 the simulated effects of the Dresden II and III reactor stations under construction have been completed. During FY

1969 it is planned to complete the simulation of the five state upper Mississippi drainage area through the year 2000 in order to determine the extent to which the river system could absorb waste heat under existing state water standards.

Also planned for FY 1969 is a start on adaptation of the basic digital simulation system to the Great Lakes region, starting with Lake Michigan. In addition, the headwaters streams of the Ohio River would be studied from a point above the Pennsylvania-Ohio border.

A preliminary investigation of the concept of colling a series of large stations situated along a canal with consecutive reuse of a single condenser canal flow would be carried out.

SUPPORTED BY U.S. Atomic Energy Commission

4.0271, COLLECTION OF JUVENILE MIGRANTS FROM RIVERS AND STREAMS

D.W. BATES, U.S. Dept. of Interior, Fish Passage Res. Program, *Seattle, Washington*

Anticipating that certain types of hydro-electric developments may either destroy large numbers of young migrant fish or may be impassable, a major research effort is being made to find practical and economical methods of collecting these young fish from rivers and streams before they reach the areas of danger. Methods of fish guidance and collection presently in use are only partially successful, or not applicable to large projects, or overly expensive. Research will be directed toward improving the efficiency of guiding techniques that have shown promise in the past, such as electricity, louvers, and lights; exploring the possibilities of more effective combinations of techniques; and developing new concepts of fish guidance and collection that would use a minimum of structure in the water. Facilities and methods for holding, handling, and transporting fingerlings will be investigated.

Four field stations are now in operation for such testing. Primary features of these stations are the flume installations which provide flexibility, wide range of velocity control, ease of fish observations and enumeration, and the testing of wild fish in as near to natural conditions as possible. Since the beginning of this project considerable advance has been made in the deflection or guidance of young migrants by means of flow accelerations and decelerations.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

4.0272, METHODS OF ANALYSIS AND DETERMINATION OF EFFECTS OF ALTERNATIVE USES OF FORESTED LANDS ON STREAMFLOW

S.P. GESSEL, Univ. of Washington, Graduate School, *Seattle, Washington* 98122

Research is proposed to investigate: 1. the effects of forest management, harvesting regimes, and alternative uses of forested lands on hydrology of certain river basins in Washington. 2. the application of multivariate statistics for evaluation of alternative land uses and design of complex hydrologic models. 3. development of analog computer models for solution of complex hydrologic problems involving alternative uses of forested land.

Long-term U.S. Geological Survey streamflow records will be used with climatalogical records in multivariate analysis to develop regression equations for predicting daily streamflow. Major changes in vegetative cover which alter water yield should result in significantly different equations.

These equations will be used to develop analog models of the influences of various parameters and treatments on water yield of a river for a variety of physiographic conditions.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Washington

4.0273, HYDROLOGY OF WATERSHEDS ON SHALE SOILS

W.H. DICKERSON, West Va. University, Agricultural Experiment Sta., *Morgantown, West Virginia* 26506

Secure basic hydrologic data from small agricultural watersheds on shale soils. Determine effect of chiseling on runoff from these soils as reflected by peak rates of flow and total yield. Relate effects of chiseling to soil properties and to production.

DESCRIPTION OF WORK - Four small watersheds of approximately 10 acres each, are being studied to determine runoff patterns and obtain basic hydrologic data. Instrumentation includes type H flumes with water stage recorders, standard and recording rain gauges and a fairly elaborate installation of resistance blocks to indicate soil moisture. After a calibration period, which is still in progress, two of the watersheds will be chiseled and two will be retained as checks. The effect of chiseling on hydrologic behavior will be determined by hydrograph analysis. An attempt will be made to relate the effects of chiseling to soil properties and to production by carrying out laboratory analyses of the soil and securing observations on forage production of the area.

SUPPORTED BY U.S. Dept. of Agriculture
West Virginia State Government

4.0274, ALTERNATE TO STORM WATER SEPARATION

C.C. RUSHMAN, Chippewa Falls Government, *Chippewa Falls, Wisconsin*

The project includes construction of a combined storm water pumping station and storage pond; increased interceptor pumping capacity; increased pumping conduit, and final settling tank capacity; combined relief sewer, and some separation.

I will demonstrate the control and elimination of storm water bypasses by diverting to a storage pond for sedimentation with subsequent discharge to the Waste Water Treatment Works, where the wastes will receive both primary and secondary treatment, with chlorination.

The design, operational procedures, and treatment efficiency will be evaluated. Comparison with separation of storm and sanitary sewers will also be evaluated.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Chippewa Falls City Government -
Wisconsin

4.0275, REDUCTION OF FLOOD RUNOFF, SEDIMENTATION AND STREAMFLOW IMPROVEMENT IN UNGLACIATED AREAS

R.S. SARTZ, U.S. Dept. of Agriculture, *La Crosse, Wisconsin*

Objective: To determine: (1) importance of forests in runoff and erosion control in Mississippi Valley; (2) disposition of precipitation on forest, brush, and other steeply sloping lands under different treatments, (3) and the influence of plantations on erosion and elements of the water cycle.

Plan of Work: The Staff is measuring flood flows from plots and experimental watersheds to determine the source of the flood runoff. They are measuring the interception of overland flow from upland field by forested slopes and are attempting to increase the effectiveness of the forest in dissipating this flow. They are continuing to evaluate the effect of forest plantations on snow buildup, soil freezing, and other soil properties and the effect of natural forests on soil freezing.

SUPPORTED BY U.S. Dept. of Agriculture

4.0276, IMPACT OF WINTER DRAWDOWN ON A SLOW-GROWING PANFISH POPULATION AND ASSOCIATED SPECIES

H. SNOW, State Div. of Conservation, *Madison, Wisconsin* 53701

Objectives: To determine through, before and after studies, the effects of a winter drawdown on survival, natural mortality, exploitation rate, growth rate, and age composition of all major fish species with special reference to the bluegill. To determine physical and chemical changes in water quality, before, during and after drawdown.

Procedures: A record of fishing statistics will be obtained through the use of a permit system of fishing at Murphy Flowage, Rusk County. Anglers will be interviewed and their catches examined at a checking station by Department personnel. Data on length, weight, scale samples, recovery of marked fish, and stomach samples of certain species will be obtained from angler caught fish. Other information necessary to complete a record of fishing success will be obtained. Information on individual anglers such as age, sex, residence, distance traveled, bait used, and fishing method used will be collected. All creel census information obtained is coded for machine tabulation.

Spring population estimates of standing crops of fish in Murphy Flowage will be accomplished by mark and recapture methods by trap netting and shocking. Fish marked by finclipping during spring estimates will provide marked fish for a population estimate based on angler returns. Population estimates during 1968-69 will be used to indicate population trends occurring after the drawdown.

Continued growth rate determination of game and panfish will be based on fish collected by netting, shocking and angler caught fish.

A water quality inventory of Murphy Flowage will be conducted to determine some of the more important characteristics that may have a bearing on fish ecology, Standard methods will be used to make water chemistry determination for pH, alkalinity, oxygen, conductivity, and light penetration.

During November 1967 the water level will be lowered several feet. This will reduce the total volume from 50 to 75 percent. The lower level will be maintained throughout the winter and refilling to normal level will take place in April, 1968.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Wisconsin State Government

4.0277, WATER RESOURCES OF SOUTHEASTERN WISCONSIN - FOX RIVER BASIN

R.D. HUTCHINSON, U.S. Dept. of Interior, Water Resources Division, *Madison, Wisconsin*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with State and local agencies in Wisconsin.

Purpose: To determine the quantity and quality of water available for man's use and man's effect on the water supply in southeastern Wisconsin.

Methods: Available information on streamflow, lake stages, ground- water levels, pumpage, climate, water use, geology and quality of water will be compiled and interpreted. Seepage measurements and a ground- water flow map will be used to determine the interrelationships of ground water and surface water. The relationship of water use to the piezometric surface, water quality, and surface-water and ground-water conditions will be established.

A projection of anticipated water use to a definite future date will be made and the possible effects on the entire water resource will be described. The effects of alternate water-use possibilities will be illustrated.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Wisconsin State Government

4.0278, FLOOD INUNDATION STUDY, WISCONSIN

J.O. SHEARMAN, U.S. Dept. of Interior, Water Resources Division, *Madison, Wisconsin*

Purpose - To determine inundation limits for flood discharges so that meaningful zoning ordinances may be formulated.

Methods - The priority of areas where flood inundation studies will be conducted is to be determined by potential and/or existing hazard and the availability of topographic and hydrologic data. A sufficient number of channel characteristics will be obtained by field surveys to allow computations of water surface profiles in the selected reaches. The inundation limits for selected discharges (and for an actual flood where possible) will be presented on topographic maps.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Wisconsin State Government

4.0279, EFFECT OF IRRIGATION ON STREAMFLOW IN CENTRAL SAND PLAINS OF WISCONSIN

E.P. WEEKS, U.S. Dept. of Interior, Water Resources Division, *Madison, Wisconsin*

Purpose - To determine the effect of the expanding development of ground-water for irrigation on streamflow and ground-water levels.

Methods - Continuous or periodic measurements of streamflow (seven stations) ground-water levels (about 30 wells) precipitation (about 4 gages) and soil moisture (about 10 stations) will be made to determine the water budget in each basin. Aquifer thickness will be determined from existing wells and about 80 test holes. Hydraulic properties of the aquifer will be determined from five aquifer tests and by analysis of water-level recessions in several observation wells. Water useage will be determined from well pumpage and irrigated acreage inventory. Effects of pumpage will be computed from mathematical models of each basin based on nature and configuration of basin boundaries and hydraulic properties of the aquifer in the basin.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Wisconsin State Government

4.0280, HUMBOLDT AVENUE POLLUTION ABATEMENT PROJECT

H.A. GOETSCH, Milwaukee City Government, *Milwaukee, Wisconsin*

Reduction of degree of pollution in the Milwaukee River is proposed by increasing the efficiency of intercepting devices and by using a detention tank to capture and treat the storm overflow of combined sewage for an urban area comprising 570 acres which constitutes approximately 3% of the total combined sewers of the City. This includes the measurement of flows and quality at critical points within the collector system affecting the control of facilities to be constructed. The facility will be thoroughly evaluated with regard to efficiency and cost of utilizing this method of treatment.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Milwaukee City Government - Wisconsin

4.0281, ARID LAND ECOLOGY AND ENVIRONMENT STUDIES IV. WATER QUANTITY MANAGEMENT

H.G. FISSER, Univ. of Wyoming, School of Agriculture, *Laramie, Wyoming* 82071

The objectives are: (1) To determine the relationship of forage production to precipitation and other physical site characteristics. (2) To determine the relationship in terms of cover and composition, of vegetation on non-grazed sites to grazed sites. (3) To determine the relationship of forage production to soil moisture and temperature on selected sites. (4) To determine the effects of shrub control and grazing treatment on soil movement.

Forage production will be measured annually on study sites in western Wyoming using clipped plots of various sizes on transects. Average height, basal or crown cover, and composition will also be measured on plots, and a photographic record will be made. Precipitation measurements will be taken either four times a year or monthly at each site. Vegetation transects are located by restricted randomization inside and outside exclosures on various sites.

Soil moisture and temperature measurements will be made at different depths by use of neutron probes and thermistors.

Vegetation relationships of five shrub communities in the Big Horn Basin to soil and precipitation characteristics will be determined.

Analysis of data will be conducted with aid of electronic computer programs.

SUPPORTED BY U.S. Dept. of Interior - Bu. Land Mgmt.

4.0282, THE ECONOMICS OF WATER TRANSFER - AN APPRAISAL OF INSTITUTIONS

W.D. SCHUTZ, Univ. of Wyoming, Agricultural Experiment Sta., *Laramie, Wyoming* 82071

Objectives: 1. To appraise the legal-institutional-administrative devices and processes through which transfers of water between uses and users take place and 2. To assess the consequences of these devices and processes on the economic efficiency and equity of water use and 3. To suggest desirable modifications in these devices and processes that might enhance economic efficiency or equity in the use of water resource.

4. WATER QUANTITY MANAGEMENT AND CONTROL

This research will involve an examination of present legal arrangements and processes concerned with the transfer of water rights, and also it will involve economic analyses of respective water uses. This latter step will provide a basis for generalizing as to the economics of transfer within and provide a basis for generalizing as to the economics of transfer within and between uses. Lastly the adequacy of present transfer arrangements will be appraised and suggestions made for changes where such are deemed desirable.

SUPPORTED BY U.S. Dept. of Agriculture
Wyoming State Government

4.0283, HYDROLOGIC FORECASTING AND EFFECTS OF FLOODS ON MEANDERING ALLUVIAL RIVERS WITH LARGE FLOODPLAINS

S. BRUK, Jaroslav Cerni Institute, *Belgrade, Yugoslavia*

The aim of this research project which is funded under the Special Currency Program of the United States is to develop mathematical models for forecasting of flood waves on rivers with meandering alluvial channels and large floodplains. Experimental methods will be proposed for verification of the model, including model tests on aerodynamic and hydraulic scale models and field investigations on a reach 3 to 5 kilometers long. The field investigations will be conducted on the Morava River which is an important tributary of the Danube.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

5. WATER QUALITY MANAGEMENT AND PROTECTION

Identification of Pollutants; Sources and Fate of Pollution; Effectsof Pollution; Waste Treatment Processes; Ultimate Disposal of Wastes;Water Treatment; Water Quality Control.

5.0001, WATER RESOURCES NEMATOLOGY

E.J. CAIRNS, Auburn University, School of Agriculture, *Auburn, Alabama* 36830

The investigation will begin with first a determination of the kinds of nematodes to be found in the various major types of water resources while seeking correlations with the major factors of the environment; second, investigations of the role of nematodes in bottom muds and rooted aquatic plants; and third, to investigate their role in food chains and other biotic cycles in the water resources. The proposed work will not be directly involved with public health aspects of water resources. In addition to the general survey, permanent sampling sites may be established where repeated observations over extended time periods of the effects of natural and man-made influences will be of value. Ecological data will be collected using accepted techniques for the water and bottom soils. Nematodes will be cultured with their community associates for the study of their bionomics and for the use and training of others in aquatic nematology.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Auburn University

5.0002, EVALUATION OF EARTHY MATERIALS FOR USE IN DECONTAMINATION OF WATER

J.B. DIXON, Auburn University, Water Resources Research Inst. , *Auburn, Alabama* 36830

An aquatic herbicide and representatives of two groups of potential water contaminants are being investigated in the laboratory to determine their reactions with clays of soils and sediments. The influence of clay mineral type and interlayer hydroxy-Al on the fixation and relaese of diquat aquatic herbicide is being investigated. Mineralogical and environmental factors influencing the sorption and decomposition of endrin, dieldrin, and aldrin are being investigated. The influence of clay mineral type and anion reactions which may indicate how amiben is held are being investigated. The amount and type of reactions with clays will be considered in relation to leaching of amiben. Natural molecule sorption on clay minerals and soil clays is being investigated employing a vacuum sorption-desorption apparatus. This study is directed toward perfecting a method which will aid in predicting extent of reaction of clay minerals with organic water contaminants.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Auburn University

5.0003, EFFECT OF HERBICIDES ON AN AQUATIC ENVIRONMENT

H.H. FUNDERBURK, Auburn University, School of Agriculture, *Auburn, Alabama* 36830

To study absorption, translocation and distribution of a phloem mobile herbicice (2,4-D) and a xylem mobile herbicide (simazine) in Eurasian milfoil. This will enable us to obtain basic information reqarding the movement of chemicals in submersed plants as well as providing basic information to solve a specific problem.

To study the effect of diquat, paraquat, simazine, dischlobenil, and at least 1 additional promising aquatic herbicide on certain metabolic processes of aquatic plants. This will provide additional information regarding the mode of action of these particular herbicides.

To study the degradation of diquat, simazine, and 2,4-D in an aquatic environment (water, plants, soil, and fish). This will provide additional information on the fate of chemicals in the aquatic environment which will tell us, among other things, how long a chemicaal can be used in a given location.

To determine the effect of promising aquatic herbicides on fish. This will provide information on the effect of the chemical directly on the fish as well as indirectly, e.g., measuring the effect on the fish food organisms.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0004, THE DISPOSITION OF PESTICIDES IN THE SOIL

A.E. HILTBOLD, Auburn University, Agricultural Experiment Sta. , *Auburn, Alabama* 36830

Objective: To determine the distribution of pesticides in selected soils and their drainage waters, using sites to which known amounts of pesticides have been applied. B. To determine the physical, chemical and biological processes, and soil characteristics which are important in the disposition of pesticides in soils.

Procedures: Determine movement of atrazine, diuron, Treflan, and DMA in soil columns in laboratory under influence of leaching and evaporation of water. Determine volatilization of these herbicides from soil using radioactive labeled materials in planchets as function of temperature. Determine adsorption of labeled herbicide by soil clay minerals and organic fractions in water suspensions. Determine priming effects of organic matter decomposition on microbiological breakdown of herbicide as shown by bioassay. Verify microbiological processes by use of microbial inhibitors and sterilization. Determine relative rates of herbicide decomposition in soils treated repeatedly with herbicide vs. untreated soils. Isolate and identify microorganisms active in detoxication.

SUPPORTED BY U.S. Dept. of Agriculture
Alabama State Government

5.0005, TEXTILE WASTE TREATMENT PRACTICE

L.J. HIRTH, Auburn University, School of Chemistry, *Auburn, Alabama* 36830

The effects of textile wastes on receiving streams and on municipal treatment facilities may be minimized by reducing the volume and/or strength of the wastes either by manufacturing process changes or by industrial waste treatment. It is proposed to conduct an examination of existing textile plant waste treatment practices(A) To determine the present textile waste treatment practices and the problems involved; (B) To determine the workability, efficiency, and loading of existing systems of waste treatment; and (C) To conduct engineering-cost analyses of the existing systems of waste treatment to determine the most efficient means of satisfactorily treating specific wastes.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Auburn University

5.0006, GAMMA RADIATION OF TEXTILE WASTE WATER TO REDUCE POLLUTION

J.F. JUDKINS, Auburn University, School of Engineering, *Auburn, Alabama* 36830

The object of this proposal is to study gamma irradiation as a means of treating textile waste. The gamma irradiation will be supplied by a Cobalt-60 source with a variable geometry and a maximum disintegration rate of 12,000 curies.

Polluting agents common to textile waste are starch, basic hypochlorite bleach, dye compounds, sulfides, sulfites, and various detergents. The research will be broken down into three phases. These will be the study of the effect of gamma irradiation upon (1) aqueous solutions of individual polluting agents, (2) mixtures of the polluting agents, and (3) industrial samples of textile wastes. Experimental parameters, such as pH, dissolved oxygen concentration, temperature and radiation dosage will be varied.

The effect of the total irradiation dose and dosage rate on the starch camples will be evaluated by viscosity change, starch-iodine spectra and reducing sugars formed.

Standard chemical analysis will be used to determine the radiolysis products of the sulfides and detergents while radiolysis of the dyes will be evaluated spectrophotometrically. The chemical and biochemical oxygen demands of the radiolysis products and the original samples will also be measured.

Attempts will be made to predict optimum radiation dosage and dosage rate for degrading a particular waste to a satisfactory level. These predictions will then be tested by the radiolysis of actual textile industrial waste water samples.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Auburn University

5.0007, COLOR REMOVAL FROM TEXTILE DYE WASTES BY COAGULATION

J.M. JUDKINS, Auburn University, School of Engineering, *Auburn, Alabama* 36830

The treatment methods presently used for textile dye wastes have not been very successful in removing the color from these wastes. The discharge of highly colored wastes into streams is objectionable.

Laboratory studies using the standard jar test will be conducted to determine the extent of color removal from textile dye wastes by coagulation. Several coagulants, including alum and ferric sulfate, both with and without polymeric agents will be evaluated at different pH levels. Color removals will be measured with an electrophotometer. Initial and final BOD and sulfide concentrations will be determined on sulfur dye waste samples. The costs of the more promising treatment methods will be studied on a plant-scale basis.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Auburn University

5.0008, DYNAMICS OF CHEMICAL & PHYSICAL CHARACT OF WATER, BOTTOM MUDS & AQUATIC LIFE IN A LARGE IMPOUNDMENT ON A RIVER (PHASE II)

J.M. LAWRENCE, Auburn University, Water Resources Research Inst., *Auburn, Alabama* 36830

This study of impoundments on parts of the Chattahoochee and Flint Rivers will supplement work completed under OWRR Project B-00 -ALA (Phase I). This study will indicate: (1) input-output relationships of salts and organic matter brought into the impoundment by creeks, streams and rivers and their distribution in water, biota and bottom muds within the impoundment and its tailwaters; (2) the influence of treated domestic pollution on chemical and physical characteristics of water throughout a long, relatively deep, power impoundment; (3) the importance of paper mill waste introduced into the prevailing domestic sewage pollution upon aquatic plant development and upon fish population conditions in downstream areas of such polluted impoundments; (4) critical periods and conditions that may affect aquatic life in this and similar impoundments; (5) the dynamics of physiochemical characteristics of mainstream impoundments and aid in the establishment of water quality criteria for multi-purpose impoundments.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Auburn University

5.0009, CHEMICAL CONTROL OF WEEDS IN PONDS

J.M. LAWRENCE, Auburn University, Agricultural Experiment Sta. , *Auburn, Alabama* 36830

1. To evaluate the activity of commercial and experimental herbicides and algacides on common pond weeds of this area. 2. To determine the toxocological effects of the more promising aquatic herbicides and algacides to fish and fish-food organisms under controlled laboratory and field conditions. 3. To investigate effects of more active aquatic herbicides and algacides on production of plankton, fish-food organisms, and fish in treated pools and ponds.

Some 25 to 50 potential aquatic herbicides will be available for controlled laboratory evaluations each year. The more active of these herbicides will be evaluated in the laboratory for toxicity to fish. Controlled field evaluations of the most promising herbicides on 14 species of aquatic weeds and 2 species of fish will be set up each year. Each field evaluation is designed for 2 years duration, and will provide information on herbicidal activity, water quality, plankton and fish production.

SUPPORTED BY U.S. Dept. of Agriculture
Alabama State Government

5.0010, BIOLOGICAL AND CHEMICAL OXIDATION OF SELECTED ORGANIC PESTICIDES

G.M. LEIGH, Auburn University, School of Engineering, *Auburn, Alabama* 36830

The purpose of this project is to determine the extent of biological and chemical degradation of certain of the chlorinated hydrocarbon pesticides that pose water pollution problems.

Lindane, heptachlor, endrin, and DDT in water solution will be subjected to the oxidizing action of chlorine, potassium permanganate, and potassium persulfate at three pH levels.

The degradation of lindane and heptachlor in water solution by acclimated organisms will also be studied.

Changes in pesticide concentrations will be determined with increasing contact times by electron-capture gas chromatography.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Auburn University

5.0011, WATER POLLUTION BY DAIRY FARM WASTES AS RELATED TO METHOD OF WASTE DISPOSAL

T.A. MCCASKEY, Auburn University, School of Agriculture, *Auburn, Alabama* 36830

Initial work of this project will include an examination of existing waste disposal systems on Alabama dairy farms and the apparent correlation of the waste with water contamination. Immediately available for this phase of the study are four dairy farms of the Alabama Agricultural Experiment Station System representing several soil and water conditions of the southeast. A number of large commercial dairies in the vicinity of Alabama cities will contribute to the study.

Field research will include studies of four systems of dairy farm waste disposal: 'dry' manure accumulation and periodic spreading with conventional equipment; semi-liquid manure collection in underground tanks and spreading on fields in liquid form using tractor-drawn equipment; liquid manure spreading via irrigation systems at frequent intervals; aerobic lagoons. Sampling sites will include: feedlots, croplands, pasture lands, streams or waterways, farm ponds, groundwater.

Laboratory studies will include the enumeration of the following groups of bacteria: fecal coliform and streptococci; salomonellae; shigellae; Clostridium perfringens. Chemical tests such as COD, pH, alkalinity, water hardness, nitrate and nitrite content, tannin and lignin, etc. will be made.

Field and laboratory data will be correlated with the view of developing guidelines on acceptable waste disposal systems for commercial dairy farms.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Auburn University

5.0012, PREDICTING AND PREVENTING FISH KILLS

H.S. SWINGLE, Auburn University, School of Agriculture, *Auburn, Alabama* 36830

Objectives: 1. To improve methods of management of fish populations for sport fish production.

Procedures: 1. The effect of air introduced into the deepest water of a 22-acre pond upon stratification and oxygen distribution will be studied and compared with the effects of electric pumps circulating water from the deeper waters to the surface.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Alabama State Government

5.0013, STUDIES ON THE INTERACTIONS OF BACTERIA AND AQUATIC NEMATODES

G.R. WILT, Auburn University, School of Veterinary Medicine, *Auburn, Alabama* 36830

The purpose of this research is to determine the kinds of bacteria ingested by aquatic nematodes in water resources and to seek basic information relating to bacteria-nematode interactions. This work will not be directed toward public health aspects, but rather toward a much broader base.

Bacteria will be isolated from single, surface-sterilized nematodes of known identity. Isolation and culturing will be done under a variety of conditions to insure the greatest number and diversity of bacterial types. The enumeration and identification of bacteria will be done by standard microbiological procedures.

Various substances obtained from active cultures of nematodes will be studied for their effect on bacterial growth by respirometric techniques, and/or turbimetric techniques of determining total growth in media containing test substances, as compared to growth in control media without these substances.

Experiments with nematodes in the same stage of development and exposed to certain bacterial metabolites will be conducted with the Cartesian diver apparatus in order to determine effects on nematode respiration. Alternative methods of studying the effect on nematodes of bacterial metabolities will be considered.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Auburn University

5.0014, ELECTROSORPTION AND DESORPTION PROCESS FOR DEMINERALIZATION

R.E. LACEY, Southern Research Institute, *Birmingham, Alabama*

In the proposed additional work the electrosorption process will be evaluated for demineralization of natural brackish waters containing appreciable quantities of calcium sulfate and calcium bicarbonate.

Experiments will be conducted on two natural brackish waters over periods up to three months with each feed water to determine the degree of demineralization, coulomb efficiencies, extent of interference of scale-forming substances, and resistances per cell pair.

Experiments will be performed also to study the application of filmforming materials containing ionogenic groups onto porous substrates to form electrosorption membranes.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

5.0015, DEMINERALIZATION OF WASTEWATER BY THE TRANSPORT-DEPLETION PROCESS

E.W. LANG, Southern Research Institute, *Birmingham, Alabama*
(14-12-443)

The primary objectives are to determine the technical feasibility of the transport-depletion process for reducing the dissolved solids of secondary wastewater and to determine how well the transport depletion process can overcome the problems that have been encountered when conventional electrodialysis is used with wastewater. Other objectives include determining operating limits of the process, including types of feed pretreatment, when demineralizing secondary effluent, obtaining engineering design data and providing preliminary cost estimates to indicate the economic promise of this process for demineralizing wastewater.

To achieve these objectives, it is proposed to install and operate a transport-depletion stack and auxiliary equipment at a local sewage treatment plant. The treatment plant effluent, augmented with salts to bring the composition up to typical sewage effluent composition if necessary, will be demineralized over a wide range of operating conditions. The maximum demineralization capacity of the unit and the ability of the unit to operate without intolerable increases of electrical resistance with different types of water pretreatment, with a range of solution velocities within the stack compartments, and with high ratios of product-waste flows will be determined.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0016, FREQUENCY DISTRIBUTION OF BIOLOGICAL POLLUTANTS IN SHELLFISH AND THE MARINE ENVIRONMENT

W.F. HILL, U.S. Dept. of Hlth. Ed. & Wel. , P.H.S. Gulf Coast Mar. Lab. , *Dauphin Island, Alabama* 36528

It is the purpose of this investigation to determine, define, and evaluate the potential public health hazards attributable to the presence of pathogenic microorganisms (including pollution indicators), viruses, and biotoxins in the marine biota and the associated environment. Samples will consist of oysters, marine sediments, soils adjacent to the marine environment, and seawater collected from shellfish growing areas of the Gulf of Mexico and South Atlantic States. Sampling will be on a monthly basis. The tasks are oriented toward: (1) determining the enteric virus population as to frequency and type distribution in estuarine waters from selected sampling stations in the Mobile Bay area and (2) determining the fate of coliform, fecal coliform, and selected enteric pathogens with emphasis on the influence of soil types and climatic conditions on survival. Hydrographic and ecological parameters associated with these tasks will also be evaluated.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0017, BIOLOGICAL METHODS RESEARCH

W.F. HILL, U.S. Dept. of Hlth. Ed. & Wel. , P.H.S. Gulf Coast Mar. Lab. , *Dauphin Island, Alabama* 36528

The purpose of this investigation is to develop new and/or improved methods for (a) determining fecal pollution of shellfish and shellfish growing waters and (b) isolating, concentrating, and enumerating viruses from the marine environment. Studies to be initiated will be concerned with (1) evaluating rapid methods for detecting and enumerating fecal coliform organisms; (2) investigating the feasibility of using chemical indicators for fecal pollution; (3) developing methods for isolating enteric pathogens from shellfish and shellfish growing areas; and (4) developing and evaluating new and/or improved methods for isolating, concentrating, and enumerating viruses from shellfish, and the marine environment.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0018, INVESTIGATIONS ON CIGUATERA-LIKE BIOTOXINS IN SHELLFISH

W.F. HILL, U.S. Dept. of Hlth. Ed. & Wel. , P.H.S. Gulf Coast Mar. Lab. , *Dauphin Island, Alabama* 36528

Mass cultures of the toxigenic marine dinoflagellate, Gymnodinium breve, have been established and will be increased in volume of production to provide large quantities of material for (1) studies oriented toward the isolation, purification, and characterization of the ciguratera-like toxin produced by this organism; (2) investigations of the process by which G. breve toxin is accumulated, retained, and eliminated by edible shellfish, (3) the development of analytical techniques for rapid quantitation of the toxin, and (4) studies designed to assess the toxicity of G. breve aerosols.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0019, DEPURATION OF MICROBIAL POLLUTANTS IN SHELLFISH

B.E. HUNTLEY, U.S. Dept. of Hlth. Ed. & Wel. , P.H.S. Gulf Coast Mar. Lab. , *Dauphin Island, Alabama* 36528

The purpose of this investigation are (1) to determine, define, and evaluate (a) the environmental conditions that predispose oysters to accumulate and eliminate microorganisms. (b) the conditions for effective treatment and ultraviolet disinfection of seawater, and (c) the various environmental factors that influence oyster activity; and (2) to design, construct, operate, and evaluate a prototype depuration system capable of processing commercial size lots of oysters. Ongoing studies are primarily oriented toward (1) determining the effectiveness of UV radiation as a treatment method for seawater to be used in depuration with emphasis on enteric viruses; (2) determining the effect of selected salts on bacterial elimination rates of the eastern oyster; and (3) continuing the evaluation of a prototype depuration system as to operational suitability with emphasis on the elimination of fecal coliform by oysters.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0020, DEPURATION OF CHEMICAL POLLUTANTS IN SHELLFISH

F.C. KOPFLER, U.S. Dept. of Hlth. Ed. & Wel. , P.H.S. Gulf Coast Mar. Lab. , *Dauphin Island, Alabama* 36528

This study is being conducted to determine the extent and rate of accumulation of pesticides, heavy metals and/or other chemical contaminants in shellfish. Emphasis is currently oriented toward heavy metals studies in which oysters are used as the test animal. Initially, zinc was investigated, and present studies are now concerned with the uptake of chromium in three ionic states by oysters. Studies will also be undertaken of chromium in three ionic states by oysters. Studies will also be undertaken to determine the requirements for maximum elimination of chromium by oysters under depuration conditions. As this effort progresses, additional heavy metals will be studied. Atomic absorption spectrophotometry is being used for the analyses.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0021, FREQUENCY DISTRIBUTION OF CHEMICAL POLLUTANTS IN SHELLFISH AND THE MARINE ENVIRONMENT

J. MAYER, U.S. Dept. of Hlth. Ed. & Wel. , P.H.S. Gulf Coast Mar. Lab. , *Dauphin Island, Alabama* 36528

The purpose of this investigation is to determine, define, and evaluate the potential public health hazards attributable to the presence of chemical pollutants in shellfish and other marine biota and in the associated environment. Studies are concerned primarily with determining the frequency distribution of chemical pollutants including, but not limited to, trace metals, pesticides, and various organic and inorganic compounds in shellfish and the marine environment. Current emphasis is oriented toward determining the distribution and concentrations of heavy metals in oysters and seawater collected from the Mobile Bay area and in oysters collected from coastal states, other than Alabama, of the Gulf of Mexico and the South Atlantic regions. Sampling is conducted on a monthly basis. Samples are being examined for lead, zinc, copper, cadmium, and chromium by atomic absorption spectrophotometry and for mercury by a chemical method.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0022, PROJECT 2203 EFFECTS ON PHYSIOLOGY WORK UNIT 53 CHRONIC EFFECTS OF ENDRIN ON BLUEGILLS

C.J. KNOWLTON, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Marion, Alabama*

The purpose of the work is to measure chronic effects of endrin on bluegills at Marion, Alabama. The bluegills are distributed among 12 earthen ponds and are given a single set of endrin treatments, at two concentrations. Samples of fish, invertebrates, bottom sediments, water, and aquatic vegetation are collected according to a pre-arranged schedule. Residue analyses are made at Marion, Alabama, on most kinds of samples. Fish populations are studied for growth, mortality, and reproduction. Fish are examined for histopathology at Columbia, Missouri.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0023, NUTRITION OF WATER WEEDS

J.B. MARTIN, U.S. Tennessee Valley Auth. , *Muscle Shoals, Alabama*

Nutrition of various species of water weeds which have infested certain areas of the TVA reservoirs is under investigation. It is hoped that a knowledge of their nutritional requirements will lead to development of control measures.

SUPPORTED BY U.S. Tennessee Valley Auth.

5.0024, BIOLOGICAL PROPERTIES OF SEWAGE LAGOONS AT TUSKEGEE, ALABAMA

K.S. CHAHAL, Tuskegee Institute, School of Agriculture, *Tuskegee Institute, Alabama* 36088

This study will determine the efficiency of sewage lagoons and the effect of microorganisms and their byproducts on the quality of water in receiving streams. Samples of raw sewage and lagoon effluent will be analyzed for total solids, BOD, dehydrogenase activity, total microbial count, and relative proportions of different kinds of microorganisms during different seasons of the year. Microbial byproducts will be extracted from cultures of microorganisms isolated from samples. The biological activity of the byproducts will be tested using mammalian tissue culture technique. Parameters for bioassey will be cytochemical changes, synthesis of protein and nucleic acids, and total cell count. Identification of compounds will be by IR and UV spectrophotometry, gas, paper, and thin layer chromatographic methods.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Auburn University
Tuskegee Institute

5.0025, CONSERVATION OF FRESH-WATER RESOURCES BY DEEP-WELL DISPOSAL OF LIQUID WASTES

D.M. GRUBBS, Univ. of Alabama, Water Resources Program, *University, Alabama* 35486

This project will evaluate the geological and engineering parameters of subsurface rock formations which will permit disposal of liquid waste by deep-well injection procedures. Criteria and techniques will be sought which will have both quantitative and qualitative regional application in the development of underground disposal facilities. This will in turn alleviate the problem of usage of surface waters as carriers of waste effluent. Studies will be focused upon: 1. Derivation and analysis of information such as rock core and cuttings lithology, analysis of reservoir fluids, results of rock matrix and cementing material, electrical and other well-logging parameters, and petrophysical data such as porosity and permeability; 2. Laboratory analysis from simulated injection of liquid wastes into actual reservoir core samples to determine capacity, receptivity, continuity and compatibility, and pressure-time-distance response as a basis for prediction of systems behavior; 3. Development of mathematical models applicable to the identification and evaluation of potentially receptive disposal zones. Determination of restrictions to be placed upon types and volumes of liquid wastes which may be injected into specific deep-well reservoirs.

5. WATER QUALITY MANAGEMENT AND PROTECTION

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Alabama
Alabama State Government

5.0026, DEVELOPMENT OF WASTE STABILIZATION LAGOONS FOR APPLICATION IN ALASKA

S.E. CLARK, U.S. Dept. of Interior, Alaska Water Laboratory, *College, Alaska* 99701

The project objectives are to evaluate waste stabilization lagoon efficiencies while operating under Alaska's severe climatic conditions and to develop operation techniques which will assure adequate waste treatment throughout the year. A pilot plant located at Eielson Air Force Base is being placed in operation this winter utilizing the theory of storage of the winter's wastes with spring, summer and fall discharge. A polishing lagoon will be placed in operation during the warmer months of the year.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0027, SUBARC AERAT LAG INVES BIOKIN REQUIR SEASON & DIURN EFF ON NUT BAL

S.E. CLARK, U.S. Dept. of Interior, Alaska Water Laboratory, *College, Alaska* 99701

The project objectives are to evaluate: a. To develop design and operational standards for artificially aerated waste stabilization lagoons under Alaskan conditions. b. To evaluate parameters contributing to effluent quality, power and maintenance costs, reliability under rapidly varying ambient conditions, and the effects on the receiving waters.

A pilot plant has been constructed and will be placed in operation at Eielson Air Force Base.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0028, COMPLETE MIX ACTIVATED SLUDGE UNIT PROCESS ADAPTION TO LOW TEMP

S.E. CLARK, U.S. Dept. of Interior, Alaska Water Laboratory, *College, Alaska* 99701

The project objectives are to evaluate the influences of Alaska's severe climatic conditions upon the activated sludge process in the loading range between 0.02 and 0.40 no. 5-Day BOD per no. of MLVSS, and to develop techniques for minimizing the detrimental climatic influences. Laboratory scale pilot studies utilizing settled sewage are in progress to determine low temperature biokinetics including a major emphasis devoted to developing techniques of effective solids separation that will be feasible in the Alaska environment and under the Alaskan inflated economy. Large scale outdoor pilot facilities are planned.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0029, STUDY OF ASSIMILATIVE CAPACITY OF ARCTIC AND SUB-ARCTIC STREAMS

P.J. FREY, U.S. Dept. of Interior, Alaska Water Laboratory, *College, Alaska* 99701

Information on the effects of extreme environments (have periods of darkness or of light, total ice cover for nine months of the year, low maximum water temperature) on a river's capacity to assimilate pollution, and on the organisms which inhabit the streams and are responsible for the degradation of pollution will be obtained so that it will be possible to predict and evaluate the effects of pollution on these streams.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0030, EFFECTS OF LARGE SCALE FOREST FIRES ON WATER QUALITY IN THE INT. AK

F.B. LOTSPEICH, U.S. Dept. of Interior, Alaska Water Laboratory, *College, Alaska* 99701

The purpose of this project is to evaluate the significance of large scale forest fires as polluting agents in Alaska's interior. Evidence from work in other states suggests that soil properties change as a result of burning, the degree of change being proportional to the severity of burning. Little or no work is available on the effect of these changes in soil properties on water chemistry of streams draining burned watersheds. Moreover, the effects of burning on stream biota, resulting from aberrations in water chemistry, has received little attention. This project is designed to compare soil chemistry to water quality of streams draining these watersheds. Species composition of stream biota will be related to water chemistry to provide information on the significance of burning to biological changes caused by forest fires.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
U.S. Dept. of Interior - Bu. Land Mgmt.

5.0031, TOTAL ORGANIC CARBON AS A POLLUTION CONTROL PARAMETER IN SUB-ARCTIC WATERS

E.W. MUELLER, U.S. Dept. of Interior, Alaska Water Laboratory, *College, Alaska* 99701

Organic materials are one of the major sources of natural pollutants in arctic waters. The scope of this research is to evaluate a number of methods for determining the concentration of organic materials in the natural waters of Alaska. The approach will involve a series of experiments with oxidation of the organics to carbon dioxide and measurement of the carbon dioxide in a non-dispersive infrared analyzer. Combustion will be accomplished both at high temperatures in a stream of oxygen, and through wet chemical oxidations. Typical compounds will be used as standards to determine the effectiveness of the method. Comparison will be made between chemical oxygen demand of field samples and the values found by total carbon determination.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0032, ORGANISMS RESPONSIBLE FOR TOXICITY OF ALASKAN CLAMS

M.B. ALLEN, Univ. of Alaska, Inst. of Marine Sciences, *College, Alaska* 99735

The aims of this project are: (1) to identify the organism(s) responsible for toxicity of clams and mussels in Southeast Alaska. (2) To isolate these organisms in axenic culture and study the effect of environmental variables on their growth and toxicity, with the aim of being able to predict when clams might or might not be toxic, or hopefully, eventually to control toxicity in the shellfish population.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0033, DYNAMICS OF THE NITROGEN CYCLE IN LAKES

V.A. BILLAUD, Univ. of Alaska, Inst. of Marine Sciences, *College, Alaska* 99735

The transformation rates within the freshwater biological nitrogen cycle are under investigation using the stable isotope of nitrogen, 15N as a tracer. The role of the nitrogen cycle in the productivity regimes of lakes, in bloom development, in under-ice winter metabolism are all included. The role of denitrification is emphasized, as well as nitrogen fixation, both under aerobic and anaerobic conditions. Possible heterotrophy or mixotrophy under winter and spring ice-cover are investigated using tritium labeled organic compounds. Gas chromatography is being used to study gas production during anerobic metabolism in lake waters. Detailed limnological studies of lakes in the subarctic are concurrently being carried out.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0034, BIOLOGICAL EFFECTS OF HEAVY METAL POLLUTION

D.K. BUTTON, Univ. of Alaska, Inst. of Marine Sciences, *College, Alaska* 99735

The single major process that mediates the conversion of the world's non-living biomass to reusable components is microbial degradation. The effort here is directed toward understanding this process as it occurs in nature with particular reference to aquatic systems. Since rates are normally controlled here by chemical concentrations it is useful to describe this relationship. These extracellular components may have a process-supporting, neutral or inhibitory effect.

Since heavy metal pollution is a growing phenomenon of our waters due to mining industry and car exhaust, and since the nature of enzymes is to bind available heavy metals with a concomitant alteration in catalytic ability this specific project is directed toward examining heavy metal poisoning of microorganisms, in theory, and as it occurs in Alaskan mining areas.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0035, ECOLOGY & NITROGEN CYCLE IN A MARINE PLANT COMMUNITY

J.J. GOERING, Univ. of Alaska, Inst. of Marine Sciences, *College, Alaska* 99735

The physiological ecology of eelgrass (Zostera marina) communities will be examined in concurrence with the dynamics of the nitrogen cycle in a lagoon on the Bering Sea coast of Alaska. A comparison of natural conditions will be made with an area receiving untreated sewage. This will include an examination of the relationship between the primary producers and nitrogen cycle, with emphasis on the role played by nitrogen in the total productivity of the community. Also to be included is the control of the environment on the growth and morphology of the dominant primary producer, eelgrass. The contribution of organic matter, particulate and dissolved, from the eelgrass communities to near-shore oceanic food webs will also be investigated.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0036, BIOLOGICAL DEGRADATION OF WASTES UNDER PSYCHROPHILIC ENVIRONMENTS

R.S. MURPHY, Univ. of Alaska, Inst. of Water Resources Res. , *College, Alaska* 99735

Waste discharges into natural surface waters in arctic and subarctic environments have traditionally been regulated by standards developed for temperature climates. Consequently, the natural abilities of streams and lakes at high latitudes to assimilate wastes is comparatively unknown at present.

This investigation will study metabolic reaction rates of mixed microbial cultures natural to a psychrophilic environment. Original cultures will be obtained from streams, lakes, and soils of Interior Alaska. The metabolic rates will be investigated in 2 liter respirometer vessels at temperatures ranging from 0.5 degrees C to 20 degrees C. Pure substrates as well as complex substrates (sewage) will be utilized.

The results of this investigation will be an aid in the prediction of the effect of a waste discharge upon a natural body of water. In addition, these same parameters will be used for the design of biological treatment processes operating under psychrophilic regimes.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Alaska

5.0037, PRACTICAL APPLICATION OF FOAM FRACTIONATION TREATMENT OF LOW QUALITY WATER

R.S. MURPHY, Univ. of Alaska, School of Engineering, *College, Alaska* 99735

A bench-scale study using foam fractionation techniques to remove iron and color from a groundwater was recently completed. The results indicated that the process was sufficiently efficient to warrant the construction of a 100 gallon pilot plant in order to determine the economics of the process in the field. This research will be concerned with the construction, operation, and economics of this pilot installation. Greater than 99.5 percent iron removal is predicted (raw water: 30mg/l Fe) for this unit.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Alaska

5.0038, EVALUATION OF AN OXIDATION-DITCH WASTEWATER TREATMENT PLANT IN SUBARCTIC ALASKA

R.S. MURPHY, Univ. of Alaska, School of Engineering, *College, Alaska* 99735

The project plan is designed to evaluate an existing oxidation- ditch wastewater treatment facility located in the sub-Arctic near Fairbanks, Alaska. Operation procedures, problems and economics of the system will be studied. Sufficient data will be obtained such that a mathematical model describing the biokinetics and oxygen requirement of the system can be formulated. Investigations will cover both the warm and cold temperature regimes as well as the transitions between these extremes.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
University of Alaska

5.0039, MONITORING THE EFFECTS OF LAND USE ON SALMON PRODUCTION

T.C. HOFFMAN, State Div. of Comm. Fisheries, *Juneau, Alaska*

Objectives: To complement and extend the presently established joint monitoring effort of the U.S. Forest Service and the Alaska Department of Fish and Game in order to determine if stream changes due to logging and other causes occurred and to what extent these changes affected the potential of these streams to produce salmon fry.

Characteristics Monitored: (1) Composition of streambed spawning areas. (2) Streamflow and water temperature. (3) Stream channel configuration and amount and kind of debris in the stream. (4) Classification of soil types in the watershed. (5) Sources of sediment. (6) Production of salmon fry and survival. (7) Assessment of adult salmon escapement.

Characteristics studied prior and subsequent to land use and observations taken yearly.

The studies to date have been a cooperative venture between the U.S. Forest Service and the Alaska Department of Fish and Game with each agency responsible for part of the work. The study is primarily to establish a base for management action and is presently being conducted in one important salmon producer in Southeastern Alaska and will be extended to three with special reference to logging and road building.

Procedures: For these characteristics monitored by the Alaska Department of Fish and Game as described in Fisheries Research Institute, University of Washington Field Manual dated 17 February 1964.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.
Alaska State Government

5.0040, FERTILIZATION OF WOODS CANYON LAKE

J.A. ERCOLE, State Game & Fish Department, *Phoenix, Arizona*

Objective: To determine the cost per pound of increased harvest derived from artificially fertilizing an infertile 50-acre trout lake.

Procedures: 1. Ten vertical columns of water in the lake will be isolated by tubes made of thin translucent polyethylene film. The tubes will be positioned in random groups and anchored firmly. The lower ends will be sealed with large balloons after tubes are placed in lake.

Commercial grade fertilizers, in solution, will be added to the tubes in controlled amounts. Four replicated experiments will be conducted simultaneously. Two unfertilized tubes will serve as controls.

Optical depth, turbidity, pH, total dissolved solids, and temperature and oxygen stratification determinations will be obtained periodically during each series of fertilization experiments.

2. A large plant of three inch rainbow trout will be made. These trout will be marked with a double fin clip differing from the original clip. Growth rates and condition factors will be computed from marked fish; condition factors will be computed for any unmarked fish trapped in the net. 3. In order to establish the 'before and after' effect of fertilization, several measurements will be made which will indicate changes in certain limnological features of the lake.

Quantitative study of plankton will be conducted during the spring, summer, and fall months at one month intervals.

4. A creel census will be conducted during the fishing to obtain an unbiased estimate of fisherman hours and total harvest.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Arizona State Government

5.0041, BLUE-GREEN ALGAE POISONING

T.J. MCMICHAEL, State Game & Fish Department, *Phoenix, Arizona*

Objectives: To describe the distribution of blue-green algae on the Three Bar Wildlife area.

Procedure: 1. Search the literature to determine what algae are capable of producing toxins. 2. Collect and preserve samples of algae from water sources on the Three Bar during the summer months. 3. Identify the algae to determine if any of them are known toxin producers.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Arizona State Government

5.0042, ADVANCED WASTEWATER TREATMENT USING POWDERED ACTIVATED CARBON IN RECIRCULATING SLURRY CONTACTOR-CLARIFIERS

C.F. GARLAND, Infilco Incorporated, *Tucson, Arizona* 85703
(14-12-400)

The objective of this project is to determine the process and operating parameters for adsorption of dissolved impurities from the secondary effluent of a municipal activated sludge plant by powdered activated carbon in two stages of continuously recirculating slurry contactor- clarifiers. The proposed work includes: 1. Preliminary laboratory investigations to evaluate three different commercial grades of powdered activated carbon will be performed during the procurement and construction periods (10 weeks). Carbon coagulation studies, adsorption isotherm studies, and adsorption rate studies will determine which activated carbon will be used in the subsequent field operations. 2. A 10-30,000 gal/day, two stage countercurrent, continuously recirculating contactor-clarifier will be constructed and evaluated during continuous operation for a twelve-week period. The independent process variables of flow rate, activated carbon feed rate, and slurry solids inventories will be investigated over ranges sufficient to determine the optimum combination for removal of adsorbable substances as determined by COD measurements. A brief study will be made of a 'single-stage' contacting system.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0043, TUSCON WASTEWATER RECLAMATION PROJECT

P. BEERMANN, Tucson City Government, *Tucson, Arizona* 85701

The project objectives are to demonstrate the chemical, biological, and virological safety, and the aesthetic acceptability of including renovated wastewater as a dependable and substantial portion of the future Tucson water supply and to determine what species of fish will live and provide the optimum production and growth rate in renovated wastewater. The renovated water will be supplied from a pilot scale spreading basin - horizontal flow filtration facility and experimental ponds.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Tucson City Government - Arizona

5.0044, SOILS, PESTICIDES, AND THE QUALITY OF WATER

G.R. DUTT, Univ. of Arizona, Agricultural Experiment Sta., *Tucson, Arizona* 85721

Objectives; a. Existence of pesticides in the soil solution. b. To identify the properties of pesticides and of soils that control the extent of movement of pesticides in and through soils. c. To ascertain the solubility characteristics of pesticides sorbed on soil particles and hence the effect on suspended soil on the concentrations of pesticides in water.

Description of Work Proposed: The interactions of triazines and substituted ureas with soil components, e.g., water, organic fractions and mineral fractions, will be studied in coordination with Hawaii. The solubility of the pesticides will be determined in distilled water and in solutions containing certain solutes. Procedures will be developed for extracting triazine from soil components. Sorption isotherms will be found for various organic fractions and thermodynamic coefficients determined for these constituents. Attempts will be made to see it predictions of concentration of pesticides in the effluent from the columns can be made from measurements of soil and water constituents and distribution coefficients found in the equilibrium studies.

SUPPORTED BY U.S. Dept. of Agriculture
Arizona State Government

5.0045, NITROGEN TRANSFORMATIONS IN SOIL

G.R. DUTT, Univ. of Arizona, School of Agriculture, *Tucson, Arizona* 85721

The reactions of NH4, NO3 and CO(NH2)2 fertilizers with soils will be studied. The results of these studies will be used to develop a system analysis model of the soil system to predict the nitrate transformations taking place in soil-water systems under variations of time, moisture contents, temperature and oxygen along a flow line in the soil system.

SUPPORTED BY Arizona State Government
U.S. Dept. of Interior - Bu. Reclamation

5.0046, PLAQUING AND FLUORESCENT ANTIBODY METHODS FOR DETECTION AND IDENTIFICATION OF ENTEROVIRUSES

P.P. LUDOVICI, Univ. of Arizona, Water Resources Research Ctr., *Tucson, Arizona* 85721

The proposed study is aimed at developing practical plaquing techniques for the direct detection and separation of enteroviruses from natural wastewaters. Emphasis will be placed on the use of primary and established cell lines and differential overlay media.

Fluorescent antibody procedures will be employed to devise a more rapid technique for the identification of these plaque-forming enteroviruses from natural wastewaters.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Arizona

5.0047, FACTORS AFFECTING ZOOPLANKTON PRODUCTION IN FOUR ARIZONA LAKES

W.J. MCCONNELL, Univ. of Arizona, Arizona Coop. Fishery Unit, *Tucson, Arizona* 85721

The goal of the investigation is to identify factors other than rate of primary productivity which influence the production of zooplankton in four lakes. Factors being considered are toxic and beneficial trace metals, bacterial populations and plant nitrogen content. Trace metals concentrated in aquatic macrophytes are being analyzed by atomic absorption spectrophotometry, bacteria are being counted directly under phase contrast, and nitrogen in aquatic macrophytes is being determined by the Kjeldahl method. Zooplankton biomass is being measured with a metering tow net.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Arizona State Government
University of Arizona

5.0048, LIMNOLOGICAL EFFECTS OF ORGANIC WATERSHED LITTER

W.J. MCCONNELL, Univ. of Arizona, Graduate School, *Tucson, Arizona* 85721

An understanding of some important and unique watershed effects on small impoundments in the semi-arid Southwest is sought. The effects for which elucidation is proposed relate to the interaction of a flashflood drainage regime, great seasonal differences in rainfall and the intensely cyclical deposition of organic watershed litter in lakes of the region.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0049, THE QUALITY OF ARIZONA WATERS WITH PARTICULAR REFERENCE TO FLUORIDES

H.V. SMITH, Univ. of Arizona, School of Agriculture, *Tucson, Arizona* 85721

Work on this project to date has consisted of compiling analyses of waters from the Tanque Verde area, east of Tucson. The analyses are arranged according to the legal description of each well included in this study.

Wells in Township 13 S, Ranges 15 and 16E; Township 14 S, Ranges 15 and 16, and 17 E; Township 15 S, Ranges 15, 16, and 17 E.

Work on this project has not proceeded to the point where conclusions may be drawn or the results plotted on a map.

SUPPORTED BY University of Arizona

5.0050, SPORT FISHERY POTENTIAL IN RECLAIMED WASTEWATER

C.D. ZIEBELL, Univ. of Arizona, Arizona Coop. Fishery Unit, *Tucson, Arizona* 85721

To measure growth rates, condition and survival of channel catfish, trout and Tilapia fingerlings in ponds filled with reclaimed municipal waste water after tertiary treatment with gravel filters. Oxygen content, pH, zooplankton and benthos are being monitored on a routine basis by appropriate methods.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
University of Arizona
Tucson City Government - Arizona
U.S. Dept. of Interior - F. Water Pol. Ctl

5.0051, INTERACTION OF INORGANIC AND ORGANIC FERTILIZER MATERIALS WITH PESTICIDES AS RELATED TO WATER QUALITY IN SOILS

D.A. BROWN, Univ. of Arkansas, School of Agriculture, *Fayetteville, Arkansas* 72701

The effect of Agricultural pesticides on plant, animal, and human life is important to all people in this country. Since it appears evident that agricultural pesticides and fertilizers will continue to be used on a large scale basis and since pesticides is a potential cause of poor water quality, it is important that an agricultural pesticide fertilization program which will help to minimize the contamination of water with pesticides be worked out.

The immediate objective of this research is to evaluate the interaction between organic and inorganic fertilizers and the behavior of pesticides in soil as related to water quality. Emphasis will be placed on the solubility, adsorption, and degradation of pesticides as influenced by differing concentrations of organic and inorganic fertilizers in soil. The ultimate objective is use of the data found above in order to predict the potential effect of pesticides on the quality of domestic, recreational and agricultural water supplies. Four pesticides (aldrin, prometryne, trifluralin, an amiben), seven fertilizers (ammonium nitrate, ammonium sulfate, anhydrous ammonia, urea, potassium chloride, triple super-phosphate, and limestone) each at a low and a high rate of application, and three soils (Crowley silt loam, Sharkey clay, and Dundee silt loam) will be used. Isotopically tagged pesticides will be employed in the solubility and adsorption studies. The rate of diffusion in these soils will also be studied in terms of pesticide fertilizer interaction.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Arkansas

5.0052, INTERACTION OF INORGANIC AND ORGANIC FERTILIZER MATERIALS WITH PESTICIDES AS RELATED TO WATER QUALITY IN SOILS

D.A. BROWN, Univ. of Arkansas, Agricultural Experiment Sta. , *Fayetteville, Arkansas* 72701

Objectives: (1) To evaluate the effect on solubility and adsorption of pesticides in soil containing various concentrations of fertilizer materials, (2) to determine the degradation rate of pesticides in soil containing differing amounts of fertilizer materials, and (3) to predict the potential effect of results found under objectives 1 and 2 on the quality of water which may be used as domestic, recreational, and agricultural water supplies.

Description of Work: The solubility and adsorption of four pesticides, Aldrin, Prometryine, Trifluarlin, and Amiben will be measured in three soils, Crowley silt loam, Sharkey clay, and Dundee silt loam at two rates each of ammonium nitrate, ammonium sulfate anhydrous ammonia, urea, potassium chloride, triple superphosphate, and limestone. Solubility of the pesticides will also be measured in pure water and in aqueous solutions of the fertilizers. Radioactive- tagged pesticides will be used in these studies. Degradation of the pesticides of the soil-pesticide-fertilizer combinations will be measured with gas chromatography techniques; infrared and D.T.A. analysis will also be used if necessary. The potential affects of pesticides applied to soil upon water quality will be evaluated using the results obtained under objectives (1) and (2).

SUPPORTED BY Arkansas State Government

5.0053, A EUTROPHICATION MODEL OF THE WHITE RIVER BASIN ABOVE BEAVER RESERVOIR IN NORTHWEST ARKANSAS

R.A. GEARHEART, Univ. of Arkansas, Water Resources Research Ctr. , *Fayetteville, Arkansas* 72701

This research will attempt to evaluate the various nutrient contributors to a reservoir in Northwest Arkansas, namely Beaver Reservoir. The purpose is to predict by use of a mathematical model the rate at which this relatively new reservoir will accumulate nutrients. This involves identifying and quantifying on a time-series basis those elements which accelerate eutrophication. The three most common elements known to affect aquatic productivity are carbon, nitrogen, and phosphorus. The major contributors of nutrients to receiving waters are: sewage effluent, urban runoff, agriculture practices, and recreational activities, - all of which can be isolated and monitored in this particular system.

The implementation of this research is as follows: 1) A preliminary examination and isolation of nutrients contributors. 2) Location of sample points based on preliminary examination. 3) Establishment of a sampling schedule which will yield the greatest information with the smallest error. 4) Collect necessary data for input into mathematical model. 5) Construct and computerize mathematical model with acquired data. 6) Predict future eutrophication rates with mathematical model.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Arkansas

5.0054, FLOOD REDUCTION AND IMPROVEMENT IN TIMING OF WATER YIELD IN THE OZARKOUACHITA UPLANDS

T.L. ROGERSON, U.S. Dept. of Agriculture, *Harrison, Arkansas* 72601

Object: To determine how vegetation and ground cover affect the water cycle in problem soils, and to devise practices to prolong low flows and reduce floods and erosion.

Plan of Work: The program is concerned with the water problems related to two key soils: cherty silt-loams and sand-clay soils. Using plot studies and gaged experimental watersheds on these soils, the staff is investigating their plant-water relationships. They are measuring overland flow and erosion from prescribed burning, and will also conduct basic studies on the movement of water into and through these soils.

SUPPORTED BY U.S. Dept. of Agriculture

5.0055, DEMONSTRATION OF A FACILITYFOR THE BIOLOGICAL TREATMENT OF COMPL EX CHLOROPHENOLIC WASTE

A.E. SIDWELL, Jacksonville City Government, *Jacksonville, Arkansas*

A full scale (2-4 MGD) demonstration and evaluation of the joint treatment of industrial herbicide and municipal wastes, by the use of a municipal biological system composed of : primary clarification, bio-filters aerated and stabilization ponds. The herbicides are of the chloro and chloro-oxyacetic acid deriviatives of phenol. Investigations will be conducted to determine how the concentration of the phenolics in a receiving stream can be reduced to a level below the tests and odor threshold, also to investigate the biological factors related to the removal of the herbicides during treatment. Suitable methods are to be developed for the identification of the various herbicide compounds. The adequacy of nutrient value in the joint waste to allow complete bio-processing of chlorophenolics and related compounds will also be demonstrated.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Jacksonville City Government - Arkansas

5.0056, EFFECT OF SURFACE FILMS ON GASES DISSOLVED IN WATER

J.G. HAWKE, Univ. of Sydney, *Sydney, Australia*

Efforts directed towards elucidation of mechanism of gas transport processes through thin films on water, which is related to studies on evaporation of water through monolayers. In use of monolayers to retard water evaporation and H2S loss from sewers etc.; effect on marine life by its control of other gases should be considered. Further, CO2 diffusion through films is a necessary preliminary study to our understanding of respiration in plants and animals.

Immediate efforts are concentrated on CO2 although some work with H2S has been done. The Hawke transmission coefficient 'T' will be measured as a function of temperature for a number of long -chain compounds etc. to determine dependence of activation energy (E) on molecular structure, e.g., chain length, polar head groups, packing etc. The CO2 work will be extended to H2S, oxygen and certain organic vapors. Biological membranes are thought to contain enzymes whose function it is to lower the activation energy. The effect of charged monolayers and inhibitory or facilitating agents added to the substrate may assist our understanding of the function of biological membranes.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0057, EXPLORATORY STUDIES ON SIMPLIFYING DISPOSAL OF FOOD PROCESSING WASTES

A.I. MORGAN, U.S. Dept. of Agriculture, *Albany, California*

Object: To minimize problems of disposing of food processing wastes by removing soluble salts, oxidizing organic solutes, and/or reclaiming waste water.

Plan of work: Major emphasis will be directed toward developing treatments for soluble, and suspended solid, wastes from fruit and vegetable processing operations. Treatment of effluents will involve three phases: (1) Salt removal: Lye peeling wash waters, or unreusable brine will be desalted by electrophoresis, ion exchange, ion exclusion or electrodialysis. Salts will be recovered in cathode cells, by ion exchange regeneration, or ion exclusion rinsing. The value of recovered salt or caustic will be exploited where possible. Starch, or other insolubles, will be recovered from wash wastes by settling, filtration or centrifugation. (2) Oxidation of organic solutes: Disposability of fruit cannery wastes will be improved by spraying onto extended surfaces, oxidation at an anode in an electrolytic cell, spraying into warm air after intense heating under pressure, adsorption on charcoal which can be regenerated, adsorption on clays which can be discarded or by other inexpensive methods. (3) Water reclamation: Water of reusable quality will be removed from waste streams by reverse osmosis, electro-osmosis, or direct osmosis.

SUPPORTED BY U.S. Dept. of Agriculture

5.0058, OPERATION OF POTATO PROCESSING PLANTS TO REDUCE WASTE AND STREAM POLLUTION

M.L. WEAVER, U.S. Dept. of Agriculture, *Albany, California*

Object: To help alleviate the growing problem of disposing of wastes from plants processing potatoes into food products, without polluting streams or the air, through the development of new or modified in-plant operations to reduce the quantity of wastes discharged and/or to convert them to a form more readily adaptable to available methods of waste treatment.

Plan of Work: Investigations will be made to determine the basic nature of the waste material, i.e., amount and kind of both mineral and organic solid particles, amount and kinds of soluble materials, pH, biological oxygen demand, chemical oxygen demand, etc., associated with different types of processed potato food products. The most economical and efficient means of removing suspended solids from aqueous plant wastes will be sought. Also, how to separate the mineral matter from insoluble organic solids. Possible uses for the suspended organic solids will be explored. Investigations will be made of ways to reduce the total quantity of soluble solids to be disposed of and to concentrate these for more efficient secondary treatment. Special attention will be given to the peeling operation in order to reduce the disposable waste.

SUPPORTED BY U.S. Dept. of Agriculture

5.0059, SANITATION, WASTE DISPOSAL AND PEST AND VECTOR CONTROL

H.F. LUDWIG, Engineering Science Inc. , *Arcadia, California*

Technical Objectives: The objective of this work unit is to identify the overall sanitation requirements in the postattack period and purpose procedures for maintaining the health of the surviving population. Develop information on the effects of fallout materials on sewage and waste water systems. Apply all of the above to the five cities study.

Approach: Develop by questionnaire and interview preattack endemicity of significance in each of the five cities and their preattack environmental disease requirements. Evaluate the ability of environmental recovery resources considering various factors that would tend to degrade the system such as fallout and blast and fire damage.

Progress: July 67 - December 67. Methods are being developed which would: (1) permit evaluation of the overall vulnerability of water systems; (2) provide a method of determining the optimal repair vulnerability of water systems; (3) provide a quantitative measure of the effectiveness of repair and recovery efforts. It is anticipated that these concepts would be adaptable to other utilities (sewer, solid waste collection, etc.).

SUPPORTED BY U.S. Dept. of Defense - Army

5.0060, A STUDY OF THE REMOVAL OF CARBONACEOUS, NITROGENOUS AND PHOSPHORUS MATERIALS FROM CONCENTRATED PROCESS WASTE STREAMS

H.F. LUDWIG, Engineering Science Inc. , *Arcadia, California* (14-12-431)

This work is a laboratory evaluation of potential digester supernatant treatment processes. The study will include the characterization of process waste streams, the summarization and assessment of treatment technology and design and performance criteria for components of a treatment system.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0061, FLOC STRENGTH AND FILTERABILITY OF PRE-TREATED WATER

H.F. LUDWIG, Ludwig Engin. & Sci. Res. , *Arcadia, California*

This study is primarily concerned with the effect of floc characteristics on the performance of rapid sand filters. Floc strength is to be investigated as a measure of flock characteristics. Floc strength will be measured by the degree of floc breakdown after being exposed to a velocity gradient producing shear stress.

The filterability of pretreated water is to be measured by the Silting Index utilizing a membrane filter, by Boucher's Index, and by floc retention capacity of a rapid sand filter.

The effect of pH, alum dosage, coagulant aids, mixing conditions, and lime addition on floc strength will be investigated; their effects on filter performance, expressed by filterability indices, will be studied in pilot plant operation.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0062, EFFECTS OF PESTICIDES ON AQUATIC ANIMALS IN THE ESTUARINE AND MARINE ENVIRONMENT (ABBREV)

R. EARNEST, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Belvedere - Tiburon, California* 94920

The objective of the work is to measure acute toxicities of various pesticides to marine and brackish water invertebrates and fishes. The work will be done in the laboratory, in running water aquaria into which pesticides are metered in appropriate amounts. The bioassay work will be organziaed and conducted so that probit analysis will be used for statistical analysis and comparison. Chemical analyse will be used to monitor amounts of pesticides being tested.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0063, R.I.-MIXING PROCESSES IN ESTUARIES

H.B. FISCHER, Univ. of California, School of Engineering, *Berkeley, California* 94720

This research will study the underlying processes which cause mixing and dispersion in estuaries through a re-examination of the fundamental mixing and transport processes. A laboratory flume will be used to study the effect of partial stratification on turbulent mixing, both in the vertical and transverse to the main flow direction. In addition, the convective patterns in a simplified model estuary will be observed in detail, in an attempt to combine knowledge of turbulent mixing and convective patterns to predict the overall dispersive pattern. Methods will be sought to predict the values of transfer coefficients in real estuaries, and to show the effect on these coefficients of engineering modifications to the estuary. Results of these studies will be used to improve present methods for forecasting pollutant dispersion.

SUPPORTED BY U.S. National Science Foundation

5.0064, PREPARATION OF MONODISPERSE EMULSIONS

S.L. GOREN, Univ. of California, School of Chemistry, *Berkeley, California* 94720

The research program has as its principal objective the development of a technique for the preparation of monodisperse emulsions of controlled drop size. The method we wish to exploit is the precipitation of drops from a supersaturated solution of three components onto already existing nuclei. We plan to study the kinetics of nucleation and the size distribution of drops which are formed for several different ways of producing the supersaturation. The results should be of use in many fields of emulsion research as, for example, in the testing of equipment for breaking liquid-liquid emulsions.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0065, TRANSIENT LOADING EFFECTS IN THE ACTIVATED SLUDGE PROCESS

D.I. JENKINS, Univ. of California, School of Engineering, *Berkeley, California* 94720

The current and proposed research is investigating (a) the short- term transient behavior of activated sludge systems in the most significant practical situation in which they occur, i.e., in reactors such as contact stabilization units where deviation from completely mixed conditions exist; (b) the physical properties of activated sludge that influence its removal by sedimentation/clarification and the variation of these properties with organic loading and sludge growth rate; and (c) the chemical, biochemical, and microbiological properties of activated sludge in an attempt to provide a better representation of active solids than the measurement of VSS and to determine the reason for the deviations of activated sludge systems from a theoretical growth model.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0066, TASTES AND ODORS IN WATER SUPPLIES

D.I. JENKINS, Univ. of California, School of Engineering, *Berkeley, California* 94720

The proposed research is a continuation and broadening of current work concerned with the identification and resolution of the source and nature of odorous compounds in natural waters. Emphasis is on the study of aquatic organisms as one of the major contributors to the problem of taste and odor in waters.

Conventionally the major odor categories include medicinal (phenolic-type compounds), fishy (nitrogen and sulfur-containing compounds), sulfidal and terpenoidal. Papers have been or are in the process of being written on the latter two categories: The sulfidal work involved odors (in descriptive terms) of rotton eggs, skunk, spoiled cabbage, etc., which are associated with simple mercaptons, sulfides and disulfides; the terpenoidal work involves odors (in descriptive terms) of earthy, woody, musty, floral, etc., and includes a variety of essential oils.

The earthy-smelling compounds isolated from blue-green algae and from various actinomycetes are not only the most widespread but also the most troublesome because extremely minute quantities render waters impotable. For this reason emphasis is being directed toward the resolution of the earthy-smelling compounds coupled with the determination of their metabolic production for control aspects.

In addition to developing biological growth units and sampling techniques, microanalytical techniques have been used and developed involving gas chromatography, infrared spectroscopy, mass spectrometry and PMR.

Cooperation with the local water purveyor has enabled an exchange of samples and information on actual reservoir waters.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0067, ORTHOKINETIC FLOCCULATION OF HETERODISPERSED SYSTEMS

W.J. KAUFMAN, Univ. of California, School of Engineering, *Berkeley, California* 94720

The broad aim of the proposed research continues to be the elucidation of the relationships of the rate of orthokinetic flocculation to the hydrodynamic parameters describing turbulence in stirred reactors. In the present proposal theoretical formulae are presented that relate the rate of flocculation to the rate of energy dissipation and the turbulence spectrum and the rate of deflocculation, or breakup, to similar turbulence parameters and floc strength. It is expected that the establishment of these relationships will lead to the more rational design and operation of the flocculation and precipitation systems employed in water and waste treatment. The principal aim of the proposed research will be to validate these expressions experimentally or to modify them as appropriate to describe the flocculation process under steady-state conditions in stirred reactors. Recognizing that improved flocculator performance may accompany increased rates of energy dissipation only if the flocs are sufficiently strong to resist breakup, a secondary objective will be the investigation of floc strength and particularly those chemical physical factors that may increase the resistance of floc to the shearing forces of turbulence. One of the limited aims of this phase of the research will be the development of a suitable device to measure or provide an index of floc strength.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0068, THE ACCEPTABILITY OF MINERAL TASTE IN DOMESTIC WATER

A.L. KNUTSON, Univ. of California, School of Public Health, *Berkeley, California* 94720

The major specific aim of this research is to measure consumer attitudes toward mineral taste occurring in 30 carefully selected California water systems : and then to develop, by statistical procedures, the best fitting mathematical function which will describe the relationship between amount of mineral content in water and measured consumer attitudes. The functional relationship, once developed, will allow limiting standards to be recommended for mineral content in domestic water. Recommending such standards on the basis of scientific data constitutes the general purpose of this research. The standards recommended will also represent an important step toward the attainment of the long range goal of this type of research: the establishment of definitive limiting standards for mineral content in domestic water in order to fully ensure potability for daily consumption.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of California

5.0069, KINETICS OF ALGAL SYSTEMS IN WASTE TREATMENT

W.J. OSWALD, Univ. of California, School of Engineering, *Berkeley, California* 94720

The objectives of this research are: (1) To study the kinetics of algal and algal-bacterial symbiotic systems in biological waste treatment in relation to variables of substrate concentration (primarily, carbon nitrogen, and phosphorus sources), light exposure, cell concentrations, and applied turbulence on both a laboratory and on an outdoor pilot plant scale. (2) To develop a kinetic model that would incorporate the above variables, and make it possible to establish design parameters with which can be made the rational evaluation and prediction needed in utilizing algal and algal-bacterial systems in biological waste treatment, i.e., in primary, secondary, and tertiary (algae nutrient removal) waste water treatment. (3) Using the kinetic approach, to rationally develop criteria and parameters for use in the design of systems for accomplishing maximum removal of nutrients through assimilation by algae or algal-bacterial biomasses and bringing about maximum photosynthetic production of oxygen, thereby increasing the efficiency of the system, and hence reducing their areal and volumetric requirements in practical applications. (4) Finally, through the development of a rational kinetic model for algal systems, (a) to provide a basis for a more adequate exchange and a clearer interpretation of data on waste treatment and field studies involving such systems than is presently possible, and (b) to arrive at a common denominator in the exchange of information with other scientific groups engaged in studies on systems involving algae.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0070, HIGH-PRESSURE VAPOR EXTRACTION OF SOLUBLE ORGANIC SOLUTES FROM AQUEOUS INDUSTRIAL WASTE STREAMS

J.M. PRAUSNITZ, Univ. of California, Graduate School, *Berkeley, California* 94720

This work proposes to study gas-liquid-liquid phase equilibria in aqueous systems at high pressures using a gas as the extracting solvent. Such equilibria may form the basis of a possible separation process for certain industrial waste streams. By contacting an aqueous solution of organic solutes with a gas (such as ethylene or carbon dioxide) at advanced pressures (vicinity of 600-1000 psia) two liquid phases are formed, one of which is very much richer in the organic solute than the other. Decantation of the two liquid phases is then followed by pressure release to recover the gaseous solvent.

SUPPORTED BY University of California

5.0071, SYSTEMS ANALYSIS FOR GROUNDWATER MANAGEMENT

D.K. TODD, Univ. of California, School of Engineering, *Berkeley, California* 94720

The purpose of this proposed research will be to study selected problems in the management of groundwater systems so that future operation of the nation's ground water resources can be more effectively and economically conducted.

(1) Improved modeling techniques; (2) Time lag of groundwater inflow; (3) Sea water basin boundaries; (4) Groundwater quality variations. (5) Economic optimization operation.

The salt water boundary for a coastal aquifer has been modeled with discharge, recharge, and geometry of the outcrop as variables. The influence of the dynamics of interface on basin management will be investigated for a range of aquifer conditions.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of California

5.0072, ELECTROOSMOTIC PUMPING FOR DEWATERING SEWAGE SLUDGE

J. GREYSON, North Amer. Rockwell Corp. , *Canoga Park, California* (14-12-406)

To investigate the application of the phenomenon of electroosmosis to dewatering of sewage sludge. The major tasks of the investigation will include measurements in electroosmotic water flux rates out of sewage sludge contained in electroosmotic cells of various designs. The influences of cell geometries electrode type and configuration, and the chemistry and physics of sewage sludge will be assessed as to their importance in optimizing dewatering efficiency. Sludge treatment techniques and/or appropriate filtering media will be sought which will serve to increase electroosmotic dewatering efficiency.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0073, DILUTE SOLUTION REACTIONS OF NITRATE ION AS APPLIED TO WATER RECLAMATION

F.C. GUNDERLOY, North Amer. Rockwell Corp. , *Canoga Park, California* (14-12-52)

1. Undertake a literature search of dilute solution reactions of the nitrate ion. Two groups of reactions are expected to be useful: Reduction of nitrate to nitrite, and deamination to nitrogen.

2. Carry out a testing program using the most promising chemical systems to determine feasibility of chemically decomposing nitrate ion.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0074, A STUDY OF A PROCESS FOR PHOSPHATE REMOVAL FROM WATER SUPPLIES USING LANTHANUM PRECIPITATION

H.L. RECHT, North Amer. Rockwell Corp. , *Canoga Park, California* (14-12-183)

A laboratory investigation of the steps of a new process for phosphate removal from waste water will be performed. This process involves lanthanum precipitation of the phosphate followed by an alkali lanthanum recovery cycle. The purpose of the proposed program is to assess the technical feasibility of the process.

The speed and completeness of phosphate removal, and of each of the other process steps, as well as the extent of lanthanum and other reagent losses, will be determined parametrically in batch laboratory test using both pure solutions and sample water obtained from local treatment plants. From the results of the laboratory investigation, the technical feasibility of the process and an initial estimate of possible process economics may be determined. The results will also serve as a basis for design of an integrated laboratory process demonstration unit, which in turn would provide design data for an actual process demonstration pilot plant.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0075, PARAMETRIC STUDY OF THE KINETICS OF PRECIPITATION AND NATURE OF THE PRECIPITATE OBTAINED IN PHOSPHATE REMOVAL USING IRON AND ALUMINUM SALT

H.L. RECHT, North Amer. Rockwell Corp. , *Canoga Park, California* (14-12-158)

The rate of precipitate formation and the physical nature, chemical composition, and solubility of precipitates of phosphate with iron and aluminum under various conditions encountered in wastewater treatment will be investigated. Parameters to be studied include phosphate composition and concentration; pH; T.D.S.; precipitate formation; and stand time, temperature, and degree of agitation of solution during precipitate formation. Tests will be performed on pure solutions, synthetic wastewater effluents, and with secondary effluent. Results of experimental work will be used to explain the difference between predicted theoretical phosphate removals and actual removals, to identify and explain the mode of action of wastewater components contributing to the differenc, and to suggest improved techniques for obtaining more complete phosphate removal by these chemical precipitation methods.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0076, DEVELOPMENT PROGRAM FOR TREATMENT OF WASTEWATER BY AERATION

B.L. TUFFLY, North Amer. Rockwell Corp. , *Canoga Park, California* (14-12-434)

To develop the 'U-tube' aeration concept for applications in aeration of sanitary sewer wastewater. This program is considered to be Phase I of a 3-phase program to develop an effective technique, employing the U-tube aeration principle, for aerating sewer wastewater streams. Two applications of particular interest are aeration of secondary effluent from a sewage treatment plant and in-situ aeration in sanitary sewer lines to prevent the formation of anaerobic conditions.

The major tasks for the Phase I study will be a combination of analyses, engineering design studies. and pilot-scale experiments which will accomplish the following: 1. Provide experimental verification of oxygen transfer efficiencies and explore practical aspects of U tube operation. 2. Investigate two major applications: a. Aeration of effluent from sewage treatment plant (design and systems study, not experiments). b. In-situ aeration of sanitary sewer lines.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0077, TERTIARY ACTIVATED SLUDGE TREATMENT TO RECLAIM WASTES FOR WATER SUPPLY FOR AGRICULTURAL AND RECREATIONAL PURPOSES

J.R. WRIGHT, Chino City Government, *Chino, California* 91710

The objective is to demonstrate the performance of a novel treatment method wherein both secondary and tertiary treatment are accomplished with an activated sludge process designed to permit: (1) greatly increased organic loadings; (2) high rates of cell production resulting in a high nutrient removal (nitrogen and phosphates); and (3) greatly reduced plant construction costs. The reclaimed water would be used tfor recreational and irrigational purposes in the proposed Prado Regional Park, being planned and developed by San Bernardino County. The full utilization of the available water resource in this arid area will help meet the needs created by the development of the Prado Regional Park.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Chino City Government - California

5.0078, SORPTION AND MOVEMENT OF POLLUTED WATER IN SOIL

J.W. BIGGAR, Univ. of California, School of Agriculture, *Davis, California* 95616

Necessary information linking the reactions between pesticide and soil, and pesticide and plants, to the characteristics of each other, the soil solution environment, temperature and water movement is very spotty and incomplete. Thus this proposal is for a project to obtain a reasonable amount of related information on typical soils and selected pesticides related to fixation and movement. Depending upon the type of soil, organic additive and environment, a number of reactions will determine the extent of movement and persistence in soils. The organic additive may be absorbed by soil, exchanged, absorbed by plants, decomposed into more or less mobile, toxic products, precipitated or leached into ground water, drainage water and streams.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0079, SOILS, PESTICIDES AND THE QUALITY OF WATER

J.W. BIGGAR, Univ. of California, Agricultural Experiment Sta. , *Davis, California* 95616

Objectives: (1) To establish whether movement through the soil constitutes a significant source of the pesticides found in surface and ground water; (2) To identify the properties of pesticides and of soils that control the extent of movement of pesticides in and through soils; (3) To ascertain the solubility characteristics of pesticides sorbed on soil particles and hence the effect of suspended soil on the concentrations of pesticides in water; and (4) To ascertain the effects of management of pesticides and land on the transport, by all means, of pesticides to water supplies.

Description: Measurements will be made to establish the solubility of materials in aqueous solutions. Adsorption studies at one or more temperatures on soils and clays will be conducted. Diffusion measurements in soil and clay plugs by the use of radioisotopes and miscible displacement experiments involving soil columns will be conducted.

SUPPORTED BY U.S. Dept. of Agriculture
California State Government

5.0080, CHEMISTRY OF BORON IN CALIFORNIA SOILS

R.G. BURAU, Univ. of California, School of Agriculture, *Davis, California* 95616

The proposed research will consist of laboratory investigations on California soils which have naturally accumulated various forms of boron in such quantities that the introduction of boron-sensitive plants may be delayed until extensive reclamation is performed.

The objectives are as follows: 1. To determine the boron desorption and adsorption characteristics of several representative high-boron soil profiles and profile segments. 2. To correlate the relative ease of boron desorption with other more easily determinable soil characteristics to serve as a basis for classifying field soils with respect to boron reclaimability. 3. To evaluate leaching treatments and amendments which may reasonably be expected to enhance the rate of boron desorption and/or prevent build-up of toxic soil solution concentrations of boron during reclamation. 4. To determine the forms of boron in various high-boron soils and to evaluate the influence of each form on the rate of boron release.

The main approach will be to determine soil solution boron concentrations as indices of relative plant toxicity as well as to characterize the rate of desorption during repetitive equilibrium extractions and during soil column leaching. This information will be related to chemical and physical characteristics of both the solid and the aqueous phases.

SUPPORTED BY University of California

5.0081, WATER QUALITY IN RELATION TO PHYSICAL AND CHEMICAL PROPERTIES OF SOILS AND WASTE WATERS THEREFROM

L.D. DONEEN, Univ. of California, School of Agriculture, *Davis, California* 95616

This research proposal is concerned with the relations between soil properties and water quality and between soil properties and quality of its waste water which percolates into underground basins or (re-appears) in surface waters. Several approaches are contemplated to study the major processes and conditions which affect water from the time it is applied on irrigated lands to its removal. The re- usability of the waste water for irrigation and other purposes would depend upon its chemical characteristics.

Proposed studies: 1. Predictions on the solubility of gypsum and lime in water and soil-water systems involving laboratory experiments and computer programming. 2. Predictions on the quality of waters percolating through non-cropped, stratified soil columns and stratified substrata (laboratory and field models, computer programming). 3. Predictions on the distribution of salts in cropped soil profiles and solutes in drainage waters under varying degrees of leaching requirements (laboratory and lysimeter models, computer programming). 4. Re-use of drainage waters from cropped soil profiles (lysimeter studies). 5. Salinity and permeability parameters for agricultural water quality classification scheme (laboratory, lysimeter, and field data).

SUPPORTED BY University of California

5.0082, REMOVAL OF STRONTIUM-90 FROM ORGANIC WASTES

M. GOLDMAN, Univ. of California, School of Veterinary Medicine, *Davis, California* 95616

For the past six years a waste treatment facility has been in operation, decontaminating biologic wastes from a colony of Beagles being fed Sr-90-containing diets. The 200 Beagles and the associated cage cleaning procedures generate about 700 gallons of waste per day. Reduction of solids concentration is accomplished utilizing aerobic and anaerobic digestion plus chemical clarification and flocculation prior to pH adjustment and final cationic exchange on Dowex-50.

During 1966 the ion exchange decontamination factor was approximately 3000 in the processing of about 250,000 gallons of waste. The exchange capacity averaged 1.8 mCi of Sr-90/cu ft of resin/3100 gallons of waste processed. Ion exchange is monitored on-line, utilizing a bremsstrahlung counter. Bremsstrahlung counting has been used to detect Sr-90 concentrations of 0.3 pCi/ml. Expended cationic resins are buried, off-site.

SUPPORTED BY U.S. Atomic Energy Commission

5.0083, PREDICTING THE EFFECTS OF CHANGES IN IRRIGATION WATER TEMPERATURE CAUSED BY WATER PROJECTS

R.M. HAGAN, Univ. of California, School of Engineering, *Davis, California* 95616

Construction of reservoirs on rivers flowing from high elevation watersheds will often lead to a lowering of downstream water temperature with possible detrimental effects on irrigated crops. These effects on crop growth and yield cannot be estimated unless the magnitude and duration of the effects of irrigation with cold water on the soil temperature regime are known.

The proposed research plan involves use of a fully instrumented plot in the field to determine the effect of the temperature of irrigation water on soil temperature. The various factors which influence the change in soil temperature resulting from irrigation with cold water -- such as amount and temperature of the applied water, the heat and moisture characteristics of the soil, and weather conditions will be evaluated. These data will be used to check predictions of changes in soil temperature regime following irrigation with cold water. Data will be obtained on the temperature regime on heat and moisture transfer in Yolo loam before, during and after irrigation with water of different temperatures. These include continuous measurement of the soil temperature and of the soil moisture content down to 4 feet below soil surface, as well as measurements of the net radiation and evaporation from the soil surface. Laboratory investigations to determine some of the heat and moisture characteristics of the soil will be made in conjunction with the field experiments.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of California

5.0084, THE ENGINEERING MANAGEMENT OF AGRICULTURAL WASTES

S.A. HART, Univ. of California, Agricultural Experiment Sta. , *Davis, California* 95616

Objectives: To develop a philosophy, to research into the fundamentals, and to develop practical technology in the sanitary management of livestock manures, crop residues, and other agricultural wastes.

Proposed work: Work is presently being conducted under USPHS Research Grant EF-265, 'Sanitary engineering applied to livestock manures.' Under this, a manure lagoon experiment, a manure pumpability test, and an activated sludge (aerobic treatment process) stabilization of manure experiment are being pursued.

A USPHS Research Grant application, 'Treating suspended solids in food plant wastewaters,' has been submitted. If approved, studies on the separation of suspended solids from the wastewater effluent would be conducted. This would be a study on the removal, and on the treatment of both the removed solids and on the remaining effluent.

SUPPORTED BY California State Government

5.0085, SELECTED FACTORS INFLUENCING TASTE OF DRINKING WATER

R.M. PANGBORN, Univ. of California, School of Agriculture, *Davis, California* 95616

This laboratory study of selected factors influencing taste of drinking water has completed an investigation on the effect of solution temperature on the taste threshold, subjective intensity and degree of liking of varying concentrations of sodium chloride. The second phase will involve direct measurement of temperature in the mouth to ascertain the effect of solution temperature on thermal changes at the receptor sites. Additionally, samples of saliva will be collected to determine whether response to sodium compounds is related to the sodium content of the saliva.

The effect of carbonation of mineralized waters on resultant taste quality will be established, followed by studies on chlorinated and fluoridated waters.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0086, ANIMAL, FORAGE AND WATER RESOURCES FOR BEEF PRODUCTION

C.A. RAGUSE, Univ. of California, Agricultural Experiment Sta. , *Davis, California* 95616

Objectives: (1) To obtain further information regarding animal and plant performance on continuous vs. rotation irrigated pastures. (2) To determine what special problems of irrigation water management may be related to continuous and rotation grazing systems. (3) Preliminary evaluation of animal and plant performance where irrigated pasture is used as a supplement instead of as total intake.

Description of Work Proposed: Land at Davis and at the Sierra Foothill Range Field Station will be used. Grazing experiments at Davis will measure animal average daily gain, carcass gain and quality, forage intake and digestibility and forage botanical composition, availability and utilization. Fractional intake from irrigated pasture will be achieved by using fractional acreages and regulating length and frequency of grazing interval. Feed-lot treatments will be used as controls. Water in the soil profile will be monitored and irrigation amounts and frequencies adjusted to prevent plant water stress. Measurements will be made to determine if differential degrees of soil compaction occur as a result of grazing management. Field Station work will be developmental; project to be revised before active grazing experiments are begun.

SUPPORTED BY U.S. Dept. of Agriculture
California State Government

5.0087, COOPERATIVE BIOLOGICAL PEST CONTROL RESEARCH

J.R. TEERINK, Univ. of California, School of Engineering, *Davis, California* 95616

General Objective: Determine economical methods of control of biological pests in water storage and conveyance facilities which will not adversely affect the beneficial uses of water.

Activities: 1. Investigation of life cycle and reproduction rates of aquatic plants found in California canals and reservoirs. 2. Investigation of selected chemicals to control aquatic plants. 3. Laboratory and pilot model studies to determine effects of chemicals on aquatic pests under controlled conditions of velocity, turbidity, and water quality. Also determine persistence of chemicals after treatment. 4. Field evaluations of biological growths in aqueducts.

SUPPORTED BY California State Government
University of California
U.S. Dept. of Interior - Bu. Reclamation
U.S. Dept. of Agriculture

5.0088, EUTROPHICATION OF SURFACE WATERS - LAKE TAHOE

P.H. MCGAUHEY, Lake Tahoe Area Council, *El Cerrito, California* 94530

This project is designed to demonstrate what compounds, nutrients, etc. occurring in the effluent from conventional or advanced waste treatment processes or storm water runoff contribute to the eutrophication of surface waters in general, and in Lake Tahoe in particular. Initial studies will be in laboratory-scale growth units with later studies in plant demonstration ponds.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Lake Tahoe Area Council

5.0089, BIOLOGICAL METHODS OF SLUDGE DEWATERING

F.R. BOWERMAN, Aerojet General Corporation, *El Monte, California* 91734 (14-12-427)

A twelve-month program is proposed to investigate the poly-beta hydroxybutyric acid depolymerase activity of various microorganisms and to prepare extracts displaying such activity. These enzyme preparations would be applied to typical microbial sludges obtained from activated sludge plants to determine the effect on water retention of the sludge. Satisfactory demonstration of a beneficial effect would lead to screening of microorganisms for an extracellular source of the enzyme. Factors that affect enzyme production and stability will also be investigated.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0090, A METHOD FOR ASSESSING THE EXTENT OF POLLUTION FROM STORMWATER RUNOFF FROM AN URBAN AREA

D.L. FEUERSTEIN, Aerojet General Corporation, *El Monte, California* 91734

The program will prepare designs of and develop a cost effectiveness evaluation procedure for a number of alternative solutions to storm and combined sewer problems extant at the City of Sacramento, Calif. The program will utilize a systems approach and will be designed to provide a solution to the problem at Sacramento that will have applicability to sewerage systems throughout the nation with similar characteristics. The program will: (1) provide hydrologic bases and waste water compositions for the design of seven candidate systems; (2) develop preliminary plans for each alternative system to assess the costs; (3) estimate construction, operation, and maintenance costs of each system; (4) collate and evaluate data from field investigations so as to provide a maximum national utility; (5) and provide recommendations in the form of a ranking of alternative systems in terms of cost and adverse or beneficial effects on the community.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0091, ROLE OF SOLIDS IN COMBINED SEWAGE POLLUTION

D.L. FEUERSTEIN, Aerojet General Corporation, *El Monte, California* 91734

The program will establish the characteristics of combined sewage that are of significance with respect to solids separation operations and will investiage the feasibility of applying these operations for reduction of pollution from combined sewage overflows. The program consists of the collection and analysis of representative samples from the heterogeneous combined sewage and the conduct of laboratory studies to assess the impact of solids on disinfection practices. Sampling methods provide for determination of gross particle size distribution by screens in situ; thus actual effects of screening on particle coelescence and disintergration, solids separation and retention, and flow disturbance will be integrated into the results.

The sampling program will be performed in San Francisco, Calif.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0092, RENOVATION OF MUNICIPAL WASTEWATER BY REVERSE OSMOSIS SYSTEMS

D.L. FEUERSTEIN, Aerojet General Corporation, *El Monte, California* 91734 (14-12-184)

To perform laboratory-scale investigations to enhance and extend existing knowledge of the reverse osmosis process to waste water renovation applications and to determine operating parameters and relations required for system evaluation and optimization, as set out herein.

Laboratory-scale studies shall be performed using several grades of municipal waste water representing a broad spectrum of effluent qualities.

Except where noted and where necessary to the conduct of this program, flat membrane tests cells shall be utilized.

The laboratory-scale studies shall consist of three separate series of tests designed to elucidate and quantify for the reverse osmosis process the general performance, the effect of suspended solids on performance, and the membrane degradation by suspect compounds.

A mathematical model will also be developed to express the effect of above variables on process performance.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0093, DEVELOPMENT OF ECONOMICAL METHODS OF BORON REMOVAL FROM IRRIGATION RETURN WATERS

L.E. GRESSINGH, Aerojet General Corporation, *El Monte, California* 91734

The purpose of this contract is to perform a laboratory investigation (Phase I) and a field evaluation (Phase II) of methods for the economical removal of boron from irrigation return water in conjunction with the reverse osmosis process.

In Phase I, two or three conventional water treatment processes will be selected, through laboratory studies and cost analysis, as the most promising methods of boron removal for future testing in field scale operation. The purpose of the field evaluation (Phase II) is to develop realistic design criteria and process costs in order to prepare economic estimates of boron removal facilities in reverse osmosis plants of 1, 10 and 50 mgd capacities.

Three removal approaches will be used in this study. They are: by a pretreatment step prior to reverse osmosis processing; by conversion of the boron to a form impermeable to the reverse osmosis membrane; and as a post-treatment operation on the reverse osmosis product stream.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

5.0094, ANALYTICAL INSTRUMENTATION FOR DETERMINING LOW LEVELS OF TOTAL ORGANIC CARBON IN WATER

R.M. ROBERTS, Aerojet General Corporation, *El Monte, California* 91734 (14-12-182)

The Contractor shall provide the necessary personnel, materials, and facilities, and it shall exert its best efforts to demonstrate the feasibility of measuring, on a absolute basis, the total organic carbon (TOC) content of water containing 0.1 to 20 milligrams-per-liter (mg/1) of such contamination expressed as TOC. An instrument based on the measurement principal derived there from shall then be designed, fabricated, evaluated, and suitably refined; after which, the refined instrument shall be demonstrated at the Cincinnati Water Research Laboratory.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0095, REVERSE OSMOSIS TO REMOVE DISSOLVED SOLIDS FROM RENOVATED WASTE WATER USED IN GROUND WATER RECHARGE

D.E. BOEN, Eastern Municipal Water Dist. , *Hemet, California* 92343

The objective of this project is to demonstrate the use of reverse osmosis in reducing the concentrations of total dissolved solids in sewage treatment plant effluents, which are used in a ground-water recharge program. The reduction is necessary in order to maintain satisfactory concentrations of salts and refractories in ground water despite continuous recycling. Further, the aim is to demonstrate the use of the reverse osmosis unit as an integral element in the total system of water reclamation and reuse required because of the water shortages in an arid area.

The treated effluent, used in the ground-water recharge program, will aid in maintaining the proper balance of water quality in the total water management system.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Hemet City Government - California

5.0096, TERTIARY SEWAGE TREATMENT FOR REUSE

W.H. EPPINGER, Irvine Ranch Water District, *Irvine, California* 92664

The purpose of this project is to demonstrate a system of tertiary sewage treatment which will provide a final effluent, from secondary treatment plant effluent, which will meet quality requirements for recreational, agricultural, and other uses. Such a water can therefore be fully used in the District's water reclamation and reuse plan.

The project is expected to demonstrate a novel method of phosphate removal through sludge concentration and chemical addition; an increased organic loading rate to the existing aeration units; and the removal of tastes, colors, turbidity, odors, and ABS with adsorption in carbon contractors. It is also expected to demonstrate the removal of viruses with chemical addition and filtration and a high rate of nitrogen removal through the addition of pure organics in the carbon adsorption units.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Irvine City Government - California

5.0097, EFFECT OF PHOSPHORUS REMOVAL PROCESSES ON ALGAL GROWTH

J.W. SCHERFIG, Univ. of California, School of Engineering, *Irvine, California* 92664

Increasing eutrophication of surface waters combined with a growing need for recreational water areas necessitate greater concern for removal of biostimulants including the classic nutrients from treated waste water. Major emphasis has been on methods for reducing the phosphorus and nitrogen content in effluents by combinations of chemical and biological processes.

There is however, little scientific evidence indicating that the efficiency of a treatment process in terms of the removal of biostimulants, can be measured only by the degree of phosphorus or nitrogen removal. Organic compounds acting as growth stimulants (such as vitamins) may be produced in significant quantities in traditional biological waste treatment processes.

Because of the complex and little understood phenomen related to algae blooms, the efficiency of current and proposed phosphate removal processes must be evaluated with respect to the removal of all biostimulants. The research proposed will seek to evaluate the individual steps in a sequence of treatment processes on the direct basis of algal growth in their effluents. It is believed that such information will provide a more rational basis for design of waste water treatment plants.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0098, A SALT BALANCE INVESTIGATION ON THE SANTA ANA RIVER BASIN ABOVE PRADO DAM

G.T. ORLOB, State Water Resour. Contr. Bd. , *Lafayette, California* 94549

Objectives: The development of methods and techniques whereby the quality of the underground basins of the Upper Santa Ana River can be controlled within the objectives prescribed by the Santa Ana Regional Water Quality Control Board, including: 1) Determination of salt balances for ground water units as they relate to the cause or causes of the change in water quality conditions of the study area, 2) Assessment of the relative contributions to the changes from each cause, 3) Development of practical means and economical means for controlling water quality where required, 4) Assessment of the existing water quality objectives, and 5) The use of automatic data processing and modeling techniques for prediction of water quality changes in a ground-water system.

Approach: The use of 'systems analysis' techniques where applicable, collection of pertinent data, and engineering evaluation of the system.

SUPPORTED BY California State Government

5.0099, CANNERY WASTE RESEARCH PROJECT

G.T. ORLOB, State Water Resour. Contr. Bd. , *Lafayette, California* 94549

Objective: The development of tools for engineering-economic analysis of cannery and municipal waste treatment systems; including: 1) modeling of unit process performance, 2) cost analysis of unit processes 3) economic analysis of in-plant treatment systems 4) preliminary design of optimum waste handling systems for cannery wastes and 5) development of equitable municipal treatment allocation schemes

Approach: 'Systems Analysis' for studying waste treatment problems via the tool of the digital computer. Use of 'dynamic programming' as a tool for optimum design.

SUPPORTED BY California State Government

5.0100, PROPOSAL TO DEVELOP A HIGH-PRESSURE-FOAM WASTE WATER TREATMENT PROCESS

D.E. GARRETT, Garrett Res. & Dev. Co. Inc. , *Laverne, California* 91750 (14-12-176)

A pressure foaming process will be investigated for removal of soluble organics, suspended material, and certain inorganic materials. The use of pressures above atmospheric allows advantage to be taken of dissolved air flotation. Work would include dissolved air alone and a two-phase mixture of water containing dissolved air and air bubbles. Soluble organic and suspended solid removal can be obtained without use of additives. Inorganic removal will require use of flocculating chemicals.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0101, RADIONUCLIDE METABOLISM IN AQUATIC ANIMALS

F.L. HARRISON, Univ. of California, Lawrence Radiation Laboratory, *Livermore, California* 94551 (W-7405-ENG-48)

The rate of accumulation and loss of radionuclides by fish and shellfish is being evaluated to better predict the amount of radioactivity which may be acquired from the consumption of contaminated aquatic animals. Our approach to the problem is to study in depth representative marine and fresh-water animals, to investigate in these animals the metabolism of those elements that are present in significant concentrations and whose radionuclides are produced in nuclear events, and to consider environmental variables that might be expected to affect their radioactive burden. Long-term experiments on the uptake of radionuclides are performed in aquarium systems designed to maintain essentially constant the level of one or two elements. This simulates an environment that might exist downstream from a reactor or from leaching from a large source.

The fresh-water clam, Anodonta nuttalliana Lea, has been used as a representative bivalve mollusc. A series of short-term experiments with radionuclides showed that divalent ions such as those of Ca, Mn, Zn, and Co were accumulated in the labial palps, gills, mantle and calcareous tissue. Trivalent ions such as those of Fe, Sc, Eu, and Cr were accumulated in the digestive tract. The uptake of Mn54 and Zn65 were observed over a period of five months. Uptake rates varied widely in the body parts. The effects of temperature, stable-element concentration and size on uptake rates were evaluated. Increases in temperature and Mn and Zn concentrations resulted in increased uptake rates. In general, the large animals had a lower uptake rate per gram tissue than the small ones.

SUPPORTED BY U.S. Atomic Energy Commission

5.0102, BIOLOGICAL AVAILABILITY OF NUCLEAR DEBRIS TO AQUATIC ANIMALS

F.L. HARRISON, Univ. of California, Lawrence Radiation Laboratory, *Livermore, California* 94551 (W-7405-ENG-48)

The accumulation of radionuclides from debris from specific Plowshare events is being observed in aquatic animals. Because of their physical or chemical state some radionuclides in debris may be unavailable to animals. This parameter is important to know under conditions where the feasibility of an event is questionable if the activity released were totally available to organisms in the ecosystem.

Debris is added to marine and fresh-water aquarium systems and the levels of specific radionuclides compared in the water and in edible parts of representative aquatic animals in the food chain of man (fish, clams and crayfish or crabs). Concomitant with the balanced aquarium studies, aliquots of the debris are leached with waters from representative ecosystems as controls to determine whether availability changes occur in the presence of the living organisms.

SUPPORTED BY U.S. Atomic Energy Commission

5.0103, MORPHOLOGY AND STABILITY OF STREAM CHANNELS IN SOUTHERN CALIFORNIA

R.B. HICKOK, U.S. Dept. of Agriculture, *Lompoc, California*

Objective: Methods for predicting and control of gully and stream channel erosion, and sediment deposition damage.

Plan of Work: Evaluate processes of channel aggradation, degradation, horizontal realignment, and changes in cross-sectional shape and net sediment yield in relation to types of bed and bank materials, upstream sediment sources, streamflow regimes and control measures.

SUPPORTED BY U.S. Dept. of Agriculture

5.0104, A STUDY OF THE EFFECT OF ULTRASONIC ENERGY ON WASTE WATER

R. ROD, Amer. Process Equipment Corp. , *Los Angeles, California* 90045 (14-12-196)

To prepare a report covering a study of the effect of ultrasonic energy on three characteristics of waste water, namely; disinfection, ammonia nitrogen content and refractory organic content. In each of the three areas of interest, the feed water shall be processed through two different air-operated ultrasonic atomizers, one operating at 50 KHz and the other at 100 KHz. In addition, an ultrasonic atomizing nozzle energized by an electro restrictive transdoer-horn assembly operating at a frequency of 20 KHz shall be evaluated.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0105, FABRICATION AND EVALUATION OF AN ULTRASONIC FILTRATION SYSTEM FOR TREATING COMBINED SEWER OVERFLOWS

R.L. ROD, Amer. Process Equipment Corp. , *Los Angeles, California* 90045 (14-12-195)

Development and test of an automatic sewage filtration system that cleans itself with ultrasonic energy, applied not only during backwash cycles, but also periodically during forward flow to enhance the dirt holding capacity of the filter.

The system consists of multiple canisters manifolded together, each containing a permanent porous filter element, and each fitted with an ultrasonic transducer, which is energized by an ultrasonic generator control circuit, for cleaning the filter element.

Filter pore sizes to be evaluated are 100, 50, 20, 10 and 1 micron. Laboratory tests will determine: Biochemical oxygen demand reduction; suspended solids reduction; and analysis of results to determine most economical and practical pore size, and over-all system configuration.

Initial work in Los Angeles, California, followed by fabrication in Panama City, Florida, and field tests at a site to be designated.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0106, BACTERIOLOGY OF BIODEGRADABLE SURFACTANTS

D.A. ANDERSON, Calif. State College, Graduate School, *Los Angeles, California* 90032

This investigation is concerned with responses of typical Gram negative and Gram positive bacteria when grown in the presence of various molecular varieties of syndets. Representative anionic or nonionic biodegradable surfactants used include: dodecylbenzene sulfonates (linear), ethoxylated alcohols, ethoxylated alkyl phenols, alkyl ether sulfates, taurates, and ricinoleates. Gram negative bacteria used are primarily strains of Escherichia coli and Pseudomonas spp. Gram positive forms are mostly Staphylococcus spp. and Bacillus spp.

Gram negatives typically exhibited a temporary inhibition of growth in the presence of certain surfactants followed by rapid proliferation with profuse production of a pervasive slime. Roles of cell membrane leakage, extracellular synthesis of slime, or both, are being studied. Chemical nature of the slime is being investigated. An apparent blocking of phage receptor sites by slime has been observed and is under study. Attention is also being given to effects of the slime on pili and flagella.

With Gram positive bacteria, quite different growth responses have been noted. Non-sporing or vegetative cells of sporeformers appear to be uniformly rendered nonviable. Lethal damage to cell membranes or cell walls is under study. In addition to the usual chemical and physical procedures, extensive use is being made of electron microscopy.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0107, CHARACTERIZATION OF THE ACTIVATED SLUDGE PROCESS AT THE HYPERION TREATMENT PLANT

A.D. LEIPZIG, Los Angeles Bd. of Pub. Works, *Los Angeles, California* (14-12-148)

The objectives of the testing program to be carried out at the Hyperion Treatment Plant in Los Angeles can be divided conveniently into two parts. The first objective will be to develop a set of plant characteristics which will represent the average (24 hr. composite) performance of the plant.

The second objective (corresponding to Phase II) will be to study the time dependent or transient behavior of the plant by varying the influent stream in some predetermined way as a function of time and then making measurements of flow and concentration at various stations as a function of time (at one hour intervals). The purpose of Phase II will be to generate the necessary data to develop a dynamic or time dependent mathematical model for the activated sludge process.

The model will then be used to select the most practical method for controlling the plant to achieve improved plant performance and a more uniform water quality at the effluent weirs of the final settler.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0108, ANTELOPE VALLEY WASTE WATER RECLAMATION FACILITY

J.A. LAMBIE, Los Angeles Co. Government, *Los Angeles, California*

The objective of this project is to demonstrate how waste waters can be reclaimed and utilized for agricultural, industrial, and aquatic recreational purposes. Tertiary treatment facilities will be used to produce the desired quality of effluent. These facilities will include oxidation ponds, chemical treatment, flocculation, clarification and filtration.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Los Angeles County Government -
California

5.0109, PHOSPHORUS REMOVAL BY ADDITION OF ALUMINUM TO THE ACTIVATED SLUDGE PROCESS

C. CARRY, Los Angeles Co. San. Dist. , *Los Angeles, California* 90057 (14-12-152)

The objective is to determine the reliability, efficiency and economics of the phosphorus removal process as developed by E. F. Barth and M. B. Ettinger of CWRL. The plan is to divide the three month test period into three month-long tests as follows: 1. First month - Sodium aluminate addition. 2. Second month - Aluminum sulfate addition; lime will be added as necessary to maintain phosphate removal. 3. Third month - Both aluminum sulfate and sodium aluminate addition, the relative quantities being adjusted to maintain the pH at the optimum determined above.

Aluminum dosage in proporation to the phosphorus concentration will be optimized. The aluminum salt solutions will be added to the wastewater before the point of entry of the primary effluent into the aerator.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Los Angeles County Government - California

5.0110, SUPPORT OF THE ADVANCED WASTE-TREATMENT PILOT PLANT AT POMONA, CALIFORNIA

J.D. PARKHURST, Los Angeles Co. San. Dist. , *Los Angeles, California* 90057 (14-12-150)

The objectives of the contract are to allow continuation of studies in order to define cost estimates and operating parameters of the various AWT processes under study.

The pilot plant located at the site of the Pomana, California Water Renovation Plant has been investigating the advanced waste treatment processes since 1964. Investigation of some processes has been continued and others started as the need warranted. Investiations are continuing on absorption on granular carbon, denitrification on carbon and sand, reverse osmosis and ion exchange, among others.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0111, EDDY DIFFUSION AND BACTERIAL REDUCTION IN WASTE FIELDS

J.E. FOXWORTHY, Univ. of Southern California, Graduate School, *Los Angeles, California* 90007

The principal objectives of the proposed work are: 1. To further demonstrate the applicability of previously proposed continuous volume source diffusion models to the dispersion of conservative tracer dye and bacteria within surface waste fields in the sea. 2. To ascertain the effect of the type of submarine outfall on the rate of dispersion of tracer dye and bacteria. 3. To determine, under field conditions, the rates of disappearance of coliform and Fecal Streptococcal Group bacteria. 4. To investigate the effect of vertical mixing combined with radiant energy (sunlight) on bacterial disappearance in surface waste fields.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0112, ULTRAVIOLET ABSORPTION IN COASTAL WATERS

R.B. TIBBY, Univ. of Southern California, Graduate School, *Los Angeles, California* 90007

The proposed work revolves around the basic hypothesis that UV absorbance is a quantitative measure of the extent and dilution of a marine sewage field and that it is directly related to organic load and may be a better index to organic load than BOD.

Improved methods developed during the past year for determining dissolved, particulate and total carbon, and for separating the contributions of organic and inorganic constituents of the waste field and of the background waters, now will be applied in situ and in conjunction with the routine monitoring programs of selected waste disposal agencies in Southern California whose discharge is subject to primary, secondary, or tertiary treatment.

The procedures also may provide information on the rates of biodegredation in the marine environment.

Present studies on the productivity of phytoplankton and benthic algae by oxygen evolution and isotopic carbon uptake will be continued, and will be correlated with the release of extracellular metabolites as determined by UV absorbance.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0113, TERTIARY TREATMENT IN THE PURIFICATION OF WASTE WATER

A.F. BUSH, Univ. of California, School of Engineering, *Los Angeles - U.C.L.A. , California* 90024

Tertiary treatment process using trickling filter and clay coagulation to remove nitrates, phosphates, and biological contaminants from waste water is recommended in order to improve the prospects for wide use of reclaimed supplies.

As population density increases waste disposal must be oriented toward cleaner water with eventual use of reclaimed water rather than disposal.

Modern sewage treatment, like the septic tank, has duplicated many of the natural processes of waste stabilization. The aerobic conditions in the trickling filter and activated sludge systems have improved the process of biodegradation and effectively destroyed the proteins, carbohydrates and fats. The water is then disposed of on spreading grounds, or into streams or oceans.

One of the advantages of soil percolation is that the water is purified by passing through it. The question arises whether a system can be developed which will produce all the results of the natural soil in a water purification process. It is a well established fact that clay in the soil profile removes phosphate and detergent.

It is now proposed that such results might be produced or closely approximated by a sequence of steps in which the trickling filter, followed by clay and alum flocculation unit and sand filter becomes the tertiary step following the algae pond (which in turn follows the activated sludge treatment).

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0114, A MATHEMATICAL MODEL FOR REGIONAL TREATMENT OF WATER POLLUTION SYSTEMS

G.W. GRAVES, Univ. of California, Graduate School, *Los Angeles - U.C.L.A. , California* 90024

The aim of this study is a determination of the best integrated regional treatment plan to achieve desired dissolved oxygen goals on an estuary or connected inland waterway. In addition to permitting differential treatment at the polluters this model introduces the options of by-pass piping and piping to central regional treatment plants.

In the first phase, pure by-pass piping was employed to achieve prescribed dissolved oxygen profiles on the Delaware estuary. The solutions obtained in this phase demonstrated that by-pass piping can achieve substantial improvement in heavily polluted sections of the Delaware at modest cost with only slight deterioration in the other sections. The recuperative capability of the estuary, as reflected in the transfer functions, provides a very low cost natural treatment facility when employed intelligently. The dissolved oxygen profile of the estuary is very sensitive to the discharge pattern.

In the second phase, by-pass piping will be combined with differential treatment at the polluter. Unfortunately the combined options generate non-linear constraints in the very large mathematical programming model. Nevertheless, an attempt will be made to obtain actual numerical solutions for the Delaware estuary. The third phase will attempt to determine the optimal number, location, and capacity of regional treatment plants to be employed in conjunction with by pass piping and differential treatment at the polluter.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0115, OCEANOGRAPHIC FACTORS IN THE FUNCTIONAL DESIGN OF WASTE DISPOSAL SYSTEMS

J.W. JOHNSON, Univ. of California, Water Resources Center, *Los Angeles - U.C.L.A. , California* 90024

In the design of waste disposal systems, such as ocean sewer outfalls, cooling water waste lines from nuclear power plants, etc., a large variety of technical problems remain to be solved to place such sound design on a sound scientific basis. The three major areas of studies have been: 1. The mixing of a buoyant jet being discharged horizontally at the water surface. 2. The mixing of a series of buoyant jets being discharged horizontally from both sides of a manifold placed at the bottom of a tank. 3. The mixing caused by the mass transport associated with surface waves having a circular normal directional spectra.

The laboratory work done previously at UCB in regard to Item 1 was re-examined, and compared with the results of work done subsequently by other institutions. These results were then compared with the two sets of prototype data with which the investigators were aware: The Pacific Gas & Electric Plant at Morro Bay, California, and the discharge of the Columbia River into the North Pacific Ocean. The data compared favorably, on a gross basis. It became evident that the laboratory work should be extended to much smaller values of Froude number and that the statistical fluctuations of temperature and salinity in the mixing jet should be studied in detail.

In regard to Item 2, the results of the studies of single jets by a number of investigators were compared, and a preliminary report written on the findings. It was evident that no additional work need be done on the portion of a single jet between the bottom and surface, but that there is essentially no information on the interaction of multiple jets from a manifold. The laboratory equipment has been designed, constructed and tested, with preliminary tests made.

The results of a theoretical study of Item 3 have been negative, in the sense that there appears to be no mixing caused by the mass transport of waves with a circular normal distribution. However, the theoretical study was linear, and there may be some nonlinear mechanism that exists.

SUPPORTED BY University of California

5.0116, MARKETS TO 1980 FOR WASTE WATER TREATMENT AND RENOVATION FACILITIES

R.E. DELARUE, Stanford Research Institute, *Menlo Park, California*

The overall objectives of the study are (1) to identify markets whose growth will offer business opportunities to suppliers of equipment, chemicals, materials, and services for waste water treatment; (2) to establish a timetable for the growth rates of these markets; and (3) to identify business strategies through which companies can successfully penetrate the markets. Specifically, the objectives are to:

1. Forecast the markets of 1980 for both municipal and industrial waste water treatment facilities that will be required for treatment of waste water either for release or reuse; including cooling towers.
2. Forecast the markets to 1980 for equipment (including instrumentation) and services for both municipal and industrial facilities.
3. Forecast the markets to 1980 for chemicals, materials, and supplies that will be consumed in the operation of municipal and industrial facilities.
4. Evaluate the effects of anticipated government legislation, policies, and expenditures on the markets for waste treatment and renovation.
5. Identify and analyze the criteria necessary for sponsors to compete successfully and profitably for these markets.

SUPPORTED BY Stanford Research Institute

5.0117, REMOTE SENSING IN WATER QUALITY CONTROL

R.I. WELCH, Stanford Research Institute, *Menlo Park, California*

The study investigated methods for evaluating the California marine and freshwater resources and environment by remote sensing. Sea dyes were released in areas of known pollution to monitor effluent dissipation by multiband and color aerial photography. Sediments and vegetation conditions were studied on aerial photos. Mapping, identifying and evaluating health and vigor of kelp beds is being studied. Detection of oil slicks was investigated. Investigations were conducted with comprehensive ground checking and underwater photography.

SUPPORTED BY Stanford Research Institute

5.0118, HYDROLOGY OF CACHUMA RESERVOIR

E.R. HEDMAN, U.S. Dept. of Interior, Geological Survey, *Menlo Park, California*

The objective of this project is to evaluate proposed air-injection systems to minimize thermal stratification in large reservoirs in order to (1) increase the dissolved oxygen content of the deep water, (2) prevent the development of dissolved hydrogen sulfide and other sources of bad taste and odor, and (3) reduce the concentration of phytoplankton populations in water to be withdrawn and treated for domestic use. The chemical and biological effects of air injection in lake water will be studied. Field and laboratory experiments will be conducted to study the effects of air injection in a controlled environment. The changes in phytoplankton populations, water quality, and temperature will be studied with varied thermal stratification.

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of California.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
California State Government

5.0119, CHEMISTRY OF HYDROSOLIC METALS IN NATURAL WATER

J.D. HEM, U.S. Dept. of Interior, Geological Survey, *Menlo Park, California*

Certain metallic elements readily precipitate as oxides or hydroxides at the pH and redox potential normally occurring in aerated natural water. The most common of these elements, iron, manganese, and aluminum are being studied under this project.

One aim of the research project has been to provide a more complete understanding of the factors affecting solubility of iron and manganese in natural water so that the problems of removal from water supplies can be approached more logically.

Phases 1 and 2 of this project, the study of iron and manganese chemistry respectively, have been completed. Phase 3, concerned with aluminum chemistry, is in progress.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

5.0120, ORGANIC SUBSTANCES IN WATER

W.L. LAMAR, U.S. Dept. of Interior, Water Resources Division, *Menlo Park, California*

Wide and complex varieties of organic substances are present in water and the number of the organic pollutants reaching water supplies is rapidly increasing. Knowledge of the extent, character, and composition of organic substances in water has lagged significantly behind that of the mineral components.

The work involves largely the development of methodology for the separation, identification, and measurement of organic substances in water. The initial work has been concerned with natural organic substances in water. The processes being developed basically involve extraction, vacuum evaporation, chromatography, and infrared spectroscopy.

The development of highly sensitive techniques for the separation, identification, and measurement of pesticides in water will be continued. Recovery studies will be continued and extended to cover additional pesticides to those already investigated. Efforts will also be directed toward the development of an electron capture gas chromatographic procedure for the analysis of chlorinated phenoxy acid herbicides and their derivatives in water.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

5.0121, HYDRODYNAMIC STUDIES FOR ELECTRODIALYSIS

G.A. GUTER, Mcdonnell Douglas Corporation, *Newport Beach, California*

The scope of work will be directed toward improving the electrodialysis process through a study of the hydrodynamic factors associated with the mass transfer of electrolytes from dialysate to concentrate streams. Recognizing the importance of spacer design on the electrodialysis process, Astropower Laboratory is developing experimental techniques to study spacer hydrodynamics in actual stack configurations. A unique photographic technique has been developed which gives accurate and rapid measurements of local flow velocities of electrolyte over the surfaces of membranes and is able to detect regions of stagnant flow and the relationship of these regions to a given spacer design. The Douglas hydrostatic channel, designed especially for hydrodynamic studies on scale models, is also applicable to spacer studies and will obtain three -dimensional flow patterns and velocities in simulated electrodialysis channels. Local current density measurements such as the shadowing effect of spacers will also be evaluated. The research program will study the hydrodynamic effects of a number of spacer designs now in common use. Beyond that, new spacer designs will be evaluated and an optimum design will be determined. These experiments will include studies with large size membranes and spacers used in pilot plants of high capacity. Work with laboratory size apparatus is also included.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

5.0122, ORGANIC MATTER AND ITS ROLE IN WATER QUALITY

J.J. CONNORS, East Bay Municipal Util. Dist. , *Oakland, California* 94623

An investigation of the sources and effects of organic matter in a complex metropolitan water system with the goal of defining the bases on which controls may be economically exerted to reduce the organic content of water to an acceptable level. Consideration to be given to raw water reservoir management for this purpose, in the context of multiple use, and to the removals effected by coagulation and filtration. Later phases to recognize the qualitative differences in the maintenance of water quality.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0123, ENGINEERING INVESTIGATION OF STORM WATER INFILTRATION INTO SANITARY SEWERS OF THE EAST BAY MUNICIPAL UTILITY DISTRICT

J. WHITE, Metcalf & Eddy, *Palo Alto, California*

Sanitary sewage flows from Oakland, Berkeley, and other cities in the East Bay area are treated and disposed of through facilities of the East Bay Municipal Utility District. During periods of rainfall, stormwater gains access to the sanitary sewers, through infiltration and other means, causing overflows in the system and by-passing of the treatment plant resulting in pollution of San Francisco Bay. The work includes the selection of specific areas for intensive study, the installation of flow measuring and sampling equipment as well as raingages to obtain detailed information on the quantity and quality of storm flows as related to storm patterns, the development of alternate solutions for control of pollution, development of generalized cost data, and preparation of preliminary plans for recommended solution. Procedures include the relating of storm flows to system characteristics, rainfall, geological and geographical conditions, and land use; development of techniques for extrapolation of subarea data to whole system by systems analysis, quantitative effects on receiving waters, and cost effectiveness of various solutions. Information will be presented in a form that can be adapted for use at other localities.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0124, FURTHER STUDIES OF INFILTRATION

J.B. FRANZINI, Stanford University, School of Engineering, *Palo Alto - Stanford, California* 94305

Several aspects of unsteady and unsaturated flow in soils are under analytic and experimental investigation. Numerical procedures for analyzing moisture movement in soils have been developed for both one-dimensional and two-dimensional flow. The impedance of infiltration by pressure built-up of trapped air has been investigated. The effect of an applied pressure on horizontal flow in soils has been examined.

Future work will include an investigation of two-dimensional flow with a variety of impermeable barrier configurations. This work should lead to a better understanding of soil moisture movement which has many important applications such as: infiltration and its effect on runoff, the operation of underground drainage fields, the disposal of waste water through surface spreading, groundwater recharge, and other environmental problems.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0125, EFFECTS OF WATER POLLUTION IN SAN FRANCISCO BAY

R.K. LINSLEY, Stanford University, School of Engineering, *Palo Alto - Stanford, California* 94305

1. To determine how people are affected by water pollution in San Francisco Bay. 2. To estimate the number of people affected in various ways by water pollution in the bay. 3. To measure attitudes toward water pollution in the Bay. 4. To determine where people acquire information about pollution in the Bay. 5. To determine what actions of adjustment (substitution, curtailment of activity, reduction in frequency of participation, etc.) are taken by people as a result of water pollution in the Bay. 6. To obtain data that could be used in an assessment of the econimic value of water pollution control measures, especially the value of recreational activities and esthetics.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0126, ALGAE DEGRADATION IN WATERWAYS

P.L. MCCARTY, Stanford University, School of Engineering, *Palo Alto - Stanford, California* 94305

The aim of this research investigation is to evaluate the rate and extent of decomposition under no-light conditions of heterogeneous algae cultures of various ages and grown in various chemical and physical environments. In addition, the incremental effect of small quantities of light on this degradation rate will be studied. This will be directed towards determining the rate and extent of algae degradation so that the possible translocation of pollution by algae can be better predicted and controlled. The study will be conducted in five phases to ascertain the effects of algae type, water characteristics, aerobic conditions, anaerobic conditions, and temperature on the rates of degradation and oxygen consumption observed.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0127, STRUCTURE OF THE BLUE-GREEN ALGA TOXIN

B. WEINSTEIN, Stanford University, Graduate School, *Palo Alto — Stanford, California* 94305

For the past three years I have been working on the snythesis of a polypeptide hormone (glucagon), as well as methods for the gas chromatographic and mass spectral analysis of polypeptides. I would like to apply these techniques to the determination of the structure, and the possible synthesis of the blue-green alga toxin. At a later date, I wish to undertake the synthesis of the cyclic polypeptides malformin, phalloidin, enchinomycin, and sporidesmin, each of which is a toxic produce. In the structural area, I plan ultimately to study cobra and rattlesnake venoms. It is felt that a coordinated research effort in the area of polypeptide structure and synthesis can yield many scientific dividends, in both the organic and biochemical fields.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0128, MYCOLOGICAL PHENOMENA IN SEWAGE SPREADING BASINS

J.E. MCKEE, Calif. Inst. of Technology, Graduate School, *Pasadena, California* 91109

It is the general objective of this project to investigate the occurrence, concentration, and significance of various species of fungi in a well-ripened soil system that has been, and will continue to be, dosed daily with two feet of highly oxidized effluent from an activated- sludge plant handling municipal wastewater. Within this general objective, it is a specific aim to determine the role of major fungal species in biochemical degradation. Insofar as possible, reaction rates as well as pathways will be investigated. Special attention will be given to synergism among fungi and bacteria.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0129, THE CHEMISTRY OF MAGANESE IN NATURAL WATERS

J.J. MORGAN, Calif. Inst. of Technology, School of Engineering, *Pasadena, California* 91109

The long-term goal of the proposed research is to provide as complete a description as possible, in chemical terms, of the behavior of manganese, iron, and related elements in natural waters and in water treatment processes. The research plans to obtain a kinetic description of the processes believed to be of major significance in natural water systems where manganese and iron are significant constituents.

Four specific problems are emphasized: (i) The kinetics of the oxidation of manganese by chlorine; (ii) the role of organic ligands and reductants in determining the kinetic behavior of the system Mn(II) O2; (iii) the influence of various mineral surfaces on the kinetics of Mn(II) oxygenation; and (iv) the colloid- and surface-chemical properties of hydrous manganese oxides, particularly MnO2.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0130, MARINE WASTE DISPOSAL AND SEA URCHIN ECOLOGY

W.J. NORTH, Calif. Inst. of Technology, Graduate School, *Pasadena, California* 91109

Southern California communities are growing rapidly and depend intimately on the ocean for food, recreation, and waste disposal. At times the varied human activities seriously interfere with each other and with the natural environment. Unless preventive measures can be developed, metropolitan growth will clearly disrupt nearshore ecology to the point where few marine biological resources will survive. Our broadest objective is to alleviate this situation to the greatest extent possible.

The principal area of our concern has been the California kelp beds because their great extent, high productivity, and richness of species and biomass plainly marks them as regions of singular importance. Our overall research program is divided into two sections; one section emphasizes development of techniques for controlling and improving kelp communities while the other concentrates on gathering basic ecological knowledge that provides the background for intelligent control. This proposal is in the second category. Interactions between these two sections are outlined in an addendum enclosed herewith.

One of the chief factors affecting the kelp communities adversely is apparently an imbalance resulting from overgrazing by sea urchins. We suspect that there is a nutritional link between discharged sewage and the dense urchin populations. The proposed investigation should confirm or disprove the existence of the suspected link. If such a relation is verified, future planning of many seaside municipalities will benefit from the information.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0131, TREATMENT OF MUNICIPAL SECONDARY EFFLUENT BY REVERSE OSMOSIS

A.N. MASSE, Los Angeles Co. San. Dist. 21, *Pomona, California*

Reverse osmosis through a cellulose acetate membrane is being investigated as a process for removing dissolved inorganic and refractory organic materials from a municipal secondary effluent. A 5,000 gpd unit, using the spiral membrane configuration, manufactured by the General Atomic Division of General Dynamics Corporation has been run at 400 psi on secondary effluent passed through a 10-micron filter and on secondary effluent passed through a column of granular carbon for removal of dissolved organic material. The secondary effluent receiving only a filtration pretreatment both fouled and plugged the membranes and the feed channels. Considerably more success was obtained when the unit was fed carbon-treated secondary effluent. Over 80% of the 4,000 gpd feed is recovered as product having a TDS of less than 50 ppm and a COD of less than 5 ppm. A similar study is in progress on a fiber-glass tube unit supplied by Havens Industries. The results are similar but troubles have been encountered because of tube rupture.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Los Angeles County Government -
California

5.0132, BIOLOGICAL REMOVAL OF THE NITRATE ION ON BEDS OF ACTIVATED CARBON OR SAND

A.N. MASSE, Los Angeles Co. San. Dist. 21, *Pomona, California*

It has been discovered that dentrifying bacteria can be made to flourish on beds of granular media and that these bacteria can reduce the oxidized inorganic nitrogen forms to gaseous nitrogen. Methanol is added to the feed stream to serve as a food source to the bacteria. About 1 milligram of nitrate-nitrogen is reduced by 2 milligrams of methanol. NO3-N can be reduced to less than 1 mg/1 by addition of the proper amount of methanol. Studies have been underway using both activated carbon and sand as the media. Contact times less than 10 minutes have proven adequate. The media must be backwashed frequently, but backwashing does not disturb the dentrifying properties of the media. Other studies are in progress to determine the suitability of waste products in place of the methanol.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Los Angeles County Government -
California

5.0133, TREATMENT OF MUNICIPAL SECONDARY EFFLUENT BY GRANULAR ACTIVATED CARBON

J.D. PARKHURST, Los Angeles Co. San. Dist. 21, *Pomona, California*

The objective of the project is to develop economic and design information on the application of granular activated carbon to removing the refractory organic materials from a municipal secondary effluent. The equipment consists of four 6-foot diameter, l0-ft. deep beds of 16 X 40 mesh carbon over which the secondary effluent is passed downflow at a rate of 7 gpm/ft.2. The total flow is 200 gpm. The product COD is maintained between 3 and 12 ppm by thermal regeneration of the exhausted carbon in a 6-hearth Herreschoff furnace. The carbon exhaustion rate has been about 3500/mg. Carbon losses per cycle have been between 7-l/2 and 10% but it is believed that this would be reduced to 5% in a larger-scale operation. A cost estimate for a 10 mgd plant indicated that total costs would be about 8 cents/1,000 gal. Studies have shown that, between 4 and 10 gpm/ft2, contact time alone is controlling. Studies are underway to determine the effect of application rates below 4 gpm/ft2 and to evaluate the effect of particle size and source of carbon.

Chlorides, and Phosphate.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Los Angeles County Government -
California

5.0134, DISTRIBUTION OF LIQUIDS IN POLAR CAMPS

C.R. HOFFMAN, U.S. Navy, Civil Engineering Lab. , *Port Hueneme - Point Mugu, California*

Technical objective: Develop methods and materials to distribute water, sewage, galley wastes, fuel oil and other such liquids between and within buildings in pioneer and temporary polar camps in snow, ice and permafrost areas in temperatures to -65F.

Approach: Study heat loss, flow resistance, insulation and heating requirements for water lines, flow resistance for various size fuel lines and for sewage pipes under trickle and surge flow.

Progress: A prefabricated pipe system with heat tape, insulation and protection coating is being evaluated. Several characteristics make the pipe look promising. A survey was conducted during the summer season of Deep Freeze 65.

SUPPORTED BY U.S. Dept. of Defense - Navy

5.0135, ELECTRIC AND STRUCTURAL PROPERTIES OF ION SELECTIVE MEMBRANES

E.D. HOWE, Univ. of California, School of Engineering, *Richmond, California* 94804

The objectives of this project are: (1) to measure and explain the electrolytic transport of sodium and hydrogen ions within cationic membranes as a function of membrane water content, time after voltage application, voltage gradient, and membrane glossy structural transitions; (2) to develop and experimentally verify relationships existing between membrane exchange capacity and membrane glossy transition temperatures; and (3) to make calculational studies on ion transport data in order to formulate and test the kinetics of how typical mobile cations conduct or transport in cation-permeable membranes.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

5.0136, TOXICITIES OF CATIONS VS. ANIONS ACCUMULATED FROM SALINE SOILS

F.M. EATON, Univ. of California, School of Agriculture, *Riverside, California* 92502

Uncertainty has existed for many years as to whether the reduced growth of crops on saline soils is due primarily to the extra accumulations in plants of the cations (Ca, Mg, Na, K) or of the anions (SO4, Cl, and NO3); both are accumulated simultaneously. With knowledge in the foregoing regard, substantial advantages would be gained in appraisals of the relative values of water supplies and in estimates of the growth reductions that are associated with the types of salt found in soil solutions. With this knowledge, research can be focussed on the individual ions of the group that is primarily responsible for salt toxicity.

Relatively high concentrations of SO4, or of Cl, are found to accumulate in plants -- without important changes in the sum of cations -- when SO2, or hydrogen chloride, is supplied atmospherically to plants growing in plastic cabinets. The current research is showing growth depressions far below those of plants accumulating similar concentrations of SO4, or Cl, from saline substrates.

SUPPORTED BY University of California

5.0137, DEVELOPMENT OF ANALYTICAL METHODS FOR PESTICIDE CONTAMINANTS IN DOMESTIC, IRRIGATION AND POND WATERS

F.A. GUNTHER, Univ. of California, School of Agriculture, *Riverside, California* 92502

The quantitative estimation and qualitative identification of pesticides will be investigated using various detection devices including the phosphorus and sulfur detectors for the gas chromatograph and the emission spectrometric detector. Investigations to develop methods for specific pesticides of interest and studies to determine the water solubilities of organchlorine pesticides will be continued.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of California

5.0138, PESTICIDES AND WILDLIFE

F.A. GUNTHER, Univ. of California, Agricultural Experiment Sta., *Riverside, California* 92502

The objectives of this project are to study the relationship of insecticides to wildlife species, and to develop specific public health insect control measures in wildlife habitats, with the hope to eliminate or diminish hazards to non-target species.

The productivity, food chain relationships and biological characteristics of predominant components of the eco-system will be investigated with the introduction of commonly used pesticides. Degradation and detoxification avenues and mechanisms in a variety of habitats and organisms will be elucidated. Residues of insecticides in water, surface and sub-soil strata, aquatic vegetation and non target organisms by means of gas chromatography. Colorimetric procedures and other appropriate analytical methods will be studied. The biological and toxicological effects of insecticidal treatments influencing animal populations in the treated area will be investigated.

SUPPORTED BY California State Government

5.0139, DEVELOPMENT OF ANALYTICAL METHODS FOR PESTICIDE CONTAMINANTS IN DOMESTIC, IRRIGATION, LAKE, AND POND WATERS

F.A. GUNTHER, Univ. of California, Agricultural Experiment Sta., *Riverside, California* 92502

Objectives: 1. Develop dependable, quantitative extraction procedures for removing pesticide residues from samples of water. 2. Develop methods of analysis that will identify and measure pesticides present, and that are sufficiently sensitive to permit the use of smaller samples than are now required (e.g., 5-10 l. rather than the 1,000 l. and larger samples now employed). These methods would apply equally well to the analysis of soil samples. 3. Automate the analytical procedures as far as practical to achieve maximum output per man-hour.

Work Proposed: Procedures for extracting pesticide residues from water that will give consistent, essentially complete recovery will be developed. Carbon columns and other adsorbing media will be investigated, as well as counter-current partitioning procedures.

Analytical methods, and particularly instrumental methods that are susceptible to automation, will be developed and adapted to use for water and soil analysis. An important objective will be the development of methods of sufficient sensitivity to permit the use of relatively small water samples and thus eliminate the necessity for complicated sampling devices and adsorbants that only too frequently introduce errors that are difficult to detect and eliminate. By utilizing the latest developments in instrumentation, the two objectives of sensitivity and automation may both be achieved.

SUPPORTED BY California State Government

5.0140, SORPTION AND DESORPTION FACTORS INFLUENCING TRANSPORT, PERSISTENCE, & ALTERATION OF PESTICIDES IN VARIOUS AGRICULTURAL SOILS

H.P. HERMANSON, Univ. of California, Agricultural Experiment Sta., *Riverside, California* 92502

To identify the properties of pesticides, of soils, and of soil water that control the extent of sorption, movement, alteration, and persistence of pesticides in soils; to establish the solubilities of pesticides sorbed on soil colloids and thus the importance of any 'solubilization' effects of this colloidal reservoir. There is insufficient information concerning the effect of soil factors on the occurence of pesticides in soil water. The partitioning of several classes of pesticides between soil and soil water will be measured by radioactive tracer techniques over a range of water availability. Soil properties such as organic carbon content, cation-exchange capacity, anion-exchange capacity, specific surface, etc. will be determined on selected California soils. The relationship between the adsorption and desorption data and the soil chemical and physical data will be described and rationalized. This knowledge will aid in the efficient designing of experiments to test practical methods of reducing pesticide pollution in water, soils, and crops growing therein.

SUPPORTED BY U.S. Dept. of Agriculture
California State Government

5.0141, INVESTICATIONS ON NEW INSECTICIDES AND TECHNIQUES FOR THE CONTROL OF PEST AND VECTOR MOSQUITOES

R.L. METCALF, Univ. of California, Agricultural Experiment Sta., *Riverside, California* 92502

Laboratory and field investigations of more than 800 compounds as toxicants for larval and adult mosquitoes during the past year showed that 18 materials were very promising for field control. Seven new materials, previously selected for laboratory experiments, were field tested against Culex tarsalis. As a result of this program there are now 10 new materials which could be substituted for parathion in larvicidal operations.

Work proposed will include the continuation of the following projects: Twenty-eight new larvicidal compounds were evaluated against the top minnow, and several species of frogs for potential damage to wildlife. The residue persistence curves for alfalfa treated with parathion and Baytex were evaluated using sprays and granulars. The latter caused no detectable residues on the hay. The relative penetration of vegetative plant cover by granulars and sprays was compared. Granular formulations were found to be superior.

SUPPORTED BY California State Government

5.0142, RECOVERY OF METAL SALTS FROM CONCENTRATED BRINES BY CHELATION CONTRACT NO. 14-01-

D.O. DEPREE, Aerojet General Corporation, *Sacramento, California*

The objective of the proposed work is to establish the feasibility of recovering potable water and marketable metal salts in relatively pure form, from concentrated brine solutions by employing a regenerative chelation process.

The process under investigation includes the removal of salts from solution by the use of exchange resins and the recovery of the metal ions and regeneration of the exchange resin by reaction with selective chelating agents. The program includes (1) the synthesis of chelating agents for sodium, calcium, magnesium, and potassium, (2) the evaluation of these chelating agents both for selectivity and in regenerating ion exchange resins, and (3) the evaluation of solvents for their effect upon the efficiency of the chelatin step. The overall process will be demonstrated in the laboratory including the demineralization of a synthetic concentrated bring containing the four metal ions under study with a selected commercial ion exchange resin, regeneration of the resin with chelate solutions and recovery of the chelates by acid treatment.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

5.0143, AMERICAN RIVER HYDROBIOLOGIC POTENTIAL STUDY

L.W. HOM, Sacramento State College, Graduate School, *Sacramento, California* 95819

Purpose: To predict the hydrobiologic potential of the Lower American River for present and ultimate flow conditions. This study will consider the production of phytoplankton organisms (algae), and their effect on the water quality. The phases of this investigative study are: 1. Develop a sampling and analysis program to assess the hydrobiologic quality of waters of the Lower American River. 2. Identify, enumerate and determine biomass of organisms present in water samples. 3. Identify statistically significant hydrobiologic parameters and develop general relationships to describe existing conditions and to predict future conditions.

The evaluation of algal growth potential (AGP) on selected samples will be performed using the Skulberg Method (1966). This consists of determining the maximum growth rate or maximum cell numbers during an incubation period under controlled light, temperature and nutrient conditions.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

5.0144, COMPLEMENTARY - COMPETITIVE ASPECTS OF WATER STORAGE

K.B. MERRI, Sacramento State College, Graduate School, *Sacramento, California* 95819

An engineering-economic investigation is to be conducted of the complementary and competitive aspects of the storage of water for water quality control. The DYNAMO computer program will be employed to simulate a river basin. Hydrologic information for Holley Reservoir in Oregon has been simulated and other available information on Holley will be used to determine the cost and benefit functions. Determination of the extent and magnitude of the complementary and competitive aspects with other benefits will be scrutinized while searching for the conditions which maximize the net benefits from the reservoir. Benefits include flood control, channel improvement, irrigation, water quality control, downstream fisheries and recreation in the vicinity of the storage reservoir. A model will be developed that will produce a rational analytical approach to the evaluation of the magnitude and extent of the competitive and complementary aspects of storage for water quality control. Results obtained from this investigation should help water management agencies estimate the benefits from water stored for water quality control, guide benefit evaluation studies, and indicate areas needing further research. This model is not intended to be definitive of Holley reservoir, but is developed to accomplish the aims of this research proposal and in order that it be useful for water resource projects of this general nature.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0145, DOCUMENT LOGGING DAMAGE

J.W. BURNS, State Dept. of Fish & Game, *Sacramento, California*

Objectives: To determine the type, extent, and duration of conditions in natural and logged streams.

Procedure: Study programs will be surveyed periodically to determine the physical, chemical, and biological changes which occur naturally or are the result of logging. This entails measuring conditions and populations before, during, and after logging, and surveying streams previously logged. The methods to be developed and tested in Job 1 will be used concurrently in these surveys. Attempts will be made to correlate habitat changes with changes in fish populations.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
California State Government

5.0146, EFFECTS OF INCREASE IN SALTON SEA SALINITY ON THE SURVIVAL OF ORANGEMOUTH CORVINA, SARGO, BAIRDIELLA, AND NEANTHES

R.F. ELWELL, State Dept. of Fish & Game, *Sacramento, California*

Objectives: To determine the effect of various concentrations of Salton Sea salts on the important fishes and food chain organisms.

Premises: The Selton Sea is a valuable sportfishing resource. Based on projections, angler days use in 1967 will total approximately 660,000. Their catch will total approximately 1,000,000 fish. This resource is being jeopardized by increasing salinities. It is estimated that 1,750,000 tons of salts will have to be removed annually to maintain present salinities. However, the beneficial uses of the Salton Sea may be preserved by employing suitable engineering methods to maintain constant salinity levels. It is necessary to know the salinity tolerances of the important fishes and invertebrates so that appropriate salinity levels can be recommended to the agencies responsible for controlling the water quality of the Salton Sea.

The salinity tolerance limits can be determined for the orange- mouth corcina, sargo, bairdiella, Neanthes, and other organisms by laboratory bioassays, and then be applied to the Salton Sea.

Procedures: Exploratory tests will be conducted to determine the approximate range of concentrations which should be covered in full- scale tests. The test range to be used in the full-scale routine tests should be between the highest concentration at which all fish survive for 96 hours and the lowest concentration at which all fish die in 24 hours. The probable concentrations to be used in the exploratory tests are 44, 53, 62 and 70 percent. Once the critical concentration range has been determined, more specific tolerances will be measured by testing a series of four concentrations within the limits of this range.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
California State Government

5.0147, PESTICIDE RESIDUE DATA PROCESSING

E.G. HUNT, State Dept. of Fish & Game, *Sacramento, California*

Objectives: To develop a rapid, convenient and accurate system for recording, summarizing, storing and retrieving results of pesticide residue analyses obtained during fish and wildlife-pesticide investigations.

Procedures: Explore the various data processing systems that may be applicable to the tabulation and storage of residue data; i.e. Unisort or IBM cards. With the use of residue data on hand,

and with guidance from data processing specialist, design a system that will be feasible for the project's needs. Transcribe residue data on hand to the card system selected.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
California State Government

5.0148, STUDY AND EXPERIMENTS IN WASTE WATER RECLAMATION BY A REVERSE OSMOSIS PROCESS

T.J. LARSON, General Dynamics Corporation, *San Diego, California* (14-12-181)

To provide two reverse osmosis test units for operation at the Pomona, California, test facility of the County Sanitation Districts of Los Angeles County. Each unit will be capable of simultaneously testing 54 one-ft-long, spiral-wound reverse osmosis modules or 18 three-ft -long modules.

Conduct a comprehensive series of field-test experiments in the two units to examine the influence of various test parameters on system performance. Perform direct support of the field experiments as required, and conduct laboratory experiments and investigations to support the overall program.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0149, MEMBRANE MATERIALS FOR WASTE WATER RECLAMATION BY REVERSE OSMOSIS

H.K. LONSDALE, General Dynamics Corporation, *San Diego, California* (14-12-452)

Three new types of reverse osmosis membranes will be prepared and tested to determine whether they have advantages over conventional cellulose acetate membranes for treatment of wastewater. The three membrane types are cellulose acetate with acetyl contents different from conventional membranes, polyvinyl-pyrrolidone-polyisocyanate, and membranes formed from polymer dispersions or latices. The object of the work is to obtain membranes with high flux, high organic rejection, and inorganic rejections at least sufficient to remove the increment of minerals added to water during use.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0150, LEAD ISOTOPIC CHEMISTRY FOR POLLUTION RESEARCH

T.J. CHOW, Univ. of California, Graduate School, *San Diego - La Jolla, California* 92038

The main objectives of this project are (1) to conduct basic research on the isotopic chemistry of lead in various environments, and (2) to establish the applicability of using stable isotopes as tracers for air and water pollution studies.

The isotopic composition of lead in potential pollution sources such as gasoline, oil and gaseous fuels, coal and industrial chemicals will be monitored to determine the trends of lead isotopic composition variations. After having established their isotopic compositions in the source materials, the lead isotopes in the water and air pollutants such as urban aerosols, river and harbour waters, industrial wastes, sewage and other samples will be determined. By evaluating and correlating isotopic composition of leads in the source materials and in the contaminants, the transport mechanism of the pollutants will be elucidated.

The distribution of lead isotopes in the 'natural' environment will be studied by sampling air, rain and sea water away from 'apparent' industrial contaminations. This part of sampling program can be carried out at the 'uncontaminated' mid-ocean regions aboard research vessels during oceanographic expeditions. These results will establish the 'ground level' of lead pollutants and serve as the basis to evaluate the degree of contamination in the urban and industrialized regions.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0151, DISPERSION OF WATER AND SEDIMENTS IN THE SURF ZONE

D.L. INMAN, Univ. of California, Scripps Inst. of Oceanography, *San Diego - La Jolla, California* 92038

Field and laboratory studies of dispersion in and near the surf zone. The object of the study is to relate the diffusion coefficients of water and sand to the wave parameters so that the movement of possible beach contaminants may be estimated from a knowledge of the beach location and its wave regime.

Field investigations are conducted on a variety of beaches having different sand size and exposure to waves.

Project funding commenced fiscal 1966-67; it is anticipated that the study will be complete in December 1968.

SUPPORTED BY California State Government

5.0152, A DEMONSTRATION PLANT EVALUATION OF FOUR METHODS FOR PULP AND PAPER MILL SLUDGE UTILIZATION AND DISPOSAL

H. AMBERG, Crown Zellerbach Corporation, *San Francisco, California* 94119

This demonstration study is a full-scale investigation of four methods of utilization and disposal of primary sludge from a combined pulp and paper mill. The areas of investigation are: disposal by incinernation, utilization as 'hog-fuel' make-up in a conventional steam boiler at rates ranging between 5 and 50%, use as a dried mulching material for highway slope preparation and the evaluation of sludge as an agricultural soil conditioner.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Crown Zellerbach Corporation

5.0153, TREATMENT OF COMBINED SEWER OVERFLOWS BY THE DISSOLVED AIR FLOTATION PROCESS

R.C. LEVY, San Francisco Dept. Pub. Wks. , *San Francisco, California*

The Project consists of the design, construction, operation, and evaluation of a dissolved air flotation facility for the treatment of combined sewer overflows from the Baker Street Outfall in the City and County of San Francisco.

Features of the facility include: Dissolved air flotation to remove both particulate and liquid floatables found in the combined sewer overflows. Developmental studies have shown that 80 to 90 percent of the total hexane extractable materials in combined sewer overflows can be removed by dissolved air flotation. Excellent reductions in other pollutional parameters (COD), BOD, SS, etc.) have also been demonstrated on a laboratory scale.

Sedimentation to reduce the quantity of materials which cause accumulation of sludge banks in receiving waters. Elimination of these materials will prevent formation of floatable debris due to slow fermentation and subsequent flotation of accumulated deposts.

Chlorination to disinfect the overflows. By reducing the number of indicator organisms in the receiving waters to a safe level, standards requisite for recreation will be preserved.

In addition, coarse trash racks will be installed to remove large objects which might otherwise damage the treatment facility.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
San Francisco County Government - Calif.
San Francisco City Government - California

5.0154, REUSE OF WASTE IRRIGATION WATER TO RECOVER ADDITIONAL PETROLEUM BY WATERFLOODING

G.L. GATES, U.S. Dept. of Interior, Petroleum Research Off. , *San Francisco, California* 94111

The proposed research plan involves laboratory and some field investigations to determine the suitability of waters, particularly waste irrigation waters, for use in obtaining additional petroleum from semidepleted reservoir rocks. The main plan is to study mixtures of waste irrigation waters with waters produced from petroleum reservoirs. If harmful precipitates that may plug petroleum reservoir rock flow channels are formed, the precipitates will be identified chemically and physically. Necessary treatment methods will be devised.

Laboratory investigations will utilize the flame spectrophotometer to determine the chemical constituents of the waste irrigation waters and the waters occurring with the petroleum in the reservoir rocks. In a similar manner, the chemical constituents of harmful precipitates formed in mixing these waters will be determined. The physical forms of the precipitates will be identified using the Differential Thermal Analysis equipment and the petrographic microscope. The effect of these waters on the permeability of reservoir rocks will be determined.

SUPPORTED BY U.S. Dept. of Interior - Bureau of Mines

5.0155, BOD, SOLIDS AND NUTRIENT REMOVAL FROM SECONDARY EFFLUENT BY FOAM FRACTIONATION

F. BELICK, San Jose City Government, *San Jose, California*

The objective of this project is to demonstrate the effective removal of secondary effluent solids, Biochemical Oxygen Demand, and nutrients such as nitrates and phosphates by a Foam Fractionation System, to be located at the San Jose - Santa Clara Water Pollution Control Plant. The aim is also to determine full-scale design and operating criteria in order to comply with required BOD and solids reduction and to attain optimum phosphate and nitrate removal. The successful demonstration of the System will provide one of the first systems that will economically remove solids; BOD, and nutrients from a waste water facility in one continuous process. Such a system would be applicable to a wide range of waste discharge volumes.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
San Jose City Government - California

5.0156, PROCESS TO REMOVE CARBONACEOUS, AND PHOSPHORUS-MATERIALS FROM ANAEROBIC DIGESTER SUPERNATANT AND RELATED PROCESS STREAMS

H.A. OLDENKAMP, F M C Corporation, *Santa Clara, California* (14-21-414)

A process will be developed to remove plant nutrients and COD materials from digester supernatant liquors. The sequence of operations to be studied involve (a) heating to remove CO2, (b) addition of lime to precipitate phosphates and to coagulate organic matter, (c) stripping the alkaline slurry with air to remove ammonia, (d) settling the sludge to separate phosphates and COD material, and (e) recovery of the ammonia stripped from the alkaline slurry by scrubbing the air-ammonia mixture with sulfuric acid. From this work, a portable and proven pilot plant will result and estimates of plant costs developed for treating up to 3 MGD of supernatant liquors.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0157, CANNERY WASTE TREATMENT BY THE KEHR ACTIVATED SLUDGE PROCESS

W. PALMER, Santa Clara City Government, *Santa Clara, California*

The Kehr Process, in essence, involves a combining of activated sludge aeration of 10,000 to 15,000 mg/l mixed liquor solids with aerobic digestion in a single aeration tank. This provides high removals of BOD, solids, and nutrients; facility for periodic high strength wastes; a stabilized, drainable water sludge; and comparatively low physical plant costs.

The objectives are to: 1. Demonstrate the revised Kehr Process using liquid-solids separation by high-rate flotation-densification system of activated sludge solids. 2. Demonstrate effectiveness of the process for treating cannery wastes combined with domestic sewage having a BOD 5 of 1000 to 2000 mg/l. 3. Demonstrate performance of the process with densified return sludge solids of 4% to 8% on a dry weight basis, thus affecting plant economy by use of smaller tankage volume. 4. Determine processing requirements for application to a full-scale treatment plant.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Santa Clara City Government - California

5.0158, RENOVATION OF WASTE EFFLUENT FOR RECREATION AND POTABLE WATER SUPPLY USE

R.L. STOYER, Santee County Water District, *Santee, California* 92071

The immediate objectives of the project are to demonstrate that the effluent from a recently constructed activated sludge plant can be treated through biological, mechanical, and chemical means so that the resulting effluents can then be safely used for body contact sports and other recreational activities. It will also demonstrate the elimination of bacteria and viruses. The value of this project is enhanced by the environmental characteristics of the area. Santee is an arid region, having high rates of evaporation and a water supply shortage. At present, shortage is met by importing water. With increasing populations and rising costs of imported water, Santee and other similar communities must develop supplemental water supplies for potable and recreational uses. Treated sewage effluents, when filtered through natural ground aquifers, can be reused in lakes for body-contact sports and other recreational activities, based on purification standards and of general public acceptance. By cautiously approaching this acceptance and using the most advanced treatment techniques this project can demonstrate that man-made processes can achieve the same acceptance and purity requirements.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Santee County Government - California

5.0159, RECLAMATION OF BIOLOGICALLY, MECHANICALLY & CHEMICALLY TREATED WASTEWATER FOR POTABLE WATER SUPPLY USES (ABBREV)

R.L. STOYER, Santee County Water District, *Santee, California* 92071 (14-12-444)

Selection of the Contractor: The Santee County Water District is considered uniquely qualified to carry out the proposed work. Santee is presently the only site where ion exchange treatment of wastewater will be tested on a large enough scale to provide reliable economic feasibility data. It is therefore the only site at which a realistic comparison can be made between electrodialysis and ion exchange. To attempt the work anywhere else would necessitate the spending of large sums of money, not only for the ion exchange equipment, but for pretreating facilities that will already be available.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0160, RECOVERY & REUSE OF LIME AS A COAGULANT IN TERTIARY TREAT & NITROGEN REMOVAL FROM TERTIARY TREATED EFFLUENT

H.E. MOYER, South Tahoe Pub. Utility Dist. , *South Lake Tahoe, California*

The objectives of this project are to demonstrate a full-scale treatment plant, the advantages of the use of lime in advanced waste- water treatment, the advantages of the recovery and reuse of lime from secondary treated effluent, methods for the final disposal of waste lime sludge, and the advantages of nitrogen removal from wastewater by ammonia stripping at high pH. The plant-scale study will aim at extending the data already obtained at the South Tahoe plant from laboratory and pilot scale investigations.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
South Lake Tahoe City Government - Calif.

5.0161, INTEGRATED ACTIVATED SLUDGE-BIOLOGICAL FILTER PROCESS

D.L. SULLIVAN, San Buenaventura City Govt. , *Ventura, California*

The objective of this project is to demonstrate the feasibility and economics of treating domestic sewage with either an activated sludge process followed by a trickling filter or by a trickling filter process followed by activated sludge.

The activated sludge and trickling filter processes are reliable individual treatment methods. The need to control pollution and increase the efficiencies of existing plants requires specific design and operational data on the combined processes to enable the use of existing or expanded facilities; for economy, this will involve or necessitate the addition of activated sludge to an existing trickling filter plant or vice versa.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
San Buenaventura City Government - Calif.

5.0162, RECOVERY OF SALTS FROM SALINE WATERS VIA SOLVENT EXTRACTION

R.R. GRINSTEAD, Dow Chemical Company, *Walnut Creek, California* 94598

A study is being made of the possibilities of applying solvent extraction methods to the problem of recovering byproducts from brines which might be produced from desalination operations. The systems under study are those consisting of high molecular weight amines and carboxylic acids which form organic salts in organic diluents. By contact with brines reversible extraction of inorganic species occurs. Because of the selectivity of the system for divalent cations over monovalent, and for large anions over small ones, the system possesses inherent possibilities in the recovery of magnesium and calcium salts, nitrate, and heavy halide salts from many brings. During the first year of work, effort was concentrated mainly on physical chemistry studies of the extraction systems. During the current year, work is being done on some possible applications, such as magnesium recovery from sea water concentrates. Some exploratory work is anticipated in areas of changing the selectivity and extractability of anions by modifying the amine structure, and of cations by modifying the acid structure. The effect of temperature on the extraction equilibria will be explored, because of its possible importance in the reverse action involved in stripping the extracted salts.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

5.0163, FORMULATION OF A GENERAL MATHEMATICAL MODEL FOR THE PREDICTION OF THERMAL ENERGY CHANGES IN IMPOUNDMENTS

G.T. ORLOB, Water Resources Engineers Inc. , *Walnut Creek, California* 94529

The development of a generalized mathematical model which will represent, within the practical and reasonable limits of accuracy, the thermal changes which may be expected under alternative hydrologic, hydraulic, and climatologic conditions for operating reservoirs. It is intended that the work support and complement that already completed or underway by the Study Team in its investigation of the Columbia River System. The project was started in fiscal year 1968 and will be completed in fiscal year 1969.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0164, WATER TREATMENT BY REVERSE OSMOSIS METHOD

R.F. PAKALNINS, Mcgill University, School of Engineering, *Montreal - Quebec, Canada*

a. Proposed Research: To develop 1. characteristics, suitable for fresh water treatment; 2. a water treatment unit on a pilot plant scale.

b. Objective: To investigate the technical and economic aspects of such a unit, and its applicability to reclamation and waste treatment.

SUPPORTED BY Canadian Government

5.0165, AERATED LAGOONS & ANAEROBIC REACTORS - A FIELD & LAB STUDY OF THEIR EFFICIENCIES & DESIGN PRINCIPLES IN SEWAGE TREATMENT

C.R. FORSBERG, Univ. of Saskatchewan, School of Engineering, *Saskatoon - Saskatchewan, Canada*

(a) Proposed Research: To study an aerated lagoon at Moose Jaw and an anaerobic reactor to be constructed in the University's temperature-controlled laboratory lagoon cabinet.

(b) Objective: To explore the possibility that the first compartment of two or more anaerobic cells in series may advantageously be converted to a mixed anaerobic reactor. Limitations in use from the health and nuisance standpoints would receive special attention.

SUPPORTED BY Canadian Government

5.0166, STUDY OF EUTROPHICATION IN LAKES MAGOG & BROME

L.G. CARIGNAN, Univ. De Sherbrooke, Graduate School, *Sherbrooke - Quebec, Canada*

NO SUMMARY HAS BEEN PROVIDED TO THE SCIENCE INFORMATION EXCHANGE

SUPPORTED BY Canadian Government

5.0167, TAXONOMY AND BIOLOGY OF SLUDGE WORMS

R.O. BRINKHURST, Univ. of Toronto, Graduate School, *Toronto - Ontario, Canada*

A study of the systematics of Sludge Worms and their biology and ecology, with special reference to their use as indicators of pollution in fresh and brackish water.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0168, THE ECOLOGY OF THE MICROBIAL POPULATION OF ACTIVATED SLUDGE

P.H. JONES, Univ. of Toronto, School of Public Hlth, *Toronto - Ontario, Canada*

(a) Proposed Research: A study of the population dynamics (b) Objective: To determine the dominant population under different conditions and thereby predict the optimum conditions for the degradation of specific high strength (or toxicity) industrial wastes. (c) Relation to the Health Field: To control waterborne transmission of toxic and pathogenic matter through better understanding of the mechanism of degradation or inactivation.

SUPPORTED BY Canadian Government

5.0169, INVESTIGATIONS INTO TECHNIQUES FOR IMPROVING THE AMOUNT AND EFFICIENCY OF OXYGEN INCORPORATION INTO RAPID-RATE BIOLOGICAL WASTE TREATMENT SYSTEMS

C.C. WALDEN, Univ. of British Columbia, British Columbia Res. Council, *Vancouver - British Columbia, Canada*

This research will examine techniques for improving oxygen transfer into water and into biological oxidizing systems. Increasing the driving force for oxygen transfer by use of hydrocarbons with high oxygen solubility will be attempted and the effect of dispensing agents in reducing bulk viscosity will be evaluated. Possible effect of these agents on the rates of rapid oxidizing activated sludge systems will be examined. Oxygen transfer in present waste treatment systems is limiting; improved techniques will reduce operating costs and enhance efficiency.

SUPPORTED BY Canadian Government

5.0170, AERATED SEWAGE LAGOON INVESTIGATION - BOISSEVAIN

E.H. BALCHEN, Canadian Dept. of Natl. Health, *Winnipeg - Manitoba, Canada*

(a) The Proposed Research: To investigate operating efficiency of aerated sewage lagoon, followed by short-term detention lagoon. (b) The Objectives, briefly: To determine the practicality of this new method of aeration. (c) Relation to Health Field: To determine whether or not the proposed aeration system will be effective and safe for use as a general method of sewage treatment.

SUPPORTED BY Canadian Government

5.0171, ARABLE LAND DEGRADATION BY EFFLUENT POLLUTION

G.D. BALACKO, Manitoba Dept. of Health, *Winnipeg - Manitoba, Canada*

Proposed Research: Soil samples will be taken - as well as controls - from farmland subject to periodic flooding by lagoon effluents. Analyses conducted for build-up of salts, sulphates and conductivity.

Objective: To determine whether there is a valid case for suggested degradation of soils; and secondly whether there is any health implication related to agricultural pursuits or hazard to local water sources.

Relation to the Health Field: Since lagooning is an accepted method of conditioning waste prior to final innocuous disposal any side effects connected with this system are of significance in the health field.

SUPPORTED BY Canadian Government

5.172, TREATMENT AND CONDITIONING OF WADING AND SWIMPOOL WATERS

J.N. WARRENER, Manitoba Dept. of Health, *Winnipeg - Manitoba, Canada*

(a) The proposed research: To determine the feasibility of using high-rate recirculation plus chlorination of wading and swimpool waters rather than the standard method of filtration and chlorination.

(b) The objectives, briefly: To find a relatively simple and economical method of ensuring the safe quality of wading and swimpool waters without complexity of design, installation or operation.

(c) Relation to Health Field: To ensure healthful recreation.

SUPPORTED BY Canadian Government

5.0173, EVALUATION OF AERATED LAGOONS AS A SEWAGE TREATMENT FACILITY IN THE PRAIRIE PROVINCES

A.R. PICK, Metrop. Corp. of Gr. Winnipeg, *Winnipeg - Manitoba, Canada*

(a) The Proposed Research; To assess and compare with reference to conventional facultative lagoons and the activated sludge process, the effectiveness of three available methods of aeration of sewage in lagoons: (i) bubble tube diffusion (ii) surface aerators (iii) air gun aeration (iv) parallel systems comprised of a conventional facultative lagoon, lagoons with bubble tube diffusion, lagoon with surface aerators and an aerated lagoon with air gun diffusion will be placed in service for a period of two years.

(b) The Objectives, briefly; The efficiency of treatment and operating economics of three aeration systems for sewage lagoons will be defined. The results will be compared with those for an operating activated sludge plant and the conventional sewage lagoons. The appropriateness of the design criteria will be investigated.

(c) Relation to Health Field; To establish an efficient and economic treatment system to abate pollution.

SUPPORTED BY Canadian Government

5.0174, (U) STABILIZATION POND OPERATION IN TROPICAL AREAS (P)

K.E. LONGLEY, U.S. Army, Off. of Interocean. Can. Stud. , *Balboa Heights, Canal Zone*

TO INVESTIGATE AND DEFINE - A. THE ROLES OF PHYSICAL, CHEMICAL, AND MICROBIOLOGICAL PARAMETERS IN RELATION TO OPERATION OF STABILIZATION PONDS IN TROPICAL AREAS WITH PARTICULAR EMPHASIS PLACED UPON WASTE MATERIAL CHARACTERISTICS AND LOADINGS, DISSOLVED OXYGEN, ALGAE CLASSIFICATION AND PRODUCTION, AND THE RELATIVELY HIGH INTENSITY SUNLIGHT OF TROPICAL AREAS. B. THE EFFECTS OF VARIOUS DETENTION PERIODS, WATER DEPTHS, AND LOADING FLUCTUATIONS UPON THE OPERATION AND PERFORMANCE OF STABILIZATION PONDS IN TROPICAL AREAS. C. MAXIMUM ACCEPTABLE LOADING LIMITS, IN TERMS OF 5-DAY, 20 DEGREE C BIOCHEMICAL OXYGEN DEMAND (BOD) IN RELATION TO DESIGN AND OPERATING PARAMETERS.

PILOT PONDS IS DIVIDED INTO TWO PHASES, DURING PHASE ONE THE PONDS WILL BE OPERATED IN PARALLEL AT A 4 FOOT WATER DEPTH. INITIAL LOADINGS WILL BE APPROXIMATELY 25 AND 100 LBS-BOD/DAY, RESPECTIVELY, IN THE TWO PILOT PONDS. DURIHG PHASE TWO, ONE POND WILL BE OPERATED AT WATER DEPTH OF 2 FEET AND 6 FEET. THE SECOND POND WILL BE OPERATED AS A CONTROL AT A 4 FOOT WATER DEPTH. MAXIMUM SATISFACTORY LOADINGS WILL BE DETERMINED AT THESE DEPTHS. PONDS WILL BE OPERATED AT SELECTED WATER DEPTHS FOR A SUFFICIENT PERIOD OF TIME TO DETERMINE THE EFFECTS OF SEASONAL CLIMATOLOGICAL CONDITIONS. MODEL PONDS WILL BE OPERATED TO DETERMINE CORRELATION TO PILOT POND OPERATION AND DEVELOP DATA ON DEEP POND OPERATION. PRINCIPAL TESTS TO BE CONDUCTED INCLUDE B.O.D., BACTERIOLOGICAL (COLIFORM AND TOTAL COUNT), NITROGEN IN ITS VARIOUS FORMS, DISSOLVED OXYGEN, PH, AND ALGAE CLASSIFICATION AND COUNTING.

HAD NOT STARTED.

SUPPORTED BY U.S. Dept. of Defense - Army

5.0175, VACUUM FILTRATION OF SEWAGE SLUDGE

E.R. BENNETT, Univ. of Colorado, School of Engineering, *Boulder, Colorado* 80304

A study of the effect of filter medium size opening and chemical conditioning on the filterability of sewage sludges. It will include a reexamination of the vacuum filtration theory and the establishment of laboratory methods for determining design and operational parameters.

SUPPORTED BY Kettering Family Foundation

5.0176, WATER REUSE RESEARCH

J.E. FLACK, Univ. of Colorado, School of Engineering, *Boulder, Colorado* 80304

A study of the physical and chemical processes of advanced treatment combined with alternatives of supply distribution for reuse of a portion of the sewage effluent of a large metropolitan sewage treatment plant. Included will be a study of the economic implications, consumer resistance, legal and institutional constraints on reuse of water by cities and industries.

SUPPORTED BY Denver City Government - Colorado

5.0177, BEHAVIOR OF TRACE ELEMENTS IN WATER RECLAMATION TREATMENT PROCESSES

K.D. LINSTEDT, Univ. of Colorado, School of Engineering, *Boulder, Colorado* 80304

A laboratory study of the degree and mechanisms of removal for certain trace elements in water reclamation treatment processes, using radiotracers for the analytical measurement of process efficiencies.

SUPPORTED BY Kettering Family Foundation

5.0178, ECOLOGY OF COLORADO MOLLUSKS

R.W. PENNAK, Univ. of Colorado, Graduate School, *Boulder, Colorado* 80304

Changes in distribution and ecology of mullusks in Colorado, especially during the past 60 years, as influenced by pollution.

SUPPORTED BY University of Colorado

5.0179, LEVELS OF SECONDARY PRODUCTIVITY IN COLORADO MOUNTAIN STREAMS

R.W. PENNAK, Univ. of Colorado, Graduate School, *Boulder, Colorado* 80304

00000NO SUMMARY HAS BEEN PROVIDED TO THE SCIENCE INFORMATION EXCHANGE

SUPPORTED BY University of Colorado

5.0180, NITRATE BEHAVIOR IN SOIL WATER UNDER FIELD CONDITIONS

J.W. BIGGAR, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Approximately 20 experimental plots, will be established on the West Side Field Station, University of California, on which unsaturated hydraulic conductivity values will be measured. In addition, the movement of surface water soluble compounds, including different sources of nitrogen, will be monitored within the soil profiles on the experimental plots. Sampling and analysis will be done to measure soil-water movement through field soils under heterogeneous conditions. Tests will be made to determine the leading characteristics of a field soil that control the distribution and loss of nitrogen from soil. Results of the research will be used to test the reliability of a computer program that is being developed by the University of Arizona in a companion research contract.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

5.0181, PREDICTING NITRATE CONTENT OF AGRICULTURAL DRAIN WATER

G.R. DUTT, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Conceptual model systems involving lysimeters and greenhouse work will be utilized to determine chemical reactions and movement of nitrogen from various sources. Soils of different origin and mineral composition will be used. Data from the model systems, plus data on nitrogen uptake of various irrigated crops secured from a search of the literature, will be used to develop a computer program for predicting the nitrogen transformations taking place in soil-water systems under variations of time, moisture content of the soil, temperature, oxygen in soil air, source of nitrogen, or other factors. The computer program will be tested for reliability from data secured in a companion research contract at the University of California. The computer program will be applied in deriving estimates of the nitrogen content of drainage effluent from the San Luis Unit, Central Valley Project, California.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

5.0182, NITRATE REMOVAL FROM THE AGRICULTURAL EFFLUENTS IN THE SAN LUIS DRAIN UTILIZING ION EXCHANGE RESINS

R.R. GRINSTEAD, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The objective is to determine the feasibility of developing an ion exchange resin process for removing nitrates from agricultural drain water. The study will include: 1. Cost estimates of nitrate removal utilizing present ion exchange technology. 2. An assessment of the possibilities for developing an ion exchange resin with a higher specificity for the nitrate ion than existing resins. 3. An estimate of the ion exchange resin properties that might be developed through a research effort. 4. Cost estimates of nitrate removal utilizing resins with higher nitrate specificity than existing resins. 5. Cost estimates and plan for research program needed to develop nitrate specific ion exchange resins.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

5.0183, IRRIGATION RETURN FLOW

D.A. HOFFMAN, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Flows from irrigation projects have been unduly criticized for the deterioration of the water quality in receiving waters. Much of the salt content of many river basins has been attributed to irrigation projects. Studies based upon the transmission and fate of agricultural chemicals including fertilizers and pesticides will be supported and coordinated with related studies being performed under other Reclamation activities and by other organizations. In order to differentiate the salt contribution from natural irrigation, municipal and industrial sources two catagories have been made under the main heading.

1. Nutrient Balance. Data will be correlated so that changes in selected water quality parameters can be determined as the water passes through an irrigation project. This extensive study will utilize existing studies now underway by the Division of Project Investigations.

2. Yakima River Project. This study will investigate the effect of irrigation upon the water quality in the Yakima River, Washington, and will be coordinated with Region 1, Boise, Idaho. This project represents an area where the water quality and quantity has been extensively modified by existing uses including irrigation. Specific objectives will be toward defining the influence of irrigation and looking toward possible remedial measures.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

5.0184, LARGE IMPOUNDMENTS

D.A. HOFFMAN, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The Bureau of Reclamation has constructed numerous large impoundments which are characterized by being deep and long, located in an arid climate, and relatively unknown from the standpoint of limnological data. The lack of information is perhaps the greatest void in water data on these reservoirs. Three programs are now under study under this heading.

Lake Mead Limnological Studies --With the completion of Glen Canyon Dam and the filling of Lake Powell, the annual inflow pattern to Lake Mead has been substantially changed. Limnologic studies of Lake Mead were started in April 1964, and others were made in May and November 1966. Data collected from these surveys showed the detrimental effect of the filling of Lake Powell upon the water quality in Lake Mead. A Laboratory Report No. ChE-70 has been written on the research work at Lake Mead. Results from this study have lead to the initiation of a new study 'Eutrophication of Las Vegas Bay, Lake Mead.'

2. Eutrophication of Las Vegas Bay, Lake Mead.--During the surveys of Lake Mead it was found that the Las Vegas Bay was an area of poor quality water due to the low dissolved oxygen and high dissolved salts. As a result, it became obvious that an extensive study of this reach of Lake Mead should be made. Field studies will be made extensive study of this reach of Lake Mead should be made. Field studies will be made to quantitatively and qualitatively define, analyze, and recommend solutions needed to improve the water quality in Las Vegas Bay.

3. Pueblo Reservoir.--Pueblo Reservoir typifies a large terminal reservoir in an extensive water development project which delivers water for irrigation, municipal and industrial purposes. The study under this program is specifically directed to investigate the effect of a large reservoir and its limnological characteristics upon downstream water quality.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

5.0185, QUALITY OF WATER AS AFFECTED BY STRATIFIED FLOW (RESERVOIRS)

D.L. KING, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Purpose: To investigate by means of models and prototype measurements the movement of water through reservoirs.

The grwoing demand for sediment-free water and water at controlled temperatures and/or dissolved oxygen content requires a knowledge of the movement of water through reservoirs. Studies will be made to determine the effects of reservoir geometry and tributary waters on temperature stratification, to develop selective withdrawal techniques, and to develop methods of reoxygenation of rivers downstream from dams. The effects of earthquakes and landslides on stratified flow, wave formation, and water movement in reservoirs may also be investigated.

A general purpose research facility is being used to study the basic principles of temperature stratification, density currents, and patterns of flow approaching outlets at different levels.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

5.0186, GENERAL WATER QUALITY INVESTIGATIONS

P.R. TRAMUTT, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

A general, long-range approach is necessary for developing a coherent and purposeful water quality program. As one of the necessary steps in developing such a program, new studies of particular phases of the overall program will be explored and, where applicable, developed into individual programs. Proper integration with the work of other groups will be required, and an overall program will be coordinated with all of the Bureau programs and with related studies of Federal, state, and local agencies. In order to fully accomplish these objectives two programs have been set up under this program.

1. Coordination and Planning. A water Information Exchange Conference between the Denver Office and Regional personnel will be held in 1968. Also, an interagency meeting on Water Quality Research will be held at the FWPCA Southwest Laboratory, Ada, Oklahoma, in September 1967. Other meetings, conferences, and symposiums will be attended as the opportunity affords. 2. Special Studies. Research will be conducted on improving the techniques for the collection and analyses of water quality parameters such as nitrogen and phosphorous. The research program includes the improvement of standard methods and the development of new methods for detecting, measuring, and recording water quality parameters.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

5.0187, TECHNIQUES AND INSTRUMENTATION

P.R. TRAMUTT, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The principal purpose of this research is to develop and/or test new methods, techniques, and instrumentation to collect, analyze, and record water quality parameters for engineering and research needs. Two separate categories have been programed for this work.

1. Field Research Laboratory.--To develop a two-man portable laboratory that can be used in adequate sized boats and/or trucks for field research work. This laboratory will function as a research laboratory and will contain recorders as well as instruments for measuring many chemical parameters, such as dissolved oxygen, temperature, and any other instruments that will adequately function under field conditions.

2. Monitoring Laboratory.--This study will be directed toward developing a field laboratory kit that can be used by regional personnel for monitoring water quality data where only a limited number of parameters are to be measured. Also, part of this program will be the selection of analytical methods for use as acceptable standards for comparing our work with others.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

5.0188, STANDARDS AND CRITERIA

P.R. TRAMUTT, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

In order to establish water quality standards and criteria, it is necessary to know the requirements of the biota, materials, and users of the water. Specific studies will be made to better define reasonable standards for water quality factors of particular interest to Reclamation projects. Two areas of study are programmed under this heading. 1. Effect of Turbidity. will be conducted to quantitatively and qualitatively measure various types of turbidity producing materials as to size, source, composition, etc., in relation to hydrologic conditions and their ultimate effect on aquatic life, irrigation structures, and transmission facilities. 2. Review of Standards. be devoted toward reviewing the State Standards for certain parameters required by the Water Quality Act of 1965, in order to ascertain their applicability and effect on Bureau of Reclamation projects. Research will be performed for updating standards as new methods and requirements become evident.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

5.0189, SMALL IMPOUNDMENTS

P.R. TRAMUTT, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

In addition to the large reservoirs covered by other studies, Reclamation has many small impoundments which vary in their shape, operational mode, and climate from deep canyon reservoirs in mountain locations with a comparative high flow-through rate to shallow reservoirs located in the plains and operated with periods of long holdover.

1. Cheney Reservoir--Wichita Project.--A water quality monitoring and research program to investigate the effects of multi-level outlet conduits through shallow plains-type reservoirs was initiated in 1965 and continued through September 1967, in cooperation with the City of Wichita. The data collected by the City of Wichita will be analyzed by computer to relate the operation of the multi-level outlets with water quality.

2. Foss Reservoir--Washita Project.--A research program was initiated with Region 5 for a quality of water survey in the plains-type Foss Reservoir. The water in Foss Reservoir has been held in storage since March 1961 and the chemical quality has been decreasing due to the accumulation of dissolved salts. Also, the quality of water has been seriously affected by upstream watershed development of small retention ponds. This study has been maintained as a monitoring program for a few important water quality parameters and to establish basic requirements for a water treatment plant and/or desalinization unit.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

5.0190, BEHAVIOR OF POLLUTANTS IN WATER

R.L. WERSHAW, U.S. Dept. of Interior, Water Resources Division, *Denver, Colorado*

The objective is to study pesticide residence time, transport mechanisms, and projected residue levels in natural soil and in natural hydrologic environments. The mechanisms of infiltration and solution of certain pesticides are being studied in the laboratory and conjunctive field studies are being planned to obtain information on the parameters related to subsurface infiltration and to the migration, retention, and decomposition in ground and surface waters.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

5.0191, EFFECT OF RECLAMATION PROJECTS UPON THE QUALITY OF WATER OF THE MISSOURI RIVER ABOVE SIOUX CITY, IOWA

R.F. WILSON, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Collect and tabulate all usable quality of water records. Adjust historic estimated or recorded water quality to reflect existing conditions. Evaluate magnitude of the effect of existing and future USBR project developments upon water quality below project areas and determine the persistence of the effect upon selected downstream locations on the Missouri River.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

5.0192, CONCENTRATION OF SUGAR BEET WASTES FOR ECONOMIC TREATMENT WITH BIOLOGICAL SYSTEMS

J.H. FISCHER, Beet Sugar Development Found. , *Fort Collins, Colorado* 80521

The project is one phase of research to find an economic chemical or biological system to treat high volumes of sugar beet factory waste. One or more successful processes are necessary to satisfy effluent standards in States where sugar beets are processed.

The objective of the project is to concentrate sugar-beet factory wastes by chemical precipitation and reuse of the decanted solution in a closed recirculation system. The excess water accumulated during the operation will be treated by anaerobic and/or aerobic processes to remove BOD prior to discharge. The bioactivity will be studied concurrently.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Beet Sugar Development Foundation

5.0193, ANAEROBIC - AEROBIC SUGAR BEET WASTE TREATMENT

J.H. FISHER, Beet Sugar Development Found. , *Fort Collins, Colorado* 80521

The purpose of this project is to demonstrate the possibility of reducing and eliminating pollution and odor problems in beet sugar factory wastes through the use of facultative and algae ponds and re- circulation. Initial studies will be on treating flume water, with other wastes to be treated later.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Beet Sugar Development Foundation

5.0194, FISHES OF THE SOUTH PLATTE RIVER BASIN, COLORADO

R.J. BEHNKE, Colorado State University, State Coop. Wildlife Res. Unit, *Fort Collins, Colorado* 80521

A survey of the fish fauna of the South Platte River is being conducted with special emphasis upon native species and species with limited distribution. The distribution of present species and community composition is being related to the impact of civilization as it has altered the stream environment through pollution of water, diversion, and other means.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Colorado State University

5.0195, WATER AND WIND EROSION AND ITS CONTROL ON IRRIGATED AND NONIRRIGATED LANDS IN THE NORTHERN PLAINS

H.R. HAISE, Colorado State University, School of Engineering, *Fort Collins, Colorado* 80521

Object: For conditions of the Northern Plains: determine and characterize runoff and soil loss from natural and simulated rainfall under a wide range of soil cover and climatic conditions on irrigated and nonirrigated land; develop predictive equations to estimate runoff and soil loss; and determine causative factors associated with wind erosion and develop control measures including cropping practices, residue management, and other related measures adapted to the area.

Plan of Work: Cropping systems and cultural practices including tillage, residue management, and other surface treatments are developed and evaluated from the standpoint of wind and water erosion control for different soil-climatic areas in the Northern Plains. Small plot rainfall simulators are used to measure soil loss and runoff from water erosion, and portable wind tunnels and related aerodynamic equipment are used to measure wind profiles and velocities and to assess susceptibility to wind erosion and effectiveness of control measures. Benefits from deep tillage, subsoiling, vertical mulching, and so called minimum tillage practices are evaluated as related to erosion control benefits. Changes accompanying various cropping and cultural methods that occur in soil characteristics such as structure, permeability, aggregate stability and amounts, and volume weight aspects of the soil profile are measured with a view towards improvement of design of conservation farming methods. Relationships are developed from data collected at a number of locations in the Northern Plains to predict wind or water erosion losses.

SUPPORTED BY U.S. Dept. of Agriculture

5.0196, SOIL, PESTICIDES AND THE QUALITY OF WATER

D.D. JOHNSON, Colorado State University, Agricultural Experiment Sta. , *Fort Collins, Colorado* 80521

Objectives: (1) To establish whether movement through the soil constitutes a significant source of the pesticides found in surface and ground water. (2) To identify the properties of pesticides and soils that control the extent of movement of pesticides in and through soil.

Procedures: Atrazine and monuron will be the pesticides used. Laboratory procedures will evaluate the influence of microbial activities on the leachability and diffusion of these pesticides in soils. Column leaching techniques decided upon by W-S2 will be used. Diffusion studies in laboratory will be coordinated with similar work of S. R. Olsen, USDA, ARS, Fort Collins. Field studies will attempt to ascertain those conditions of pesticide concentration and irrigation rate which will cause these pesticides to move through an underlying water table will be analyzed to see if pesticides have moved through the soil profile.

SUPPORTED BY U.S. Dept. of Agriculture
Colorado State Government

5.0197, A STUDY OF A WATER TOXICITY PROBLEM

E.W. KIENHOLZ, Colorado State University, Agricultural Experiment Sta. , *Fort Collins, Colorado* 80521

Objectives: 1. To design a bioassay of level of inorganic toxicity in potable water. 2. To survey objectionable water, to determine specific problems, and to attempt to reduce toxicity of objectionable water. 3. To define tolerable limits of specific inorganic contaminants in poultry drinking water.

Description of work proposed: Day-old chicks or poults will be used as the assay animals. Since some of the objectionable water reportedly produces poor growth and livability of young birds, an assay will be sought which relates a bird performance characteristics directly to toxicity problems of available water. This assay procedure will then be used to compare water sources from various complaint areas, and to identify individual factors giving rise to toxic water.

SUPPORTED BY Colorado State Government

5.0198, WATER VELOCITY AND SPATIAL CO-ACTIONS OF HATCHERY TROUT AND WILD BROWN TROUT

R.E. VINCENT, Colorado State University, State Coop. Fishery Unit, *Fort Collins, Colorado* 80521

Resting microhabitat requirements of hatchery rainbow trout will be determined by the use of a flume where parameters such as water velocity, water temperature, water depth, and cover can be measured and controlled. After the resting microhabitat has been determined, wild brown trout will be introduced into the flume to observe behavior between the hatchery rainbow trout and wild brown trout. The order of introduction will then be reversed by introducing brown trout first, permitting them to become orientated and established residency, then introduce the hatchery rainbow. Displacement from optimum resting microhabitat should take place as the dominant individuals either by species or by prior residency will continue to occupy resting microhabitats with optimum water velocities.

The study is being conducted at the Pingree Park Campus of Colorado State University.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Colorado State University

5.0199, A SYSTEM FOR GEOLOGIC EVALUATION OF POLLUTION POTENTIAL AT MOUNTAIN DWELLING SITES

J.P. WALTZ, Colorado State University, Graduate School, *Fort Collins, Colorado* 80521

The proposed research is to develop a hydrogeologic classification system for mountainous terrain. The classification system is to be designed for use in evaluating pollution potential at dwelling sites in the mountains.

Streams and wells in the mountains are susceptible to contamination because sewage disposal systems are usually privately owned and may be poorly situated or constructed. In addition, contaminated surface water can usually percolate directly into the ground via exposures of fractured or jointed rock. Also, direction and rate of ground water motion in a fractured medium are difficult to determine.

The procedure proposed for this research is to collect quantitative measures of topographic, geologic, and hydrologic variables. These data are to be used in a discriminant function analysis. The data will be in two groups: group I will contain information from sites where contamination has been documented and a source of pollution can be identified; group II will contain information from sites where no contamination can be detected, but where a pollution source is present.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Colorado State University

5.0200, WATER TEMPERATURE AS A QUALITY FACTOR IN THE USE OF STREAMS AND RESERVOIRS

J.C. WARD, Colorado State University, School of Engineering, *Fort Collins, Colorado* 80521

Objectives: (1) Relate quantitatively the three parameters of the surface water since curve to the meteorologic and hydrologic factors influencing water temperature. (2) To work out methods for the quantitative application of the water temperature sine curve to all types of lakes and reservoirs. (3) To obtain methods for predicting quantitatively the effects of thermal pollution on stream and lake water temperatures. (4) To study quantitatively the diurnal variation in stream and lake water temperature at all depths.

The laminar phenomena of surface injected heat will be studied in detail to determine the degree of insulation in both horizontal and vertical axes in providing habitat for motile and non-motile aquatic organisms. New Measurements of dispersal patterns of heated waters in relation to substrate types will be accumulated.

Pre-installation studies will be continued in an area of a small river system soon to be subjected to waste waters from a thermal power station.

Heat barrier effects in a lotic environment especially as related to fishes will be a part of a continuing study.

The effects of water temperatures and ice cover on the use of reservoirs and streams by waterfowl will be studied. The effectiveness of artificial ice-preventive measures will be determined on selected reservoirs.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Colorado State University

5.0201, SMALL IMPOUNDMENT STOCKING

D.T. WEBER, State Game Fish & Parks Dept. , *Fort Collins, Colorado*

Procedures: 1. To collect basic survey data from 8 of the Banner Lakes. 2. To eradicate the fish population from 5 of the lakes surveyed under Procedure 1. 3. To stock bass only in 2 of the 5 lakes eradicated under Procedure 2 and bass-bullheads in the remaining 3 lakes. 4. To maintain stocking of conglomerate species in the remaining 3 lakes to serve as controls. 5. To measure harvest from the lakes under study after each is stocked.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Colorado State Government

5.0202, CHEMICAL, PHYSICAL AND BIOLOGICAL REACTIONS OF PESTICIDES WITH SOILS AFFECTING SOIL PRODUCTIVITY AND PESTICIDE STABILITY

F.G. VIETS, U.S. Dept. of Agriculture, *Fort Collins, Colorado*

Object: To develop principles on the chemical, physical, and biological reactions of pesticides with soils including effects of variations in soil environment on such reactions, pesticide stability and movement; and to investigate the effects of pesticides on soil properties, biology, and productivity.

Plan of Work: Study will be made of the effect of a pesticide on chemical and microbial processes currently under laboratory investigation. These include ion uptake and translocation in plants, ion diffusion and mass flow in soils, the chemical and microbial transformations of essential elements in soils, and the competition among microbial species in soils as affected by kind of crop amd plant residues, aeration, temperature, fertilizers and amendments. The second approach will be specific studies with pesticides as to their adsorption on mineral and humus constituents of the soil, their movement in the soil by water and their stability as affected by adsorption, microbial activity and variations of temperature, water and aeration of the soil environment. A laboratory for pesticide assay will be established. Chemical techniques involved will be ultraviolet, visible, and infrared spectroscopy and fluorimetry; gas, paper and column chromatography. Radioisotopes may also be used.

SUPPORTED BY U.S. Dept. of Agriculture

5.0203, GRAND VALLEY SALINITY CONTROL DEMONSTRATION PROJECT

T.G. SPANNAGEL, Grand Vall. Water Purif. Proj. , *Grand Junction, Colorado*

In three selected study areas, irrigation canals and other water conveyance channels will be lined to control the major source of recharge to the near surface aquifers, thereby minimizing the quantity of flow through mineral yielding geological formations and reducing the gradient which forces saline water into the Colorado River. Detailed field observations and measurements will be made to evaluate the effectiveness of lining in preventing seepage, the reduction in discharge to local surface streams, and the improvement in mineral quality.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Grand Valley Water Purification Project

5.0204, ORGANIC DEBRIS ON CONNECTICUT BEACHES AND SHORES

R. BENOIT, General Dynamics Corporation, *Groton, Connecticut*

General field surveys of selected sites are made. The quantity and identity of beach debris present in significant amounts is determined. Water characteristics (temperature, dissolved oxygen, salinity, turbidity) are determined. The origin of the debris is determined if possible. The microbial flora of water, sand, mud, and debris are determined in relation to the mode of decomposition of the debris.

SUPPORTED BY Connecticut State Government

5.0205, STUDY FOR FLOW REDUCTING AND TREATMENT OF WASTE WATER FROM HOUSEHOLDS

H. WALLMAN, General Dynamics Corporation, *Groton, Connecticut* (14-12-428)

The purpose of this program is to evaluate objectively all possible approaches for reducing the waste water flow from individual homes and/or to provide more complete treatment of the wastes that occur. The first phase of the program consists of gathering all available information on water use, waste disposal, and current research activities in water supply and waste disposal from the literature, opinion surveys, and personal contacts. The second phase will be to catalog and make a technical and economic evaluation of the gathered information to determine the most promising solutions to the water supply-waste disposal problems.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0206, DISPOSAL OF LIQUID WASTES

J.E. YOCOM, T R C Service Corporation, *Hartford, Connecticut*

In cooperation with an engineering firm, J. S. Minges and Associates, this study is being conducted to determine the feasibility of a centralized, shared, industrial waste treatment plant for many industries in the Bristol, Connecticut, area. However, the results may be applicable to other Connecticut cities and industries.

The special role of TRC in the project is to develop data on the technical feasibility of alternate disposal systems and to support the selection of optimum systems.

SUPPORTED BY Connecticut State Government

5.0207, REGIONAL UTILITIES STUDY-WATER SUPPLY, SEWERAGE, DRAINAGE AND REFUSE DISPOSAL

P. BOCK, Travelers Research Center Inc. , *Hartford, Connecticut*

In co-operation with an engineering firm, J.S. Minges and Associates, this study is being conducted to develop long-range plans and short-term programs for the provision and co-ordination of water, sewerage, storm drainage and refuse disposal facilities in the Capitol Region (a 29-town area in north-central Connecticut).

The development of the study involves the following general activities for the four types of utilities: l. Inventory of existing facilities 2. Development of an analytical study framework 3. Determination of future needs 4. Determination of adequacy of present facilities 5. Considerations of private 'on-lot' systems 6. Study of alternative plans 7. Preparation of long-range plans 8. Preparation of short-range development programs.

SUPPORTED BY Connecticut State Government

5.0208, THERMAL POLLUTION AND ITS IMPLICATIONS FOR THE COAL INDUSTRY-A SURVEY OF THE STATE OF KNOWLEDGE

P.B. CHENEY, Travelers Research Center Inc. , *Hartford, Connecticut*

The objectives of this study are to assemble and organize information relevant to (a) the chemical, biological and physical effects of thermal pollution, (b) the heat diffusion and dissipation capabilities of different types of water bodies, (c) alternative methods for dissipating the heat prior to discharge, and (d) the implications of an increasing demand for electric power with regard to plant sizes, plant sites and cooling technology.

The scope of the study is intended to cover the field of knowledge in thermal pollution on a national scale. That is, the focus will not be on any one region of the nation, but rather to approach the problem on the basis that a study related to thermal pollution and its effects will be relevant regardless of geographical location.

SUPPORTED BY National Coal Policy Conference Inc.

5.0209, MARINE OIL-WATER SEPARATION SYSTEM SUBGROUP V

J.H. SEELINGER, Cuno Engineering Corporation, *Meriden, Connecticut* 06453

The Contractor intends to evaluate the feasibility of using commer- cially available filtration equipment (modified) to remove residual marine fuel oil from sea water. This project will include both land- based and shipboard tests of a full scale separation system.

This project was initiated in FY 66 and will be completed in FY 70.

SUPPORTED BY U.S. Dept. of Commerce - Maritime Admin.

5.0210, PHOSPHORUS IN LAKE SEDIMENTS

R.D. HARTER, Conn. Agric. Expt. Station, *New Haven, Connecticut* 06504

Objectives: Discover the nature of the phosphorus exchange between lake sediment and water by (a) studying self diffusion of P32 through lake sediment, (b) establishing the effect of temperature on phosphorus equilibrium between sediment and water, (c) determining which fraction of mud phosphorus is exchanging with water, and (d) evaluating the rate of movement of phosphorus from sediment into water across a mud-water interface.

Procedure: Self diffusion of P32 through mud will be determined by constructing a core of bottom mud in small diameter (16 mm) glass tubes. To the base of the column, or to the water above the soil, P32 will be added. The column will be sectioned and the P32 measured. Effect of temperature on soil-water equilibrium will be established by shaking a 1:25 soil-water mixture at different temperatures until equilibrium is reached. To determine which phosphorus fraction is exchanging with the water, the mud will first be fractionated. Samples of sediment will then be extracted by shaking in large quantities of water. The sediment will be fractionated to establish change in the phosphorus fractions. Rate of exchange of phosphorus from mud to overlying water will be evaluated by placing lake sediment in large cylinders and slowly renewing distilled water over the mud.

SUPPORTED BY U.S. Dept. of Agriculture

5.0211, DEVELOPMENT OF INSTRUMENTAL TECHNIQUES FOR THE ANALYSIS OF TRACE ORGANIC CONSTITUENTS IN WATER

R.P. COLLINS, Univ. of Connecticut, Graduate School, *Storrs, Connecticut* 06268

The proposed research plan involves the development of more effective methods for isolating, concentrating, identifying and measuring trace organic constituents in public water supplies. Improved and highly refined instrumentation is needed for this purpose because of the ever increasing amounts of highly complex organic constituents which are being introduced into water supplies and for which, at the present time, no techniques exist for their detection or measurement.

Laboratory investigations would test the usefulness of the following analytical procedures: a. Coupled gas-chromatography and mass spectroscopy. b. On-column trapping procedures. c. Coupled gas-chromatography and rapid scan infrared spectroscopy. d. Thin-layer chromatography. e. DEAE column chromatography for isolating and concentrating high molecular weight organic constituents.

Upon completion of the laboratory phase the analytical procedures developed would be used in sampling Connecticut rivers and reservoirs in which difficulties from industrial effluents and/or objectionable tastes and odors had been experienced.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Connecticut

5.0212, A STUDY OF MICROORGANISMS INDUCING TASTES AND ODORS IN WATER

R.P. COLLINS, Univ. of Connecticut, Graduate School, *Storrs, Connecticut* 06268

Current research is concerned with the isolation and identification of volatile and non-volatile constituents produced by algal and actinomycetes involved in taste and odor problems in public water supplies. A combination of gas chromatography and rapid scan mass spectroscopy has been developed to aid in the identification of the odorous constituents.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0213, AUTOMATIC CONTROL OF A COMPLETELY MIXED ACTIVATED SLUDGE REACTOR

H.E. KLEI, Univ. of Connecticut, School of Engineering, *Storrs, Connecticut* 06268

The purpose of this project is to apply chemical engineering control theory on a completely mixed activated sludge reactor in an operating sewage treatment plant with the ultimate goal being to hold the BOD in the effluent at a predetermined level under various loading and operating conditions. A model reactor, highly instrumented, will be operated to obtain data both under dynamic and steady-state conditions.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
University of Connecticut

5.0214, REDUCTION OF RIVER HEAT POLLUTION BY TURBULENCE STIMULATION

V.E. SCOTTRON, Univ. of Connecticut, School of Engineering, *Storrs, Connecticut* 06268

One of the principal difficulties of 'run of the river' cooling of electrical generating stations is that the heated effluent tends to stratify horizontally in high temperature zones thus causing potentially serious damage to the biological cycle in the river. It is known that wind-generated turbulence and surface waves will aid mixing and will break up the stratification in relatively short distances. In calm periods the stratification tends to persist. A possible solution to this problem of high temperature concentration is the production of heavy turbulence in the normal river motion by means of artificial river bottom roughness such as cobbling or rip rap. This heavy turbulence would reduce the zones of concentration and the peak temperature levels.

The method of attack requires an investigation of the turbulence levels generated by a variety of roughness patterns. The river flows would be simulated by low-speed air flows in order to facilitate measurement of the turbulence properties. Once data are available on the effects of various roughnesses, these results can be applied to river systems. This investigation would be carried out in the Civil Engineering Hydraulic Laboratory.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Connecticut

5.0215, AIR OXIDATION OF ORGANIC COMPOUNDS IN AQUEOUS SYSTEMS

D.W. SUNDSTROM, Univ. of Connecticut, School of Engineering, *Storrs, Connecticut* 06268

Organic compounds can be oxidized chemically in an aqueous system by heating under pressure in the presence of air. When applied to the disposal of aqueous wastes, the technique is referred to as wet oxidation. Under the usual operating conditions, the organic wastes are not completely destroyed during oxidation. The method is of particular interest since the wastes are removed by chemical rather than by biological action.

The purpose of the project is to determine the reaction kinetics of several organic compounds during wet oxidation. The rate and extent of oxidation of several organic compounds will be examined over a range of temperatures, pressures and concentrations. Since simultaneous mass transfer and chemical reaction occur during wet oxidation, the relative magnitudes of these rate processes will be established. Initial experiments will emphasize the destruction of an insoluble organic compound in a flow reactor. The results of this study should provide a better understanding of the wet oxidation process.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Connecticut

5.0216, STUDIES ON PHOSPHORUS TRANSFORMATIONS IN EUTROPHIC LAKES

R.C. TILTON, Univ. of Connecticut, Graduate School, *Storrs, Connecticut* 06268

The proposed study is an evaluation of the role of microorganisms in the transformation of phosphorus compounds in eutrophic lakes.

The proliferation of algal forms and their ability to scavenge phosphate has been well defined. However, little information is available on the role of bacteria in the phosphorus cycle of eutrophic lakes.

The research will be conducted in the central Connecticut area. Mesotrophic and eutrophic lakes in the area will be analyzed for natural and unnatural phosphate compounds. Representative mixed populations and pure cultures will be tested for the ability to utilize one or more 32P labelled phosphate compounds under a variety of environmental conditions such as available nutrient, pH, aeration, and oxidation reduction potential.

Results obtained from such a study will aid in the understanding of the dynamics of phosphorus utilization in an eutrophic lake and provide information on the environmental control of eutrophication.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Connecticut

5.0217, VARIABILITY IN DIATOM MORPHOLOGY AND WATER POLLUTION

F.R. TRAINOR, Univ. of Connecticut, Graduate School, *Storrs, Connecticut* 06268

The purpose of the present investigation is twofold: (1) to study the morphological and growth responses of freshwater diatoms to changes in the physical and chemical environment using the culture technique, and (2) to study morphological variability in laboratory cultures of diatoms incubated in natural waters. If we can demonstrate in controlled laboratory experiments as well as in cultures incubated under 'natural' conditions morphological responses of an organism to changes in environment, we would expect certain morphological types to be indicators of the chemistry of the water. Among the environmental components which will be investigated are: levels of inorganic nutrients, levels of available CO2, presence of certain organic substances, pH, temperature, and light.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Connecticut

5.0218, INDIVIDUAL WASTE DISPOSAL SYSTEMS

W.C. WHEELER, Univ. of Connecticut, School of Agriculture, *Storrs, Connecticut* 06268

The objective of these studies is to investigate oxygen and temperature levels in the dispossal fields of individuals septic systems and its effect on the over-all disposal system.

Experiments will be conducted to determine the effect of temperature and oxygen on the effluent leaving the septic tank with provisions to inject air into the drainage tile lines. The evaluation of these effects will be based upon field observations.

Both laboratory and field studies are planned. The field measurements will be made at selected locations in the state.

Instrumentation will include the use of multi-point recorders for temperature measurements, pH meter, dissolved oxygen analyzer, and the standard biological and sanitary engineering test as an aid in the evaluation of the effluents of the tests.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Connecticut

5.0219, WASTE DISPOSAL IN RURAL AREAS

W.C. WHEELER, Univ. of Connecticut, Agricultural Experiment Sta., *Storrs, Connecticut* 06268

Objectives: 1. To measure and analyze the thermodynamic, hydraulic, chemical and bacterial parameters prevalent in septic tank systems used for waste (excreta) disposal in rural Connecticut, with emphasis on temperature measurement and its interaction with the other parameters. 2. To design and test new septic systems.

Septic tank systems will be instrumented so that temperature patterns can be obtained for all phases of the treatment process. Efforts will be made to determine the quantity of influent and effluent without disturbing the operation of the systems. Bacteriological and chemical analysis will be made of influent, tank solution and effluent to determine the effectiveness of treatment processes. Laboratory and field installations will be used.

The physical properties of the disposal field will be analyzed and correlated to sewage stability and seepage rates. Effluent in the draintile and separate tanks will be subjected to supplemental air and the effect on the aerobic digestive process will be studied.

Modified septic systems will be designed, constructed and tested for more effective disposal of agricultural waste materials from poultry flocks, dairy herds and rural residences.

SUPPORTED BY U.S. Dept. of Agriculture
Connecticut State Government

5.0220, EFFECTS OF SIMULTANEOUS VARIATION OF TEMPERATURE AND DISSOLVED OXYGEN ON THE RESISTANCE OF FISHES TO CONTROLLED POLLUTANTS

W.R. WHITWORTH, Univ. of Connecticut, School of Agriculture, *Storrs, Connecticut* 06268

The effects of simultaneous variation of temperature, dissolved oxygen and a synthetic pollutant on fishes will be investigated. A continuous flow bioassay technique will be employed. The relative importance of the factors at various levels will be estimated and discussed with regard to water quality requirements of fishes.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Connecticut

5.0221, WATER QUALITY CONTROL WITH SYNTHETIC POLYMERIC FLOCCULANTS

J.K. DIXON, Univ. of Connecticut, Graduate School, *Torrington, Connecticut* 06790

The purpose of the proposed investigation is to study the floc- culating action of synthetic polymers on colloidal solid materials in water in order to understand better their use in water quality control. Well-characterized samples of polyethyleneimine, a cationic polymer, and of polyacrylamide, a non-ionic polymer, will be synthesized with different chemical and physical properties and tested as flocculants for E.coli bacteria, the latter being characteristic of bacteria en- countered as solids in the effluents from activated sludge digestion sewage plants. The results will be correlated with the theory and practice of earlier work in this field on the use of these polymers for flocculation of other solids encountered in water pollution control.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Connecticut

5.0222, INVESTIGATION OF AMPHIPATHIC WATER-SOLUBLE POLYMERS AS FLOCCULANTS AND FLOTATION AIDS IN DOMESTIC WASTEWATER TREATMENT

R.R. BROWN, Standard Brands Chem. Indus. , *Dover, Delaware* 19901 (14-12-430)

New, commercially feasible, synthetic polyelectrolytes or nonionic polymers with improved flocculation ability for suspended matter in domestic wastewater will be synthesized and tested. The incorporation of surface active groups into the basic polymeric flocculant will be studied as a possible approach to enhancing the flocculating ability of polymers. Polymers will be analytically characterized as to composition, molecular weight, surface activity, charge type, density, and active group content for evaluation as flocculants and flotation aids in wastewater treatment.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0223, EFFECT OF BORON IN BIOLOGICAL WASTE TREATMENT

S.K. BANERJI, Univ. of Delaware, School of Engineering, *Newark, Delaware* 19711

The use of boron salts in the household detergents and in various industrial operations has increased considerably in the past few years, with the result that the wastewater from domestic and industrial sources are carrying higher amounts of boron.

The proposed research plan involves, first the determination of boron salts in the local sewage and in the neighboring streams. The second part of the investigation would determine the effect of boron salts on aerobic biological waste treatment process (e.g. activated sludge process) under various operating and loading conditions. The pH, temperature and concentration of the boron salts would be some of the variables for study. Warburg Respirometer boron toxicity results would supplement the results obtained in the aerobic biological waste treatment process. Adsorption of boron on clay & biological surfaces will also be determined. The concentration of boron on surfaces may be important in biological treatment systems.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Delaware

5.0224, SPRAY DISPOSAL OF LIQUID COW MANURE

N.E. COLLINS, Univ. of Delaware, Agricultural Experiment Sta. , *Newark, Delaware* 19711

Objectives: 1. To develop the equipment needed for the daily disposal of liquid manure with a spray system. 2. To determine the safe capacity of the soil to assimilate liquid manure applied daily by a spray system.

Description: The project includes grinding and pumping liquid manure to a field disposal area. Preliminary tests will be conducted to determine the most efficient pump grinder combination and to determine the hydraulic characteristics of the liquid manure. For field disposal the liquid manure will be pumped 1000 feet to commercial sprinklers or other spreading device. Measurements of pollution, odor, insects, and microorganisms will be criteria for measuring the effectiveness of the disposal area.

SUPPORTED BY U.S. Dept. of Agriculture
Delaware State Government

5.0225, MASS TRANSFER AND CHEMICAL REACTION IN TWO PHASE FLOW

T.W. RUSSELL, Univ. of Delaware, School of Engineering, *Newark, Delaware* 19711

The basic mechanism of mass transfer and chemical reaction in two phase (gas-liquid) horizontal pipes is to be investigated so that the possibility of using two-phase pipelines for treatment of raw sewage can be evaluated.

A model of the process of chemical reaction and mass transfer has been developed and partially checked for annular two-phase flow in a horizontal pipe. Experimental work is proposed which will more fully verify the model and allow mathematical descriptions and correlations to be developed for other flow regimes.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Delaware

5.0226, BIOLOGICAL ALGICIDES

M.S. SHANE, Univ. of Delaware, Graduate School, *Newark, Delaware* 19711

The above named project is concerned with the isolation from nature, that is, ponds, rivers, reservoirs, lakes, etc., of viruses which will parasitize, replicate,and lyse algal cells.

Isolated viruses will be studied as to their effect upon the host cells under different environmental conditions, including pH, temperature, light, etc. A study of the morphology of new viruses will be undertaken by electron microscopy.

The work will first be done in flasks using standard methods for growing a large number of algal species and observing the effects of seeding these cultures with bacterial free inoculum from samples collected from areas which support large populations of algae.

Isolated algal virus will then be used to inoculate aquaria and ponds which have large populations of susceptible algae.

Hopefully, this research will be productive in establishing an algal virus collection which can help to furnish biological algicides for specific algal populations.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0227, SELF-ADJUSTING AND SELF-CLEANING FILTER FEASIBILITY STUDY

J.D. BANE, Hercules Incorporated, *Wilmington, Delaware*

This six-month program will determine the feasibility of a unique self-adjusting and self-cleaning filtration system for reducing water pollution from combined sewer systems during storm runoff conditions. The new concept is based on the expansion and leakage characteristics of Hercules' filament-wound, resin-bonded Spiralloy structures-used successfully in a number of missile motors and commercial applications. Basically, the Spiralloy filter will be designed and fabricated to expand at low pressures to yield numerous micron-size openings. During stormflow, the filter will expand in proportion to the hydraulic head and permit leakage of filtered water to a separate chamber for subsequent chlorination before final water-way discharge. The suspended and settleable solids will be retained by the filter and transported to a sewage treatment plant. Self-cleaning will be accomplished by the interior surface condition and a centerbody to impart high shear velocities along the filter wall. This approach offers an economical solution to the combined sewer pollution problem.

This program is being performed at Allegany Ballistics Laboratory (ABL), Box 210, Cumberland, Maryland. ABL is a government-owned laboratory managed by Hercules Incorporated, Chemical propulsion Division.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0228, U. S. S. R. LITERATURE ON WATER SUPPLY AND POLLUTION CONTROL

B.S. LEVINE, Individual Grants, *District of Columbia*

As stated above, this type of project is one described as Individual. For the past seven years the undersigned had sole responsibility for the conduct and progress of this project. Thus far eight volumes of this survey have been published by the U. S. Department of Commerce, Federal Scientific and Technical Information of which Volume 6 which deals with conditions for the sanitary discharge of sewage and waste water into natural water bodies is probably the most significant. This volume is a complete thoroughly revised and reedited translation of the original work by Dr. S. N. Chrkinskii, Professor and Corresponding Member of the USSR Academy of Medical Sciences. Professor Abel Wohlman of Johns Hopkins University in his introduction to this volume stated: 'Citizens and Scientists accept the universality of the problem of determining the 'Conditions for the Sanitary Discharge of Sewage and Waste Water into Natural Water basins'. Dr. Levine deserves, therfore, the thanks of thousands of workers in making available in English the thoughtful exposition in the present volume'.

'The document not only should be read, but both its philosophy and the conclusions should be tested against the principles and practices prevailing in the United States......Even a cursory review of the chapter headings reveals a rewarding prospect, while the detailed text is replete with challenging principles.'

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0229, AN ENGINEERING INVESTIGATION OF STORM AND COMBINED SEWER PROBLEMS

J.G. CLEVELAND, Avco Economic Systems Corp. , *Washington, District of Columbia* 20006

This project proposes to develop and demonstrate a methodology for assessing the extent of pollution from storm water runoff in an urban area, identifying the sources for effective pollution abatement and control. The method is unique in that it will provide an economical solution to the urban storm water pollution problem by an application of improved urban planning, zoning and land-use regulation, rather than extensive structural facilities.

The scope of the project includes: 1. A field assessment of storm water pollution in terms of analytical measurements from 'discrete' runoff sheds. The selection of runoff sheds will be based on land use practices. 2. The development of functional relationships between the various land-use and analytical pollution measurements. 3. Validation of methodology for pollution assessment. 4. The determination of cost and benefits of alternate considerations for the review of land-use practices desired to reduce the sources of pollution. 5. The development of the plan for implementing remedial measures necessary to abate or control dispersed pollution problems. The City of Tulsa, Oklahoma has been selected for the study. Tulsa is unique in having detailed land use records which will facilitate this study.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0230, IDENTIFICATION OF LIMITING FACTORS IN THE BIOLOGICAL TREATMENT OF SEWAGE

G.V. LEVIN, Biospherics Research Inc. , *Washington, District of Columbia* 20011 (14-12-129)

The purpose of this contract is to explore the microbiological and biochemical wastewater literature to determine the intrinsic factors which limit the effectiveness of biological treatment of sewage. Comparisons of the fundamental microbial metabolic rates with those achieved in practice will be made. The information gained will be used to identify significant areas in which sewage treatment does not take full advantage of the biological processes. Once these areas are identified, laboratory and pilot plant research programs can be designed to develop improved treatment methods and practices. The information developed will be particularly useful in purifying the input to a mathematical model describing the activated sludge process which is being developed at the Cincinnati Water Research Laboratory.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0231, BIO-MASS DETERMINATION - A NEW TECHNIQUE FOR THE CONTROL OF AERATION SEWAGE TREATMENT PROCESS

G.V. LEVIN, Biospherics Research Inc. , *Washington. District of Columbia* 20011 (14-12-419)

To examine a new method, conceived and developed by personnel of Biospherics Research, Inc. for the rapid determination of bio-mass and to assess the feasibility of applying this method in the control of sewage treatment processes. The proposed method is the firefly bioluminescent assay for microbial adenosinetriphosphate.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0232, SORPTION BEHAVIOR OF ORGANIC PYROPOLYMERS IN AQUEOUS SOLUTION

S.D. BRUCK, Catholic University of America, School of Engineering, *Washington, District of Columbia* 20017

The investigation of the sorption behavior of organic pyropolymers is proposed with special reference to the removal of organic materials (including pesticides), radioactive substances, and ions, such as NH_4 , from secondary effluents. These pyropolymers can be readily prepared from commercially available heterocyclic/aromatic polyimides and, unlike activated carbons, are characterized by the presence of a large number of nitrogen and oxygen atoms, lesser quantities of hydrogen, and depending on the starting material, ionic groups. These properties, plus the fact that the microporosity of the pyropolymers can be altered by varying the preparative conditions and thermal treatment, make these systems attractive candidates for the study of the sorption - desorption processes and for the elucidation of the physico-chemical parameters that enhance these processes. Direct comparison will be possible between the sorption - desorption properties of the pyropolymers and those of activated carbons studied by other workers.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0233, THERMAL DESTRUCTION OF TYPE E CLOSTRIDIUM BOTULINUM

C.W. BOHRER, Natl. Canners Association, *Washington, District of Columbia*

The determination of the heat resistance of Clostridium botulinum type E in selected food products forms the foundation of this project. This organism, long ignored as dangerous in food products, has been implicated in several recent outbreaks of botulism. In order to define clearly what the potential hazard may be, details of the growth, spore formation, toxic production, and particularly the resistance to heat and chemical and physical agents must be known. The effects of spore production medium, recovery medium for heat or chemically injured cells, and heating substrate on resulting resistance also will be surveyed. A determination of the time-temperature relationships for inactivation of the type E toxin will be determined in foods and the influence of water activity on spore outgrowth and toxin production will be included in the study.

5. WATER QUALITY MANAGEMENT AND PROTECTION

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0234, RECONDITIONING AND REUSE OF FOOD PROCESSING BRINES

W. MERCER, Natl. Canners Association, ***Washington, District of Columbia***

Briefly the proposal is to conduct a pilot scale study to determine the feasibility of re-using spent brines from storage and processing operations in olive packing by reconditioning the brine through a charcoal absorption and filtration column. The portable filter will be operated throughout the duration of the two year project at each of four locations in the California Central Valley area.

The supporting collection, reduction and analysis of data will be directed toward eliminating the present tie-in to municipal sewage system as well as lagoon systems used by olive processors and develop economic and effectiveness data for full scale development.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
National Canners Association Research
Fdn.

5.0235, INTEGRATED TREATMENT OF LIQUID WASTES FROM FOOD CANNING OPERATIONS

W.A. MERCER, Natl. Canners Association, ***Washington, District of Columbia***

The objectives of this proposal are as follows: (1) to determine the feasibility of employing a high rate trickling filter in the San Jose, California canning plant to treat strong organic wastes encountered in vegetable and fruit processing operations, which although low in volume (approx. 20% of total), contribute as much as 60% to the total BOD load. The filter will be 14 ft in diameter and 21.5 ft. high, employing synthetic media and operating in a range between 100 and 200 gpm. It will be subjected to variations in flow, pH control and nutrient addition to determine its optimum working parameters. (2) To determine the effectiveness of using an air flotation process with and without addition of flocculants in removing suspended solids prior to secondary treatment. (3) To evaluate the center discharge solids separation techniques and its effect on the total BOD content.

A study will also be made of the usage of edible acids as a bacteriostatic agent to prevent growth in recirculated flume water. Following the one year testing operation, it is proposed to select units to be incorporated in full scale plant operations for a further demonstration project. The reason for the low project cost is due to NCA already having on hand several pieces of equipment required to test these processes.

STATUS: Received worthwhile information on operation of units during last fall's processing operations. Will continue with evaluation of the various units this fall.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
National Canners Association Research
Fdn.

5.0236, ARCTIC ECOSYSTEMS

S.G. SHETLER, Smithsonian Institution, ***Washington, District of Columbia*** 20560

Longterm studies of selected arctic ecosystems will be initiated in the summer of 1968 with the Smithsonian Expedition 1968. The Expedition will establish several sites, to be revisited in subsequent years, in the Brooks Range of Alaska, where two types of interdisciplinary ecosystem programs will be started, with different members of the team concentrating on one or the other program:

(1) Pollination Ecosystems. The total pollination interrelationships of selected plant communities will be studied, with special attention given to the role of insects in the pollination of arctic plants in general. (2) Aquatic Ecosystems. Composition, productivity, and energy cycling will be studied in selected inland lakes and streams.

It is hoped that analogous sites can be found at a later time in Europe and Asia for the purpose of making circumpolar comparisons of the ecosystems studied. The project only now is being formulated, and it is expected that additional scientists will be joining the team, both from within and outside the Smithsonian Institution.

SUPPORTED BY Smithsonian Institution

5.0237, RESERVOIR WATER QUALITY INVESTIGATION

D. ROCKWOOD, U.S. Army, Corps of Engineers, ***Washington, District of Columbia***

This is a five-year engineering study which has two principal parts: (1) Collection and interpretation and (2) Analyses of associated data. The ultimate aim is to develop methods for determining functional requirements and criteria for use in planning, design and operation of a reservoir for specific water quality control needs of the project basin.

Water quality surveys are now being made in 16 Corps-operated reservoirs selected to sample variability in geography, climate, reservoir geometry and release structure. The surveys include physical, chemical and biological changes, with time and space, at inflow, within the reservoir, outflow and at points below the dam. It is also planned to identify the nature and concentration level of pollutants entering or anticipated to enter the project streams.

The analysis phase of the program aims to answer the following specific questions before establishing criteria for economical design of water quality control storage and release facilities: 1. Given the release rate, its temperature and quality levels, what will be the temperat[illegible] and quality of water at points downstream from the release point? 2. What level or levels of a reservoir must be tapped to meet specific water quality needs? 3. What is the water quality control need in terms of storage and release facilities? 4. What water quality monitoring equipment may be integrated with hydromet network for operating the reservoir for water quality control needs together with other authorized purposes?

SUPPORTED BY U.S. Dept. of Defense - Army

5.0238, THE ECONOMIC ANALYSIS OF WATER POLLUTION BY PESTICIDES AND OTHER AGRICULTURAL WASTES

G.C. TAYLOR, U.S. Dept. of Agriculture, ***Washington, District of Columbia***

Objectives: Identify the nature and sources of agricultural water pollutants and the resulting economic impacts and costs of alternative measures for reduction of adverse effects; and develop a general framework of analysis and formulate recommendations for control systems applicable for agricultural water pollutants.

Approach: Formulation of a general conceptual framework to produce an analytical model including pollution sources, transmission links to points of economic pact and alternative abatement measures. Selection of one or more watersheds for case study. Collection of data for coefficients of the analytical model. Evaluation of cost benefits of pollutants and alternative control systems. Refinement of the analytical model. Formulation of recommendations with respect to methodology and to appropriate systems of control for agricultural water pollution situations.

SUPPORTED BY U.S. Dept. of Agriculture

5.0239, INDUSTRIAL WATER USE IN THE UNITED STATES

K.L. KOLLAR, U.S. Dept. of Commerce, Bus. & Defense Serv. Admin. , ***Washington, District of Columbia*** 20230

The Business and Defense Services Administration is preparing a report relating water use by manufacturers to selected economic factors based on data obtained in three Industrial Water Use Surveys of 1954, 1959, and 1964 performed by the Bureau of the Census.

The study is concerned primarily with eight major industry groups: primary metals; chemicals and allied products; pulp and paper; petroleum and coal products; food and kindred products; stone, clay, and glass; transportation equipment; and textile mill products. The analyses of the water use in those groups, which together account for about 95 percent of all water used in manufacturing, will be presented for the Nation as a whole, for 20 industrial water use regions, and for states. Economic factors such as number of employees, productivity, value added, are to be related to gross water use, consumption, recirculation and discharge. The patterns of water use, as they differ from region to region, and from census year to census year are to be investigated.

SUPPORTED BY U.S. Dept. of Commerce - Bus. & Def. Serv.

5.0240, APPLICABILITY OF ARDOX CATALYST TO OXIDATION IN SPACE WASTE MANAGEMENT

A.A. BACHER, U.S. Dept. of Interior, Fed. Water Pol. Contr. Adm., *Washington, District of Columbia*

Objective: a. Problem - To provide efficient waste management processing in spacecraft applications for long-term manned space flight missions. b. Application: Long term manned spaceflight missions. c. Large weight and power savings may be achieved in future spacecraft life support systems where more efficient means of waste management process reactions can be developed.

Approach: The technical approach to be used in this research effort will be to test the maximum oxidizing capability of the ARDOX process on four process applications: (1) Water Reclamation with organic constituents, (2) Activated Sludge Process for Closed Life Support Systems, (3) Anaerobic Microbial Waste Treatment for Closed Life Support Systems, and (4) Zimmerman Process Effluent.

Progress: No significant progress to report at this time.

SUPPORTED BY U.S. Natl. Aero. & Space Adm.

5.0241, THE EVALUATION OF APPLICATION OF C-14 DATING OF GROUND WATER

B.B. HANSHAW, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242

The study is to investigate the feasibility of dating ground water by measuring its C-14 content. The absolute residence time of ground water is of considerable scientific interest and relates to the practical problems associated with waste disposal into deep acquifers and accidental introduction of radioactive fluids into subsurface materials.

SUPPORTED BY U.S. Dept. of Defense - Army

5.0242, TERTIARY TREATMENT RESEARCH AT THE JOINT FWPCA DISTRICT OF COLUMBIA PILOT PLANT

D.F. BISHOP, U.S. District of Columbia, Dept. of Sanitary Engin., *Washington, District of Columbia*

The engineering research will provide design data and cost quality relationships for a combination of tertiary processes applied to the DC secondary influent. The research contributes to the engineering development of advanced waste treatment processes and specifically to the development of pollution control techniques for water sources such as the Potomac River. It includes evaluation of nutrient removal and wastewater renovation processes using the treatment series: chemical (lime, alum, or iron salts) clarification for phosphate and particulate removal, air stripping for ammonia removal, pH controlled by decarbonation for removal of excess Ca , gravity filtration for final turbidity removal, granular carbon treatment for dissolved organic removal, and chlorination for product disinfection.

The pilot plant (100 gallons per day capacity) features automatic control systems which include measurement and control of: flow, pH conductivity, pressure and turbidity, and an automatic filter backwashing system. The filtration system also includes automatic differential pressure measurement through the length of filter media to permit evaluation of various media.

Chemical clarification is being evaluated first, with preliminary results: Ca0 dose - 250-350 mg/l; residual turbidity - 5-7 J.U.; residual phosphate - less than 0.5 mg/l.

The remaining processes will be added stepwise to the treatment series, following satisfactory development of the preceeding processes.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
District of Columbia Government

5.0243, CHEMICAL SLUDGE DISPOSAL AND CHEMICAL RECOVERY AT THE JOINT FWPCA DISTRICT OF COLUMBIA PILOT PLANT

D.F. BISHOP, U.S. District of Columbia, Dept. of Sanitary Engin., *Washington, District of Columbia*

The research will provide engineering design data for the handling and disposal of chemical sludge products in the joint FWPCA District of Columbia tertiary treatment pilot plant. These sludges may include calcium carbonate, aluminum hydroxide, and ferric hydroxide sluges. It will also determine the feasibility of recalcinating calcium carbonate sludges and removing lime for reuse in chemical clarification of wastewaters.

The research will contribute to the general development of techniques for 'ultimate disposal' of sludge produced by advanced waste treatment processes and specifically will attempt to improve the economics of lime clarification by recovery and reuse of the lime. The processes and the chemical sludge disposal system include sludge thickening, sludge dewatering (vacuum filtration, incineration and/or recalcination of the chemical sludge). The system features a pilot scale vacuum drum filter with continuous washing of the filter belt. Automatic weighing of the dewatered sludge takes continuous feeding of cake to a 30-inch diameter, six-hearth surface. The maximum furnace temperature is approximately 1900oF with individual temperature control for each hearth.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
District of Columbia Government

5.0244, FULL SCALE RAW WASTE WATER FLOCCULATION

P.V. FREESE, U.S. District of Columbia, Dept. of Sanitary Engin., *Washington, District of Columbia*

The objectives of this project are: To determine and to optimize improvement in solid capture in full scale primary settlers produced by the addition of polyelectrolytes to the raw wastewater. To determine and to optimize the effect of raw wastewater flocculation on the operational efficiency of full scale conventional wastewater treatment. To evaluate various polyelectrolytes.

Many conventional waste treatment plants are overloaded or operating at maximum capacity. Other plants have only primary treatment. Increased solids captured by raw waste water flocculation will improve plant expansion thus achieving a needed immediate reduction in water pollution.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
District of Columbia Government

5.0245, USE OF MODIFIED ACTIVATED SLUDGE TREAT TO ACHIEVE NUTRIENT REMOVAL & TO PROVIDE CONSISTENT FEED TO TERTIARY TREATMENT SYSTEM

P.V. FREESE, U.S. District of Columbia, Dept. of Sanitary Engin., *Washington, District of Columbia*

The objectives of this project are to develop on a pilot-scale, activated sludge modifications capable of achieving improved nutrient removal, to optimize aeration techniques used in biological treatment, and to produce a controlled-quality secondary effluent suitable for use in various tertiary treatment processes. In addition, the aim is to determine the optimum combination of the activated sludge process with various physical-chemical treatment systems to achieve a minimum cost for the treatment to attain various removal efficiencies.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
District of Columbia Government

5.0246, DEMONSTRATION UNDERWATER FACILITY - STORM OVERFLOW

S.A. SILVER, Underwater Storage Inc., *Washington, District of Columbia*

The purpose of the demonstration facility is to show that by storage of combined flow storm and sanitary sewers in underwater rubber bags, the present practice of dumping overflow sewage into the rivers will be eliminated. Present overflow system at Barney Circle will be diverted to flow through a Parshall Flume for measuring flow and for sampling purposes. A part of this flow will be taken through the test plant for grit removal, shredding and removal of all large particles prior to gravity flow to the two 100,000 gallon rubberized nylon containers installed on cradles anchored in the river bed. Following a rain, or when feasible during hours from 11:00 PM to 6:00 AM the liquid from the underwater tanks will be pumped out to discharge to existing interceptor sewer system for treatment at the Blue Plains sewage treatment plant. Measurement will be taken of all flow into and out of the bags and chemical samples will be taken of effluent from sewer overflow and from tank discharge.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0247, EVALUATION OF HERBICIDES FOR CONTROL OF AQUATIC WEEDS

R.D. BLACKBURN, Univ. of Florida, Agricultural Experiment Sta., *Belle Glade, Florida*

Objective: To evaluate chemical compounds for their herbicidal activity against submersed, emersed, and floating aquatic weeds.

Description: New herbicides will be evaluated on 3 submersed aquatic weeds (Elodea densa, Najas guadalupensis, and Ceratophyllum demersum); 3 species of floating aquatic weeds (Eichhornia crassipes, Salvinia rotundifolia, and Pistia stratiotes); and one emersed aquatic weed (Alternanthera philoxeroides). Submersed Weeds: Evaluations will be done in a temperature and light intensity controlled laboratory. Application rates will vary from 1 to 10 ppmw or ppmv and contact time of herbicides with plant will be varied from 30 minutes to 4 weeks. Visual evlauations will be made at various intervals. Floating Weeds: Plants will be grown in plastic containers in a greenhouse. Application rates of herbicides will vary from 1 to 10 lb/A of active ingredient. Visual evaluations will be made at various intervals. Emersed Weeds: Floating mats of alligatorweed will be grown in plastic containers in a greenhouse. Application rates will be 5 and 20 lb/A of active ingredient applied as a foliar spray. Visual evaluations will be made at various intervals to determine the percent topkill and percent regrowth.

Herbicides that show herbicidal activity on any of these weeds will be further evaluated in growth pools constructed near the laboratory.

SUPPORTED BY Florida State Government

5.0248, DEMONSTRATION OF THE LIMITATIONS AND EFFECTS OF WASTE DISPOSAL ON AN OCEAN SHELF

R.F. MCALLISTER, Florida Atlantic University, Graduate School, *Boca Raton, Florida*

The purpose of this project is to learn the existing ecological regimen of an area subject to waste injection, and the effect of waste injection on an ocean shelf through a combined oceanographic and biological survey. It is further intended to learn how, by knowledge of local currents, to optimize the location of sewage outfalls. Studies will include the analysis of water and bottom samples and classification of the fauna and flora.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Florida Atlantic University

5.0249, EFFECTIVENESS OF IODINE FOR DISINFECTION OF PUBLIC WATER SUPPLIES & TO DETERMINE PHYSIOLOGICAL EFFECTS ON A HUMAN POPULATION (ABBREV)

A.P. BLACK, Univ. of Florida, Graduate School, *Gainesville, Florida* 32601

This project is to demonstrate the effectiveness of iodine for the disinfection of polluted water supplies and to evaluate the several variables affecting such procedures to demonstrate the physiological effects, if any, on a significant number of consumers over an extended period of time. The water supplies of three state institutions will be disinfected with iodine and every sixth person of more than 600 inmates will be selected for intensive medical evaluation.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
University of Florida

5.0250, CHEMISTRY OF NITROGEN IN NATURAL WATERS

P.L. BREZONIK, Univ. of Florida, School of Engineering, *Gainesville, Florida* 32601

Factors controlling the concentration and forms of nitrogen compounds in lakes will be investigated. One phase of the project will determine the relative significance of certain components in the nitrogen budgets of lakes. The importance of rainfall, urban and agricultural runoff, nitrogen fixation and sediment laching as nitrogen sources will be assessed for the budgets of several different lakes, along with the importance of denitrification and sediment uptake as nitrogen sinks. The quantitative significance of these sources and sinks for lacustrine nitrogen budgets is virtually unknown at the present time.

The second phase of the project will study athe turnover rates of various nitrogen compunds in natural waters in order to determine the factors influencing the distribution of nitrogen among its different forms. This will involve the use of 15N isotope tracer methodolgy and in situ incubation experiments. Especially emphasized will be comparison of assimilation rates with regeneration rates; a number of environmental factors that may affect or control the rates of these reactions will also be studied. The role of organic nitrogen forms in the assimilation and regeneration processes will be investigated by 15N tracer techniques.

Numerous lakes of varying trophic status and hydrologic enviornments are available in the Gainesville area for this project. This affords the opportunity to assess the importance of certain nitrogen sources an sinks under different environmental conditons and to compare the nitrogen cycle dynamics in a wide variety of lake types.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0251, NEMATODES ASSOCIATED WITH SEWAGE TREATMENT AND THEIR SIGNIFICANCE

W.T. CALAWAY, Univ. of Florida, Agricultural Experiment Sta., *Gainesville, Florida* 32601

(1) Identify, classify, and make keys of the nematodes associated with sewage treatment; (2) Determine their biological activities in various types of treatment and their relation to stream sanitation.

Sample, process and examine samples from sewage treatment processes, unpolluted stream, especially bottom material, bottom material of streams and lakes receiving wastes, to determine which genera of nematodes or species of particular genera are the predominant inhabitant of these environments. If nematodes common to streams are found in sewage treatment, then their presence in a stream will not necessarily be indicative of pollution. The activity of these animals will be investigated either by direct microscopic examination or by observation of cultured materials. The source of these and related forms will provide further information. Study of the literature will be made to clarify this taxonomically confused group.

SUPPORTED BY Florida State Government

5.0252, THE ACTIVATION-CHROMATOGRAPHIC ELEMENTAL AND STRUCTURAL ANALYSIS OF FRESH WATER SOURCES

S.P. CRAM, Univ. of Florida, Graduate School, *Gainesville, Florida* 32601

The objective of the proposed research is the development of an analytical method for the simultaneous elemental analysis and organic structural determination of materials found in fresh water sources at trace concentrations. The experiments will involve the post-irradiation separation by gas-liquid chromatography of water sample constituents, and the analysis of the column effluent by flame ionization and beta- gamma-ray spectrometry.

The project will be directed toward the development of an analytical system which will be widely applicable, regardless of the elemental composition or matrix materials present, and capable of rapid and reproducible analyses. The elemental analysis of the samples will involve a gas chromatographic, post-irradiation separation, and analysis by gamma-ray scintillation spectrometry. The chromatographic separations will serve to enhance the sensitivity and simplicity of the activation analysis, and simultaneously, separate the degradation fragments of the organic compounds present. The specific detector response, specific activity, and functional group analyses of these fragments will be used to derive the structure of the original molecule.

The coupling experiment will be highly selective for, and sensitive to trace concentrations, and be very specific for all elements and organic materials present. Further, it represents a significant development in the understanding of basic nuclear-chemical interactions, and it will be developed specifically for the analysis of fresh-water systems in general.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Florida

5.0253, RESIDENCE TIMES OF WATERS BEHIND BARRIER ISLANDS

R.G. DEAN, Univ. of Florida, School of Engineering, *Gainesville, Florida* 32601

The proposed research comprises the development and evaluation of a numerical model to calculate the residence times of the waters in lagoons behind barrier islands and in interconnected bay systems. The numerical model will be based on the governing differential equations of motion and continuity including all nonlinearities. Wind stresses, precipitation and tidal displacements at the openings to the water system under consideration will be included as 'input' to the numerical model. The model 'output' includes predictions of water velocity and elevation as functions of time and position in the water system. The 'output' is generated by representing the water area as a grid system and solving the governing difference equations for the prescribed spatial and temporal distributions of the input functions. To assess the validity of the model, a field program will be conducted to measure the input and output functions for at least two different water systems. The validity and limitations of the model will be based on a comparison of measured water elevations and velocities with those determined from the numerical model.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Florida

5.0254, TRANSVERSAL DRIFTS IN BOTTOM PROFILE

R.G. DEAN, Univ. of Florida, School of Engineering, *Gainesville, Florida* 32601

Physical relationships between changes in the transversal profile due to sediment transport and the physical mechanisms causing such transport are sought under field conditions in the surf zone of the ocean. Pertinent parameters to be measured are the quantity of sand transport, waves (height and direction), water particle velocities, wind, tide, bathymetry, and sediment characteristics. All instrumentation and experimental facilities have been completed on the previous project for which this renewal proposal is being written.

The method of approach is to measure the time histories of the pertinent parameters over half a tidal cycle, i.e., four to six hours. Since we are measuring over a relatively short time interval a stationary process can be assumed and the techniques of spectral analysis will be employed to correlate the various parameters. This correlation allows direct cause and effect relationships to be obtained. In this manner, insight into the sediment transport phenomenon and basic processes occurring in the littoral zone of the ocean can be found.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0255, ANTI-POLLUTION AND SEWAGE DISPOSAL FOR FLORIDA COMMUNITIES

T.D. FURMAN, Univ. of Florida, School of Engineering, *Gainesville, Florida* 32601

This is a continuing study, renewable annually, of various methods of sewage treatment applicable to the semi-tropical climate of Florida. Special emphasis is directed toward modifications of design standards in order to take advantage of the warm climate and increased sunshine. The use of native filter materials is being investigated. Among the studies which have been conducted is an investigation of the efficiency and degree of treatment provided by intermittent sand filtration as influenced by size and depth of sand as well as the hydraulic and organic loading. A study of lagooning to determine the degree of treatment and efficiency of this method of sewage treatment, using both settled and unsettled domestic sewage at various hydraulic and organic loading rates has also been completed. The ecology of the flora and fauna instrumental in the treatment was investigated.

SUPPORTED BY University of Florida

5.0256, MOVEMENT AND ADSORPTION OF PESTICIDES IN STERILIZED SOIL COLUMNS

R.S. MANSELL, Univ. of Florida, School of Agriculture, *Gainesville, Florida* 32601

The objective is to determine the influence of soil and carrier solution properties on adsorption, disperson coefficient and rate of movement of pesticides, detergent surfactants, hydrophobic surfactants and tritiated water in sterilized soil columns at various degrees of saturation and flux.

Soils sterilized by gamma radiation will be set up in columns (10 cm cube, sides enclosed with acrylic plastic) for miscible displacement of tritiated water and radioisotope-tagged pesticides and surfactants. Inflow and outflow will be through porous fritted-glass plates in contact with the top and bottom of soil columns. Filtered gas, under variable pressure, will be admitted through the sides of the container to establish the desired degrees of unsaturation. A Sigmamotor pump will control flux of solutions having different surface tensions.

A flow cell in connection with a three-channel analyzer for beta spectrometry will form a liquid radiochromatography system for the nondestructive detection, analysis and recording of the radioactive chemicals eluting from the soil column.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Florida

5.0257, PRIMARY PRODUCTION AND DECOMPOSITION IN ESTUARINE WATER

H.D. PUTNAM, Univ. of Florida, School of Engineering, *Gainesville, Florida* 32601

The objective of the proposed research is to contribute to an understanding of the synthesis and decomposition of organic matter by primary producers in an estuarine environment. Studies will be conducted to estimate the productivity of certain red and brown algae which are part of the benthic community in the Waccasassa Estuary. Appropriate methods for measuring fixation of isotopic carbon by attached plants were worked out under grant No. WP-00678-03 which will be completed by this investigator August 31, 1967.

In addition an attempt will be made to define more clearly the limiting factors for primary production in the Waccasassa Estuary. Emphasis will be directed toward the interaction of chemical and biological factors.

Efforts also will be made to follow the decomposition of organic matter under anoxic conditions in estuarine sediments. These studies will be directed mainly toward the characterization of substrates which are involved in methanogenesis. The pool size of volatile fatty acids resulting from the breakdown of algae will be determined and efforts made to establish metabolic turnover rates of these components.

5. WATER QUALITY MANAGEMENT AND PROTECTION

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0258, EUTROPHICATION FACTORS IN NORTH CENTRAL FLORIDA LAKES

H.D. PUTNAM, Univ. of Florida, School of Engineering, *Gainesville, Florida* 32601

The project objectives are: (1) to determine the validity of criteria now in use in other areas in measuring trophic levels in shallow, subtropical lakes, and if necessary develop other criteria; (2) to demonstrate the validity of the mathematical model of eutrophication developed by the application of systems analysis techniques and procedures; (3) to determine the controlling factors in the eutrophication process; (4) to establish guide lines to be used by regulatory agencies in the prevention of surface water deterioration. A small lake in an unhibited drainage basin is to be used as a model for eutrophication and will be separated into control and experimental units by a dike. Nutrients will be fed into the experimental unit at a controlled rate. Changes in parameters will be determined and related to the change in nutrient flux to the unit. The ability of the lake to assimilate nutrients, the rates of recovery after nutrient enrichment ceases, and the possibility of controlling the factors inducing eutrophication will be studied.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
University of Florida

5.0259, STUDIES ON THE METHANOGENIC BACTERIA IN SLUDGE

P.H. SMITH, Univ. of Florida, School of Agriculture, *Gainesville, Florida* 32601

Experiments are being conducted to describe the methanogenic microflora in digesting sludge. A large number of pure cultures of methanogenic bacteria have been isolated and their characteristics determined.

Experiments are being conducted to determine quantitatively the roles of fatty acids in the digestion process.

A culture collection of methanogenic bacteria has been established containing all extant cultures of methanogenic bacteria. The cultures are available to interested investigators through the American Type Culture Collection.

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SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0260, APPLICATION OF IMMUNOCHEMICAL TECHNIQUES TO THE DETECTION AND IDENTIFICATION OF CHEMICAL AND BIOLOGICAL POLLUTANTS

UNKNOWN, Cordis Corporation, *Miami, Florida* 33137

The objective of this project is to develop applications of immunochemical techniques to the detection and identification of chemical and biological pollutants.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0261, EFFECTS OF PESTICIDES ON MARINE ANIMALS

C.E. LANE, Univ. of Miami, Graduate School, *Miami - Coral Gables, Florida* 33124

Supported by a previous grant from the National Institutes of Health, we designed and constructed equipment to present experimental fish with water of carefully controlled salinity, temperature and pH containing precisely regulated amounts of pesticide. In this apparatus acute-toxicity studies were conducted to establish lethal levels of dieldrin for the tarpon and some other estuarine fishes. I now seek to determine the partition of pesticides between morphological compartments of experimental animals and to assess the effects of sublethal concentrations of common pesticides on various aspects of the physiology of estuarine fishes and common invertebrates of south Florida. These studies will include: 1) the concentration and activity of selected blood enzymes; 2) qualitative and quantitative analysis of various tissue enzyme systems; 3) the effects of pesticides on respiratory metabolism of entire animals and of surviving tissue slices; 4) a description of the normal microscopic anatomy of the experimental animals and of modifications that may be induced by chronic exposure to sublethal concentrations of pesticides; and 5) the activity of ATPase enzymes in the gill epithelium will be given particular attention, since they appear to exercise principal control of gill permeability. These data should illuminate the metabolic fate and activity of pesticides in the runoff from coastal agricultural areas.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0262, WATER QUALITY AND FUNGI-NEMATODE-SEAGRASS RELATIONSHIPS

S.P. MEYERS, Univ. of Miami, Graduate School, *Miami - Coral Gables, Florida* 33124

Studies include those of fungal and nematode populations in Biscayne Bay (Miami) Florida, and their interrelationships with marine plant communities. Analyses of the nematode fauna involve field and laboratory studies of the large omnivorous species, Metoncholaimus scissus, from aspects of its aggregation and microzonicity in the field. Biometric studies of M. scissus have revealed significant infection by a microsporidian parasite. Comparable investigations are planned with other nematode taxa to ascertain the effect of protozoan infection on nematode populations. Ecological data are being analyzed from a number of different locales in the Bay to establish a 'base line' of nematological activity to check the diversity of subtropical benthic habitats. Concurrent fungal studies involve physiological investigations to establish the dynamics of cellulolytic activity and comparative cellulase production. Laboratory investigations of the Lulworthia floridana group further indicate the significance of these fungi in degradation of cellulosic material in the sea.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0263, THE BIOLOGY OF THE INFAUNA OF A TROPICAL SOFT BOTTOM AREA

H.B. MOORE, Univ. of Miami, Graduate School, *Miami - Coral Gables, Florida* 33124

A study is in progress on the biology and ecology of the infauna of the soft bottom of Biscayne Bay, Florida. This is considered typical of a tropical estuarine area. Papers have been published on the heart urchin, Moira atropos, and the lamellibranch, Tagelus divisus. Papers are in press on Chione cancellata on the fauna of intertidal muds, on sublittoral polychaetes and the biological effects of pollution in the bay. Studies are in progress on various mollusks, echinoids and brittle stars.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0264, TRITIUM AS A TRACER FOR MIXING PROCESSES

G.H. OSTLUND, Univ. of Miami, Graduate School, *Miami - Coral Gables, Florida* 33124

This is a continuing study of the distribution of fusion-bomb produced tritium in the equatorial Atlantic. Combined with salinity distribution the tritium data have yielded insight into the relative roles of horizontal and vertical mixing. Cruises in 1965 and 1967 have collected some 320 samples from the Equatorial Atlantic Current System and it is proposed to complete these analyses. The implications of these data will be investigated, relative to mixing processes, origins and time scales of components of the current system, etc.

SUPPORTED BY U.S. National Science Foundation

5.0265, STUDIES OF THERMAL POLLUTION IN BISCAYNE BAY

D.C. TABB, Univ. of Miami, Graduate School, *Miami - Coral Gables, Florida* 33124

Specific Aims - The overall objective of the research program is to determine the effects of thermal effluent on the macrofauna and -flora of Biscayne Bay, south Florida as successive generators (both conventional and nuclear) come into operation at the Florida Power and Light Company plant site at Turkey Point (Figures 1 and 2).

1. To describe the plant and animal communities in the vicinity of the Turkey Point power plant site in qualitative and quantitative terms, and to relate qualitative and quantitative changes in these communities to changes in environmental parameters, principally temperature. This will be accomplished by utilizing standardized quantitative sampling methods already tested for statistical validity in recent studies for U. S. Public Health Service (Thomas and Fishback, 1967). These studies were carried out in Florida Bay where the habitat and faunal elements are essentially the same as those expected in southern Biscayne Bay. The sampling will provide accurate data on the kinds and numbers of macroscopic animals and plants in the study area. New information thus obtained will be related to data already gathered from a number of other studies to interpret the fluctuations which will be observed.

2. To integrate all this information plus that in the literature (Raney and Menzel, 1967) for the development of an accurate estimate of the thermal depth point for the fauna and flora, and to estimate the maximum heat load that the bay can carry while, at the same time, maintaining the ecological status quo. These estimates will be translated into specific recommendations to the proper Federal authorities as to the best disposition of the heated effluent.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0266, REMOVAL OF ORGANICS AND NUTRIENTS FROM CITRUS PROCESSING PLANT WASTES

F.A. EIDSNESS, Minute Maid Company, *Orlando, Florida*

In Florida, about 52 plants of the citrus industry discharge about 130 mgd of waste, having an organic concentration amounting to 318,000 lbs. of BOD daily, into streams and lakes of Florida. This project is a step towards solving this pollution problem.

The objective of this project is to demonstrate the design and operational factors for organic and nutrient removal of citrus process waste by the activated sludge process, by stabilization in oxidation ponds with and without induced aeration, and absorption of nutrients by plant life with subsequent drying of materials in citrus feed mill.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Minute Maid Company

5.0267, FIELD EVALUATION OF REAERATING SURFACE WATERS

C.W. SHEFFIELD, Orange Co. Dept. of Water Con. , *Orlando, Florida* 32806

The objectives of the project are to perform a detailed study of the design, operational and performance characteristics of various methods for reaerating small, low level reservoirs and to compare results of reaerating methods with data from existing county lake turnover studies.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Orange County Government - Florida

5.0268, PESTICIDE MONITORING PROGRAM

P.A. BUTLER, U.S. Dept. of Interior, Biological Laboratory, *Sabine Island - Gulf Breeze, Florida*

Cooperative program involving 15 private, state and federal laboratories who collect duplicate samples of mollusks from approximately 175 estuarine stations on Atlantic, Gulf and Pacific coasts at monthly intervals. Program initiated 1965, proposed to continue until 1969; 1500 analyses completed September 1965. Samples are sent to the Gulf Breeze Laboratory for pesticide residue analysis. Eastern oyster is chief bioassay animal, also used Mya arenaria, Mercenaria mercenaria, Ostrea luria, Crassostrea gigas and some fish species. Each sample is screened for Aldrin, BHC, Dieldrin, DDD, DDE, DDT, Endrin, Heptachlor, Heptachlor epoxide, Lindane and Methoxychlor. Analyses are made wiith electron capture gas-liquid chromatography techniques.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

5.0269, RELATION OF ENVIRONMENTAL FACTORS TO THE PRODUCTIVITY OF ESTUARINE SEDENTARY FAUNA

P.A. BUTLER, U.S. Dept. of Interior, Biological Laboratory, *Sabine Island - Gulf Breeze, Florida*

The incidence of setting per square centimeter per seven days on asbestos-cement plates at one station in Santa Rosa Sound near Pensacola, Florida has been measured since 1949. Predominant fauna counted include barnacles, oysters and bryozoa. Concurrent data are collected on water salinity, temperature and tides. Meteorological data are available. All data are to be programmed for analysis. Continuing project.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

5.0270, LABORATORY BIOASSAYS

J.I. LOWE, U.S. Dept. of Interior, Biological Laboratory, *Sabine Island - Gulf Breeze, Florida*

The primary objectives of the subject project are: (1) determination of the acute toxic levels of pesticides to representative marine species, and (2) investigation of possible adverse effects of prolonged exposure of marine animals to sublethal concentrations of the common pesticides.

Short-term (96-hour or less) toxicity tests are conducted in the laboratory under controlled conditions. Most of the tests are conducted in constant-flow seawater systems using oysters, shrimp, and marine fish as bioassay animals. These acute toxicity tests will be a continuing function of the project as new chemicals are received for evaluation.

Long-term experiments (3 to 6 months duration) involving the chronic exposure of marine animals to sublethal concentrations of selected pesticides will be conducted when the efforts and results seem justified.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

5.0271, PESTICIDE KINETICS

C.W. MILLER, U.S. Dept. of Interior, Biological Laboratory, *Sabine Island - Gulf Breeze, Florida*

Investigate, under field conditions, the occurrence and distribution of insecticides in tidal areas associated with an estuary. Samples of water, soil and selected biota will be collected immediately prior to application of the test material to establish a base line indicative of previous commercial treatments. The persistence, localization and possible degradation of the test chemicals will be followed.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

5.0272, DISTRIBUTION OF LIFE WITH DEPTH

R.J. MENZIES, Florida State University, Graduate School, *Tallahassee, Florida* 32306

The objective of this proposal is to improve our knowledge of the distribution of animal life in the sea directly off the coast of North Carolina through a detailed photographic study on selected biological properties of the sea floor from shelf depth (180 meters plus or minus 20 meters) to the abyssal plain (6000 meters).

As a mechanism of significant improvement of the use of underwater photographs in biological studies, each photographic series will be coupled with samplings of animal life. Thus, this project involves the use of a grab camera, a multi-shot camera coordinated with large trawl samples, identification of species photographed, correlation of observed distribution with sediment type and hydrographic information. The aim will be to associate gross and reproducible features in the distribution of animal life with topography, hydrography (water characteristics, T, S, O2) and sediment type.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0273, PEACE RIVER POLLUTION INVESTIGATIONS

F.J. WARE, State Game & Frsh. Wtr. Fish, *Tallahassee, Florida*

On March 11, 1967 the Peace River was polluted with 1,000 acre feet of phosphate slime (phosphatic clay). The source of pollution was 200 acre slime setting basin on the property of Mobil Chemical Company. The resulting fish kill was over 90 percent of the total population in 76 miles of stream. An estimated total of 983,430 fish. Mortality was caused by mechanical means, from stress and clogging of gill filaments. Turbidities ranging to 57,000 Jackson units were recorded. A damage settlement was obtained from Mobil in the amount of $200,000.00.

The research project includes five job segments to determine the effects of industrial phosphate slime on the ecology of the Peace River and facilitate recovery through the use of habitat improvement structures (stone deflector dams) and fish stocking. Research segments are as follows: JOB I - Determination of Slime Deposits on Stream Bottom and Flood Plain. JOB II - Monitoring Stream Flow, Water Quality and Slime Movements. JOB III - Classification of Stream Habitats and Associated Aquatic Life. JOB IV - Effects of Slime on Stream Ecology and Recovery. JOB V - Installation and Evaluation of Stone Deflector Dams.

SUPPORTED BY Florida State Government

5.0274, LIME TREATMENT AND INPLANT REUSE OF AN ACTIVATED SLUDGE PLANT EFFLUENT IN THE CITRUS PROCESSING INDUSTRY

J.W. HAYES, Winter Garden Cit. Prod. Coop. , *Winter Garden, Florida*

The objective of this proposal will be to develop operational parameters and conduct an economic evaluation on lime treatment of effluent from a 2 mgd activated sludge system treating citrus wastes and in-plant reuse of the lime treatment effluent. The study will cover lime treatment, with the addition of coagulant aids, and dewatering of sludges by centrifugation for usage in cattle feed preparation. Determination will be made on this system's effective in further reducing BOD, COD, and nutrients found in the activated sludge effluent.

The proposed project intends to demonstrate the effectiveness of lime precipitation on effluent from a 2 mgd activated sludge system treating citrus wastes. The activated sludge system consists of an aeration pond providing from 24 to 36 hours detention time with the overflow being directed into a final clarifier. Operation of the activated sludge system will afford pH control along with nutrient supplementation and sludge recirculation.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Winter Garden Citrus Products Cooperative

5.0275, DEVELOPMENT OF SUPPORTING PRACTICES, SYSTEMS, TECHNIQUES AND DEVICES FOR RUNOFF AND EROSION CONTROL IN THE SOUTH

J.R. CARREKER, U.S. Dept. of Agriculture, *Athens, Georgia*

Object: (1) To develop and test improved terrace, diversion, contour and contour strip crop systems for control of runoff and erosion and to evolve better practices for the establishment and maintenance of vegetation in terrace outlets and waterways. (2) To develop techniques and equipment for studying runoff and erosion and for measuring the effectiveness of practices used in the control of runoff and erosion.

Plan of Work: Studies will be made of (1) improvement of the operating characteristics of the rainfall simulator; (2) obtaining basic data for the design of terraces, including overland and micro- channel flow characteristics, and tractive forces in soil movement; (3) improvement in the layout, cross-section, alignment and construction of terraces and waterways, including the use of parallel terraces; and (4) the effect of strip-cropping, row pattern, and other supporting practices on runoff and erosion control.

Cooperation: Georgia and South Carolina Agricultural Experiment Stations; SCS

SUPPORTED BY U.S. Dept. of Agriculture

5.0276, THE DISPOSITION OF PESTICIDES IN SOIL AND CLOSELY RELATED WATER

J.R. CARREKER, U.S. Dept. of Agriculture, *Athens, Georgia*

Object: To determine the mechanism and extent of movement by water of pesticide materials over and through the soil; the relation of this movement to the quality of water originating on agricultural land; and the effect of water and soil management practices on the disposition of pesticide materials.

Plan of work: Loss of pesticide materials in washoff and drainage water will be determined from small watersheds, field areas, small plats and Lysimeters with both natural and artificially applied rainfall. Concentration of pesticides in farm ponds will be measured to determine the distribution of the material in the water, on suspended mineral and organic matter in the water, in the microflora, and on the pond bottom, all in relation to water depth, temperature, pH, chemical composition, inflow and outflow, and other properties of the pond. Pesticides in drainage water will be compared from open versus closed drainage systems. Controlled studies of leaching, adsorption of pesticide molecules on soil particles, and other physical and chemical phenomena of pesticide movement and persistence in the soil will be investigated in relation to the soil properties as well as to both time and space, soil moisture regime, soil fertility, physiological development of the plant, and time and method of application of the pesticide material.

SUPPORTED BY U.S. Dept. of Agriculture

5.0277, PHYSICAL-CHEMICAL PHENOMENA ASSOCIATED WITH ORGANO-COLLOIDAL SURFACE INTERACTIONS

G.W. BAILEY, U.S. Dept. of Interior, Southeast Water Lab. , *Athens, Georgia*

Investigation is concerned with the elucidation of the nature of interactions between organic compounds and colloidal surface, particularly with regard to sorption, degradation and/or decomposition. It will be possible with such information to predict the behavior of a given organic in, through, and/or off soil surfaces and thus predict the possibility of such a compound entering water courses and causing a water pollution problem. With such information, it will be possible to predict the mechanism of pollutant transportation in water courses.

Three sorption parameters are being investigated: (1) Molecular orientation (by means of x-ray diffraction); (2) Bonding type (spectrophotometrically); (3) Thermodynamic properties (by means of calorimetry and/or appropriate thermodynamic relationships).

Adsorption isotherms will be run in addition to supplement the above parameters in formulating mechanism(s) of adsorption.

The applicability of the above findings to improving existing water and waste treatment processes will be tested.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0278, THE DETERMINATION OF THE STRUCTURES OF ORGANIC CONTAMINANTS IN WATER

A.W. GARRISON, U.S. Dept. of Interior, Southeast Water Lab. , *Athens, Georgia*

It is the purpose of this project to apply modern instrumentation and scientific knowledge to the task of identification of organic pollutants in water as it relates to the establishment of water quality criteria. These pollutants arise from industrial wastes, agricultural operations, and other sources. The nature of most is unknown. The project involves extraction and concentration of the organic contaminants by carbon adsorption and liquid-liquid extraction techniques, but research into other methods of sample collection is planned. The concentrated extract is fractionated by column, gas, and thin-layer chromatography, solubility separations, steam and vacuum distillation, etc. The separated and purified individual compounds are then identified by their chemical properties, infrared and ultraviolet spectroscopy, gas chromatography, nuclear magnetic resonance spectroscopy, and mass spectroscopy.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0279, NMR AND IR STUDIES OF HYDROGEN BONDING IN N-ALKYLPHOSPHORAMIDATES

A.W. GARRISON, U.S. Dept. of Interior, Southeast Water Lab. , *Athens, Georgia*

The observation of an anamoly (doubling of the isopropyl methyl proton signal) in the high resolution NMR spectra of 2,4-dichlorophenyl methyl N-isopropylphosphoramidate had led to a detailed NMR and IR investigation of the causes of the doubling. Preliminary experiments have eliminated long range P31 coupling or inherent nonequivalence due to the asymmetry of the tetrahedral phosphorus atom as possible explanations of the doubled signals and narrowed the cause of this phenomenon to a hindrance of free rotation of the isopropyl group around the C-N bond. Further experimentation involving a variety of solvents, temperatures, and concentrations has established the cause of the hindered rotation to be intermolecular hydrogen bonding between the amido hydrogen and phosphoryl oxygen. Work is in progress to determine the nature of the hydrogen bonded species, the NMR and IR spectra of other N-alkyl-phosphoramidates being used toward this end.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0280, CHARACTERIZATION OF ORGANIC CONTAMINANTS IN TEXTILE WASTE EFFLUENTS

A.W. GARRISON*, U.S. Dept. of Interior, Southeast Water Lab. , *Athens, Georgia

The object of this project is to identify organic contaminants which remain in textile wastes after conventional waste treatment procedures. The compounds present at this stage will be compared with the variety of compounds identified in the waste effluent before treatment so as to show which organics are not effected by the treatment process and which ones may be chemically changed by the process. This knowledge should lead to improvements in textile waste treatment procedures.

Various means of sample collection and concentration are being studied for application to this problem. These include liquid-liquid extraction, carbon adsorption, preparative gas chromatography, column chromatography, distillation, etc. The characterization of the separated organic contaminants will involve the use of mass spectrometry, nuclear magnetic resonance, infrared and ultraviolet spectroscopy, and gas chromatography.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0281, SOURCE DISTRIBUTION AND FATE OF C14 LABELED AND CHLORINATION HYDROCARBON INSECTICIDE RESIDUES IN FISH

A.R. GRZENDA*, U.S. Dept. of Interior, Southeast Water Lab. , *Athens, Georgia

The rate of uptake of C14-labeled Dieldrin and DDT residues by Goldfish from food and water is being determined. It appears that uptake directly from water is substantially more efficient. The distribution and turnover rate of the residues are being determined. TLC radiochromatography has shown there is no degradation of the dieldrin residues. However, in the case of DDT, degradation to DDD and DDE was observed. These metabolites occurred principally in the liver. The possible role of mitochrondria in the metabolism of these compounds is being investigated. Complete turnover of dieldrin residues was not noted in all tissues in approximately 3-weeks, when the fish were removed from the contaminated diet. Turnover rates for DDT have not yet been determined.

Similar work is being started with aldrin. Preliminary results indicate that this compound is metabolized to dieldrin at an extremely rapid rate.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0282, RURAL RUNOFF CONTROL

D.W. HILL*, U.S. Dept. of Interior, Southeast Water Lab. , *Athens, Georgia

Summary of Proposed Work: This research is designed to evaluate the contribution of rural runoff to pesticide and primary nutrient concentrations found in natural watercourses. Many phenomena are being investigated in detail, such as: adsorption mechanisms, degrees of reversibility, thermodynamic parameters, and the nature of the ionic equilibria between the particulate phase and classes of pesticides. More general interrelationships will be studied in the field including such phenomena as types and amounts of agricultural chemicals carried in surface runoff, in solution or adsorbed on different materials in the particulate phase; those that are mobile in interflow, and an estimate of the total amount received in the watercourse from other than surface runoff. An overall computer program will be constructed to incorporate those relationships that appear amenable to calculation. In some cases the fingings outlined above will be incorporated in detail whereas other relationships may be grossly simplified in an effort to emphasize those phenomena which are relatively important in contributing to water pollution by rural runoff and to de-emphasize those which are relatively insignificant. Control recommendations and methodology will result from this research.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0283, HIGH RESOLUTION NUCLEAR MAGNETIC RESONANCE SPECTRA OF ORGANIC PESTICIDES

L.H. KEITH*, U.S. Dept. of Interior, Southeast Water Lab. , *Athens, Georgia

The high resolution (100 Hz) NMR spectra of all available pesticides are being measured and cataloged with a complete and detailed interpretation. For cataloging purposes, the pesticides are divided into classes with a common chemical denominator or similar functional groups; i.e., organophosphorus compounds, carbamates, the DDT family, etc. Homonuclear double and triple resonance techniques, temperature studies, solvent and concentration effects, pH variations, hydrogen- deuterium exchange and signal integration are employed as needed to correlate the spectra with the structures of the corresponding molecules.

The extensive use of pesticides has made these compounds and their degradation products important sources of water contamination. Many of the pesticide degradation products are unknown both as to structure and toxicity. When such products are isolated and subjected to characterization studies, these spectra of the parent compounds will be a valuable reference source to aid in structure elucidation.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0284, CHARACTERIZATION OF ORGANIC CONTAMINANTS IN PAPER MILL WASTE EFFLUENTS

L.H. KEITH*, U.S. Dept. of Interior, Southeast Water Lab. , *Athens, Georgia

A number of monoterpenes, sulfides and oxygenated organic compounds have been identified from the waste effluent of a kraft paper mill which does not employ waste treatment procedures. The primary emphasis of this project, however, is on the characterization of organic compounds from the treated waste effluents of paper mills; the object being to determine pollutants which either resist the conventional treatments or are formed during the treatment process. Various means of sample collection and concentration are being studied (liquid-liquid extraction, carbon adsorption, vacuum distillation, etc.). The characterization of the organic contaminants involves the use of gas chromatography, mass spectrometry, and nuclear magnetic resonance, infrared and ultraviolet spectroscopy as the primary means of structure elucidation and confirmation.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0285, DEGRADATION KINETICS OF VARIOUS ESTER FORMULATIONS OF 2%2,4,5 TRICHLOROPHENOXYROPRIONIC ACID (SILVEX)

J.I. TEASLEY*, U.S. Dept. of Interior, Southeast Water Lab. , *Athens, Georgia

Relate the effect of ultraviolet radiation, temperature, biological activity, pH, and soil surface activity to rate of degradation of the esters of silvex in water. This information will make it possible to calculate the rate constants of degradation of these chemicals when applied as an aquatic herbicide.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0286, FLUOROMETRIC QUALITATION AND QUANITATION OF LIGNIN SULFONATES IN WATER

A.D. THRUSTON, U.S. Dept. of Interior, Southeast Water Lab., *Athens, Georgia*

Work is planned to study the potential of fluorescence spectrophotometry as a means of determining wastes from sulfite paper mills (lignin sulfonates) in water. A Hitachi Perkin-Elmer Model MPF- 2A Fluorescence Spectrophotometer has been purchased for this study.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0287, THE DISPOSITION OF PESTICIDES IN THE SOIL

O.E. ANDERSON, Univ. of Georgia, Agricultural Experiment Sta., *Athens, Georgia* 30602

A. To determine the distribution of pesticides in selected soils and their drainage waters, using sites to which known amounts of pesticides have been applied. B. To determine the physical, chemical, and biological processes, and soil characteristics which are important in the disposition of pesticides in soils.

The distribution of selected pesticides in soils will be determined by applying rates of pesticides to small, level, fallow, plots located on undisturbed profiles of differing soils of the Georgia Piedmont. Plots will be enclosed to retain rain which falls on a given plot and to prevent pesticide movement from plot to plot at the surface. At intervals, the profiles will be sampled to as much as five feet in depth and the pesticide content of the soil determined by standard methods. Studies will be extended to cropped soils after movement patterns have been characterized in fallowed soils.

Using soils selected for the movement studies, the pesticidal effect on mineralization and nitrification in unfertilized samples and in samples fertilized with an ammoniacal source, will be studied in the laboratory at temperatures from 2 degrees to 32 degrees C. by measuring the relative amounts of NH4, NO2, and NO3 at various time intervals. Variables will be types, rates, and methods of application with special attention to the placement relationship in the soil sample of pesticide to nitrogen source.

SUPPORTED BY U.S. Dept. of Agriculture
Georgia State Government

5.0288, RELATIONSHIPS BETWEEN PESTICIDES AND GEORGIA FARM POND ECOSYSTEMS

R.A. BARNHART, Univ. of Georgia, Agricultural Experiment Sta., *Athens, Georgia* 30602

This study is to provide some answers to the problems of the relationship of pesticides and farm pond ecosystems.

Most of Georgia's farm ponds are constructed on piedmont clay or coastal plains soils. These two major soil types will be employed in the experimental design which will test DDT and Endrin. Known concentrations of the pesticides will be introduced into plastic pools and the resulting concentrations in the two soil types, of flowing and nonflowing water systems, as well as concentrations contained in fishes and plants will be determined by use of gas chromatographic methods.

SUPPORTED BY U.S. Dept. of Agriculture
Georgia State Government

5.0289, BIOLOGICAL ACTIVITIES OF MARINE FUNGI

M.S. FULLER, Univ. of Georgia, Graduate School, *Athens, Georgia* 30602

The fungi are common in the oceans as saprophytes, parasites of algae, and invertebrate animals. This research has as its primary objective the aquiring of more precise information on the role of fungi in marine ecology. A group of little known coccoid organisms is to be examined morphologically, physiologically, and biochemically to determine both their evolutionary relationships and potential role in the marine environment. One such organism which may cause the gaping disease of oysters is being examined in greater detail. Two parasites each of marine algae and invertebrates are being subjected to detailed study to elucidate the (1) mechanism of host entry. (2) development of the parasites, and (3) the environmental and internal control of entry and development of the parasites.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0290, THE DISPOSITION OF PESTICIDES IN THE SOIL

J.E. GIDDENS, Univ. of Georgia, Agricultural Experiment Sta., *Athens, Georgia* 30602

Objectives: A. To determine the distribution of pesticides in selected soils and their drainage waters using sites to which known amounts of pesticides have been applied. B. To determine the physical, chemical and biological processes, and soil characteristics which are important in the disposition of pesticides in soils. Initial work will be on Treflan and Atrazine.

Procedure: Movement of herbicides in runoff water and in percolating water will be studied using tagged compounds wherever possible.

Herbicidal compounds will be applied to soil differing in properties. By soil perfusion and other techniques, breakdown rate of the herbicides as influenced by soil properties and enriched microorganisms will be determined. Attempts will be made using gas chromatography, spectral absorption, and bioassay to identify degradation products.

Herbicidal effect upon rhizosphere organisms and effect of rhizosphere organisms on herbicides will be determined after foliar and soil applications of herbicides and making plate counts and respiration studies of microorganisms. Specific root infecting fungi will be inoculated into the root zone in presence and absence of herbicides and their behavior studies.

Herbicidal effects upon soil processes as nutrification, N fixation, and X-transformations will be studied.

SUPPORTED BY U.S. Dept. of Agriculture
Georgia State Government

5.0291, ENTERIC BACTERIAL DEGRADATION OF STREAM DETRITUS

C.W. HENDRICKS, Univ. of Georgia, School of Agriculture, *Athens, Georgia* 30602

At the present time many of our clean freshwater lakes and streams are receiving loads of fecal material. Besides being aesthetically objectionable, such conditions are also a serious public health hazard, and little is known about the ability of enertic bacteria to metabolize organic materials associated with the aquatic environment. The major objective of this project is to conduct basic research on mechanisms by which enertic bacteria, including pathogens, can survive and multiply within the aquatic environment. Particular attention will be given to the understanding of the growth-promoting activity of the various types of substrates present within the stream and to describe conditions that will influence the rate of turnover of both bacterial populations and substrates. This type of knowledge should give a firm basis for the construction of a model to describe the self-purification potential of a stream and perhaps yield useful data on how presently contaminated bodies of water may be reclaimed.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0292, RELATIONSHIPS BETWEEN SUB-LETHAL PESTICIDES AND REPRODUCTION AND BEHAVIOR OF FISHES

J.P. KERR, Univ. of Georgia, Graduate School, *Athens, Georgia* 30602

This study proposes to examine the possible effects on the reproductive capacity in a few fish species of periodic and continuous exposures to sublethal concentrations of DDT and perhaps other pesticides.

Objectives: To improve knowledge on the reproductive capacity and behavior of certain fishes, especially the guppy; to assess in laboratory studies the possible effects of chronic and periodic sublethal exposures to pesticides, especially DDT and its derivatives, on the reproductive capacity of fishes, by exposing them to various pesticide concentrations and then noting changes in: (a) reproductive behavior patterns (primary emphasis) (b) general behavior patterns (c) rate of sexual maturation (d) gametogensis (e) gamete viability and fertilization.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0293, PHOSPHORUS BUDGETS OF LAKES SIDNEY, LANIER AND HARTWELL

D.C. SCOTT, Univ. of Georgia, Graduate School, *Athens, Georgia* 30602

Lakes Lanier and Hartwell although in two different water sheds are somewhat similar in type of watershed and in size. Lake Lanier, however, probably receives considerably more nutrients than does Hartwell. Preliminary studies on Lanier have disclosed some interesting vertical distributions of phosphorus and iron in the period immediately preceding fall overturn (the only time that samples have been taken by this investigator). These observations have aroused an interest in the phorphous cycle in this body of water. Parallel studies on Lake Hartwell may provide a contrasting situation which will aid in our understanding the phosphorus cycle in these impoundments and elucidate the fate of introduced nutrients in them.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Georgia

5.0294, AEROBIC DISPOSAL OF ANIMAL WASTES WITH CONTINUOUS WATER REUSE

R.E. SMITH, Univ. of Georgia, Agricultural Experiment Sta. , *Athens, Georgia* 30602

Objectives: To study the operating characteristics of a system for the disposal of animal wastes with continuous aeration and mixing of the wastes and the use of effluent from the system for the requisite dilution of low moisture animal wastes from cattle, swine, and poultry.

To determine the design parameters for the system of influent waste dilution, feeding rate, detention time, 5-day BOD reduction, and rate of sludge build-up.

Description: Prohibitive quantities of water are required to dilute animal waste for decomposition in aerobic disposal systems. This study will reuse the effluent of a laboratory aerobic disposal unit as the diluent of influent animal waste. It will determine if concentrations of any component of animal wastes will be detrimental to the growth of the requisite microbes. Information will be obtained about optimum input rates, dilution times, BOD reduction, and rates of sludge build-up.

SUPPORTED BY Georgia State Government

5.0295, RADIOTRACER STUDIES ON RAPID SAND FILTRATION

G.G. EICHHOLZ, Georgia Inst. of Technology, Water Resources Center, *Atlanta, Georgia* 30332

This project continues a current research project aimed at determining the distribution and dynamics of fine particles of given sizes in rapid sand or anthracite filters of controlled composition and size distribution. The effect of surface condition, flow rate, bed composition, and chemical exchange on primary deposition and subsequent elution of suspended matter in the filter is being studied by means of radiotracers. Continuous readings on deposition curves and detailed analysis of succeeding layers of the filter as well as the collection of dissolved tracer ions are employed to observe the behavior of the test filter under representative conditions. Analysis of the filtration curves makes it possible to evaluate appropriate kinetic coefficients for the adsorption and exchange mechanisms.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Georgia Institute of Technology

5.0296, DETERMINATION, EVALUATION, AND ABATEMENT OF COLOR IN TEXTILE PLANT EFFLUENTS

R.K. FLEGE, Georgia Inst. of Technology, Water Resources Center, *Atlanta, Georgia* 30332

Water pollution due to excess color is sometimes the result of textile mill effluents. It may be the result of discharged dyestuffs or it may be the result of an interaction of colorless dye intermediates with intermediates or finishing agents from the same or other plants or with natural organic waste in the stream. The problem has been greatly complicated in recent years by new classes of dyes and chemical auxiliaries for dyeing and finishing processes which have been introduced as a result of technologic innovations and new fibers.

The research will involve field and laboratory studies of the rate and extent of color build-up in streams carrying effluent from mills engaged in different kinds of textile processing. Laboratory investigations will include: (1) Spectrophotometric analysis of specimens from streams and mill effluents, 2) Development of spectrophotometric and chromatographic methods for characterizing the coloring matter, (3) Use of standard methods of water analysis to determine character and content of non-colored chemicals.

Field investigations will include: (1) Sampling of streams and mill effluent to obtain specimens needed to determine the time distribution and magnitude of color build-up, (2) interviewing management and technical personnel in plants which contribute seriously to the color pollution problem, (3) Correlation of laboratory and field data to provide a basis for recommendations to and action by the mills.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Georgia Institute of Technology

5.0297, DETERMINATION OF DEGRADED DYES AND AUXILIARY CHEMICALS IN EFFLUENTS FROM TEXTILE DYEING PROCESSES

R.K. FLEGE, Georgia Inst. of Technology, Water Resources Center, *Atlanta, Georgia* 30332

Work will be directed toward the development of methods for identification and quantitative measurement of dyes and chemical auxiliaries, in raw and treated textile mill effluents.

Chromatographic and indirect spectrophotometric methods of analysis will be investigated. Methods developed will be extended to cover residues, from those dyes and chemicals, originating from reactions in the dyebaths or waste treatment processes.

Dyeing formulae will be made up from widely used dyes and auxiliary chemicals. Analytical methods will be developed for identification of those known dyes and chemicals.

Effluents from commercial dyeing processes, that make use of chemicals in the model formula, both before and after conventional waste treatment, will then be analyzed in an attempt to determine the degradation product of those dyes and chemicals resulting from waste treatment processes.

Processing formulae using known dyes and auxiliary chemicals will be subjected to laboratory waste treatment techniques, simulating those used for treatment of domestic waste in conventional treatment plants and lagoons. Effluents from these experiments will be analyzed for presence of original dyes and auxiliaries and their forecasted degradation products.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Georgia Institute of Technology

5.0298, INVESTIGATION OF THE INFLUENCE OF VALENCE STATES OF IRON AND MANGANESE UPON THE BIOTA OF THE HYPOLIMNION

J.J. HEISE, Georgia Inst. of Technology, Water Resources Center, *Atlanta, Georgia* 30332

The proposed research will investigate the role of valence changes in manganese and iron cations and the resulting effectiveness of their utilization by micro-organisms of the hypolimnion. The study will investigate both the absorption of these cations in sediments and the factors which make them soluble for use by biota. Model systems will be formulated from the data obtained to predict the dynamic changes in reservoirs brought about by changes in valence states of cations that affect the biota. Additionally, optimal conditions for high quality water sources may be determined from the data.

Field work will involve the sampling of biota, water, and sediments of selected reservoir. In the laboratory, the samples will be analyzed, quantitatively and qualitatively simultaneously, for certain valence states of manganese and iron by electron spin resonance spectrometry; a secondary colorometric technique will be used to determine the total quantities of cations for comparison with valence states found; data will be evaluated to determine changes in the cations as they exist in solution, in micro-organisms, and in sediment.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Georgia Institute of Technology

5.0299, DIGESTION OF SLUDGES WITH SODIUM CHLORIDE AND SULFATE

R.S. INGOLS, Georgia Inst. of Technology, Engineering Experiment Station, *Atlanta, Georgia* 30332

The primary objective of the project is the determination of the cause of sludge digestion failure in the presence of industrial wastes containing several salts at critical concentrations. If sodium chloride plus sodium sulfide are synergistically toxic then a search will be made to find an economical solution to the sludge disposal problem.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0300, A STUDY OF GEORGIA RIVERS AND LAKES

R.S. INGOLS, Georgia Inst. of Technology, Engineering Experiment Station, *Atlanta, Georgia* 30332

The study of Georgia Rivers has been supported by a small budget over many years to permit the travel involved in observations of rivers and lakes near Atlanta for development of research work with outside support. At the moment, the support of a Water Resources Center project under public Law 88-379 has permitted an expansion of the research on water quality in the hypolimnion of lakes and the rivers below hydraulic power installations. Observations have been made while teaching or directing special student projects. Numerous basic publications have been developed and services rendered to industry and government agencies with the instruments acquired for these studies.

SUPPORTED BY Georgia Institute of Technology

5.0301, PRODUCTION AND DISPERSAL OF PATHOGENIC BACTERIAL AND VIRAL AEROSOLS BY AERATION OF CONTAMINATED WATERS

R. KING, Georgia Inst. of Technology, School of Engineering, *Atlanta, Georgia* 30332

The mechanism of bacterial aerosol production from polluted waters has been demonstrated for selected bacteria. These investigations, however, have not been expanded to include pathogenic bacteria and viruses.

It is proposed to investigate aerosol production from polluted waters as a possible pathway for the spread of tuberculosis and viral diseases.

Effects of tuberculosis have been demonstrated at extremely low concentrations of tuberculosis bacteria in the air. The spread of tuberculosis in the vicinity of certain sewage treatment plants by aerosol formation is, therefore, a possibility. Studies utilizing organisms which demonstrate similar characteristics to Mycobacterium tuberculosis will be conducted. Such an organism may be Mycobacterium smegmatis.

The survival rate of viruses has been shown to be quite high in air. An investigation to demonstrate aerosol formation by aeration of polluted waters as a means of dispersing viruses to the atmosphere will be undertaken using as subjects those viruses which attack bacteria (bacteriophages) to simulate those which are of importance to man.

Experimental equipment will include a controlled atmosphere (wind tunnel) equipped with devices for the aeration of bacterial and viral solutions under varying conditions (simulated sewage treatment processes). Down wind aerosol samples will be collected by means of slit samplers, settling plates, and others, analyzed by means of applicable microbiological techniques, and subjected to statistical analysis.

SUPPORTED BY Georgia Institute of Technology

5.0302, THE FINITE ELEMENT METHOD IN FLUID MECHANICS

P.G. MAYER, Georgia Inst. of Technology, School of Engineering, *Atlanta, Georgia* 30332

The finite element method is a powerful analytical tool in solving engineering problems. The present study is undertaken to explore the applicability of this method to hydraulic engineering.

Successful solutions have to be found in steady saturated subsurface flows. The application is to be extended to time-dependent problems. Its immediate usefulness may be in problems involving heat dissipation and the disposal of biologically or chemically degradable liquid wastes.

SUPPORTED BY Georgia Institute of Technology

5.0303, CHARACTERIZATION OF STREAM REAERATION CAPACITY

E.C. TSIVOGLOU, Georgia Inst. of Technology, School of Engineering, *Atlanta, Georgia* 30332

Research Objectives: The broad objective of this research is to fully develop techniques for the accurate evaluation of waste treatment needs and associated costs in specific situations as currently used procedures are not adequate. The principal source of difficulty and large error has been our inability to accurately evaluate the reaeration capacity of natural streams. Research begun by the Administration three years ago has been successful in providing a direct field technique for the accurate determination of stream reaeration capacity. This technique now forms the necessary basis for providing water pollution control agencies and industry with the means for accurate evaluation of and prediction of waste treatment requirements and costs.

The specific objectives of this research, are to apply the gaseous tracer method developed by the Administration to: evaluate the range of error normally associated with the various available mathematical models for predicting reaeration capacity (O'Connor-Dobbins, Churchill, etc.); on the basis of direct field observations of reaeration capacity, to develop the necessary modified and/or additional models for this purpose; and, to develop a standardized laboratory procedure for evaluating the effects of various kinds of water pollutant on the reaeration capacity of river water.

In order to assure results and procedures that are practical and directly applicable to specific problems, the proposed research is to be conducted with natural river waters and with specific real wastes such as municipal, paper mill, and poultry processing wastes.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0304, WEED AND ALGAE CONTROL, SMALL IMPOUNDMENT INVESTIGATIONS

UNKNOWN, State Game & Fish Commission, *Atlanta, Georgia*

Objectives: To determine the most effective new chemicals and/or technique for control of noxious aquatic vegetation.

To test pre-emergent treatments using soil sterilents during winter drawdowns using new herbicides as available.

Procedures: Field testing and observations of new aquatic herbicides and techniques will be initiated to determine feasibility for inclusion in management programs for the Commission. Controls will be used whenever possible in order to better evaluate herbicides and techniques tested. The numbers of experiments will be determined by the quantities of new herbicides that are available and the availability of satisfactory testponds.

New coil sterilents will be applied as available to the exposed mud flats of some ponds and evaluated the following summer after inundation. A reconnaissance survey of ponds with known weed problems will be conducted to select those most suitable for experimentation.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Georgia State Government

5.0305, HYDROLOGY OF COASTAL AREA IN THE VICINITY OF RICEBORO, GEORGIA

A.N. CAMERON, U.S. Dept. of Interior, Water Resources Division, *Atlanta, Georgia*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Georgia.

Purpose - To determine the hydraulic and chemical characteristics of surface waters in the North Newport River Drainage Basin and the piezometric surface and quality of water in the principal artesian aquifer in the vicinity of Riceboro prior to the beginning of operations of a large industry as well as after the plant is in operation.

Methods - The tidal behavior of the Newport River estuary will be studied and the amount of interchange between salt and fresh water, the time of travel through the estuary, and the dispersion patterns will be determined. Discharge measurements will be made. Chemical analyses will be made on water samples collected periodically and water quality monitors will be installed. Wind direction and velocity component data will be recorded at one station. Continuous water level recorders will be installed on four wells. Electric and gamma-radiation logs will be made of selected wells within 30 miles of Riceboro to determine the amount of casing and depth of the well and aid in interpretation of the geology and identification of the aquifer. Aquifer tests will be made at the plant site after completion of the plant wells.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Georgia State Government

5.0306, SALT-WATER ENCROACHMENT IN THE BRUNSWICK AREA, GEORGIA

D.O. GREGG, U.S. Dept. of Interior, Water Resources Division, *Atlanta, Georgia*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Georgia.

Purpose - To determine the feasibility of reducing the rate or stopping chloride contamination of the aquifer by pumping water from the underlying brackish-water zone.

Methods - Two wells will be constructed in the brackish-water zone near the focus of one area of contamination of the overlying fresh-water aquifers. One well will be pumped to reduce the artesian head in the brackish-water zone and the other used as an observation well. Water from these and existing wells will be sampled and head measurements will be obtained to observe the effects of pumping.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Georgia State Government

5.0307, TREATMENT OF KRAFT MILL EFFLUENT BY FOAM SEPARATION

R. ESTRIDGE, Georgia Kraft Company, *Rome, Georgia* 30161

The objective of this project is to explore the feasibility of using foam separation for concentration and/or removing components of high B.O.D. from Kraft mill wastes. Foaming equipment will be tested to evaluate the influence of design and operating variables or separation efficiency and to collect data for cost estimates and for design of larger-scale equipment.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Georgia Kraft Company

5.0308, TREATMENT OF SELECTED INTERNAL KRAFT MILL WASTES IN COOLING TOWERS

R.B. ESTRIDGE, Georgia Kraft Company, *Rome, Georgia* 30161

The objectives of this project are to determine the technical and economic feasibility of using cooling towers to reduce BOD and heat content of Kraft Mill Wastes and to reduce water usage in Kraft Mills. Studies will be carried out on both a pilot scale cooling tower and a large scale cooling tower.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Georgia Kraft Company

5.0309, RESERVOIR DESTRATIFICATION BY DIFFUSED AIR PUMPING FOR WATER QUALITY IMPROVEMENT

F.H. POSEY, U.S. Army, *Savannah, Georgia* 31402

Objectives: (1) To develop methods and equipment for destratification of reservoirs and water quality improvement. (2) To cause artificial mixing of water layers by air injection. (3) To increase dissolved oxygen content and to decrease iron and manganese concentrations in lower reservoir levels. (4) To eliminate stability within reservoir, caused by density layers during thermal stratification.

Progress Summary: The equipment currently is installed in a 367,500 acre-foot impoundment in North Georgia and consists of five 65-foot diameter cross-shaped air diffuser units (40 diffusers on each unit) suspended 10 feet above reservoir bottom with air supplied by five compressors, each with a capacity of 250 cfm at 100 psi. All physical, chemical, and biological parameters will be sampled and analyzed.

SUPPORTED BY U.S. Dept. of Defense - Army

5.0310, CHARACTERIZATION AND REMOVAL OF REFRACTORY COLOR COLLOIDS FROM HAWAIIAN SURFACE WATERS

N.C. BURBANK, Univ. of Hawaii, Water Resources Research Ctr., *Honolulu, Hawaii* 96822

Refractory color colloids in naturally occurring Hawaiian surface waters have long caused waters of otherwise potable quality to be regarded with aversion and as unacceptable by citizens even in the midst of drought.

Previous testing using the conventional coagulants have failed to give satisfactory removals of color.

The project is designed to determine the basic physical chemical electric properties of the refractory colloids, to determine their charge (zeta potential) and the character of the charge (cationic or anionic). It is also designed to determine the correlation of zeta potential with the dosage of coagulant or coagulant aid, the reduction of the zeta potential to discharge the color colloid, the selection of a high molecular weight coagulant aid to act as a weighing agent, and the further addition of a simple chemical or a synthetic polyelectrolyte to discharge the color colloid, to discharge the zeta potential to zero to assist in the collision and coagulation of the color colloids by the natural forces of attraction. In this the progression of the coagulation and colloid discharge must be observed with an instrument of the quality and capabilities of the zeta-meter.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Hawaii

5.0311, STUDY OF ESTUARINE POLLUTION IN THE STATE OF HAWAII

D.C. COX, Univ. of Hawaii, Water Resources Research Ctr., *Honolulu, Hawaii* 96822

A statewide survey of estuaries in Hawaii will be made to identify, from available information, present pollution problems, and sources and levels of pollution, and future pollution problems expectable from forecast development.

In Kaneohe Bay, Oahu, a field study will be made of the ecology, including bacterial pollution, trophic-dynamics of plankton, mineralization sedimentation and general water quality in relation to sewage disposal, surface runoff, and currents. Changes based on economic development will be forecast under various assumptions. The socio-economic value the various present and potential uses of the Bay will be determined under various assumptions as to methods of sewage disposal and surface runoff control.

5. WATER QUALITY MANAGEMENT AND PROTECTION

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
University of Hawaii

5.0312, SOILS, PESTICIDES, AND THE QUALITY OF WATER

R.E. GREEN, Univ. of Hawaii, Agricultural Experiment Sta. , *Honolulu, Hawaii* 96822

1. Establish whether movement through the soil constitutes a significant source of the pesticides found in surface and ground water. 2. Identify the properties of pesticides and of soils that control the extent of movement of pesticides in and through soils. 3. Ascertain the effects of management of pesticides and land on the transport, by all avenues, of pesticides to water supplies.

Leachability of surface-applied substituted urea and s-triazine herbicides will be studied in laboratory columns under controlled conditions. Equilibrium studies will be conducted to relate adsorption and desorption, if any, to physical and chemical properties of the herbicide materials and various soil constituents. Field studies will be made to determine the presence or absence of surface-applied herbicides and/or organic tracers in underground waters.

SUPPORTED BY U.S. Dept. of Agriculture
Hawaii State Government

5.0313, POLLUTION EFFECTS ON GROUND WATER RECHARGE IN HAWAII

L.S. LAU, Univ. of Hawaii, Water Resources Research Ctr. , *Honolulu, Hawaii* 96822

Determination of the absorptive and adsorptive capacities of Hawaii soils and fractured rocks with respect to certain potential pollutants of the underlying basal ground water bodies, including sewage constituents and selected pesticides that are applied through agricultural uses. Determination of quantitative and qualitative effects of recharge of the basal ground water by non-potable waters, including quantity and head increases, flow pattern and dispersion, fate and travel of pollutants after reaching the ground water bodies.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Hawaii

5.0314, IDENTIFICATION OF IRRIGATION RETURN WATER IN THE SUBSURFACE

R.H. YOUNG, Univ. of Hawaii, Water Resources Research Ctr. , *Honolulu, Hawaii* 96822

The proposed project will study the physical and chemical characteristics of return irrigation water derived from areas of tropical agriculture. Sampling will be from areas on Oahu, with principal sites at Kalauao and Kahuku, and Maui and Kauai. Well samples will be obtained from these areas for complete water analyses including determinations of pH, conductivity, chloride, sulfate, nitrate, hardness, bromide, iodide, boron, total organic carbon, and phenols. Basic data collection will necessitate sampling of rainwater, surface runoff, bulk-fallout and spring water. Tritium studies for flow tracing and age-dating of samples will be utilized. The total water quality information obtained will be collated and correlated with irrigation practices and land-use patterns to ascertain man's contributions to basal water, to assist in formulation of ground water quality standards, to identify patterns of ground water flow, rock weathering and chemical erosion.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Hawaii

5.0315, MARINE TOXINS OF THE TROPICAL PACIFIC

A.H. BANNER, Univ. of Hawaii, Hawaii Inst. of Marine Biology, *Kaneohe, Hawaii* 96744

In the investigation all marine toxins arising from the tropical biota of the reef and shore fauna of the Central Pacific that may be passed on to man, directly or indirectly, will be studied. The studies are divided into three major phases: the biological origin, the chemical isolation and identification, and the pharmacological action of the toxins. Correlated with the major aspects of the investigation is the accumulation of local island knowledge of toxic marine animals, native remedies, and the epidemiology of fish poisoning in the Pacific.

For the present year of investigation, as in the previous years, the main emphasis will be upon those fish which are regionally toxic and cause the loosely defined disease known as ciguatera: biological field studies will be conducted in French Polynesia; chemical studies will attempt to further elucidate the structure of the toxic molecule, now isolated; and pharmacological studies will be concerned both with the development of assay methods adaptable for field conditions and with investigations of the mode and site of action of the drug.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0316, PREVENTING OR CONTROLLING ACCELERATED EROSION OF UNSTABLE FOREST SOILS

W.F. MEGAHAN, U.S. Dept. of Agriculture, Intermtn. For. & Rge. Ex. Sta. , *Boise, Idaho* 83706

Object: To identify the interrelations of soil, water, and vegetation to soil stability; to determine mechanical and vegetation- cover requirements for stabilizing soil; and to study soil movement and water yield as affected by timber harvesting and roadbuilding methods.

Plan of Work: The project staff is continuing to survey natural land slumps on slopes and in channels. Studies are proceeding to evaluate the effect of hydrologic and erosion processes related to roadbuilding, logging, and natural land slumping. They are developing soil-stabilizing methods of roadbuilding, slash disposal, cover establishment, and channel structures. Pilot watersheds are being calibrated to evaluate the above processes and stabilizing procedures plus the comparison of logging methods that might be employed on steep unstable slopes.

SUPPORTED BY U.S. Dept. of Agriculture

5.0317, EUTROPHICATION RESEARCH AMERICAN FALLS RESERVOIR STUDY

V.C. BUSHNELL, U.S. Dept. of Interior, Bureau of Reclamation, *Boise, Idaho*

Eutrophication of the American Falls Reservoir has become an acute problem. This study includes sampling the reservoir at seven locations at different depths, and eleven significant inflowing streams at two- week intervals from May 1 - October 1, 1968 and 1969. Tests include: Temperature and DO on site; one quart samples with $HgCl2$ added to 40 ppm are analyzed for COD, $SiO2$, Phosphates, ammonia, nitrite, nitrate, and organic N; and one quart samples (iced) for pH, ED, B, $CO3$, $HCO3$, Cl, $SO4$, Ca, Mg, Na, K, and F. Notes are taken on visual algae conditions. One gallon samples are collected, as appropriate, for suspended solids.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

5.0318, DETERMINATION OF THE DISTRIBUTION OF RADIONUCLIDES DISCHARGED TO THE GROUND AT THE NRTS, IDAHO

J. BARRACLOUGH, U.S. Dept. of Interior, Geological Survey, *Idaho Falls, Idaho*

Program is a continuation of that conducted in previous years. The observation of migration of the radioactive isotopes contained in the aqueous wastes has been a primary part of the program. Underground movement has not yet reached a steady state and observations will continue until steady state is reached. The program consists of observation of radionuclide migration and is determined from empirical analysis of data on aquifer discharge effects observed as water level fluctuations in wells tracer studies using both natural and introduced elements for the purpose of determining both vertical and horizontal movement, determination of head differentials between aquifers and single wells and between wells and bore hole geophysical logging.

SUPPORTED BY U.S. Atomic Energy Commission

5.0319, HYDROLOGY OF SUBSURFACE WASTE DISPOSAL - NATIONAL REACTOR TESTING STATION, IDAHO

J.T. BARRACLOUGH, U.S. Dept. of Interior, Water Resources Division, *Idaho Falls, Idaho*

Objectives of this project are to acquire information on the geohydrologic and geochemical environment of the National Reactor Testing STation, requiring a study of the composition and structure of the earth materials underlying the plain, the inventory and continued evaluation of the water resources, the dynamics of the hydrologic cycle, and relevant geochemical processes. This information will help to determine within the environment the concentration of any increment of aqueous waste disposed and to define it qualitatively in time and place.

Attempts will be made to determine the direction and rates of vertical and lateral ground water movement within the basalt aquifer system, movement and dispersion of radioactive wastes, the volume of regional ground water movement and storage, and to apply the techniques of radioactive dating of the quaternary basalt and Tertiary rocks exposed in the area to the solution of structural problem significant in the geohydrology of the Station.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

5.0320, REDUCTION OF GROUND WATER INFILTRATION INTO SEWERS BY ZONE PUMPING

D.M. STOREY, Meridian City Government, *Meridian, Idaho*

The project consists of a 20 inch well, up to 100' deep and lined with a perforated casing. A pump of up to 700 gpm capacity is to be used with a probable total dynamic head of 35' to pump ground water out of the well into a drain ditch for transfer to a local stream. This will lower the water table and keep ground water infiltration out of the sanitary sewer system, thereby reducing flooding conditions to basements in the City of Meridian.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Meridian City Government - Idaho

5.0321, STREAMFLOW REGULATION AND SEDIMENT CONTROL IN NORTHERN ROCKY MOUNTAIN FORESTS

H.F. HAUPT, U.S. Dept. of Agriculture, *Moscow, Idaho*

Object: To relate forest characteristics and timber harvesting methods to snow accumulation and melt, streamflow peaks, sedimentation, and improved water yields; and to reduce streamflow peaks and sediment production and increase summer flow.

Plan of Work: The project staff is calibrating experimental watersheds to evaluate streamflow characteristics and sediment transport. Plot studies are progressing on roads and skid trails to determine, (1) erosional processes, (2) the hydrologic processes of infiltration, percolation, overland flow, and storage in relation to soils, and (3) watershed damage prevention methods. The staff is also conducting plot studies in timber-harvest areas to determine, (1) the effect of western white pine and lodgepole pine on snow behavior, (2) the effect of different cutting practices on precipitation disposition, (3) erosional processes, and (4) watershed damage prevention methods.

SUPPORTED BY U.S. Dept. of Agriculture

5.0322, AZOTOBACTER ECOLOGY

G.R. ANDERSON, Univ. of Idaho, Agricultural Experiment Sta. , *Moscow, Idaho* 83843

Objectives: (1) To determine whether or how Azotobacter propagate in the main streams and irrigation systems of Southern Idaho. (2) The identification and classification of Azotobacter from plot and soil studies. (3) To determine if Azotobacter can serve as an indicator of the toxicity of fluorine effluents.

There continues to be some promise in the possibility of using free-living microorganisms, particularly Azotobacter, as nitrogen suppliers for crops. The ecology of these organisms in Portneuf soils and related-irrigation waters will be studied. The effect of nutrients and climatological factors on Azotobacter in native waters will be followed through population changes. Unusual Azotobacter isolates from natural and artificially induced populations will be identified through known keys. The particular effect of fluorides on Azotobacter strains will be measured in soil, water, and laboratory cultures, using a fumigation chamber.

SUPPORTED BY U.S. Dept. of Agriculture
Idaho State Government

5.0323, AQUATIC ENVIRONMENT AND FOOD HABITS OF MAYFLIES

M.A. BRUSVEN, Univ. of Idaho, Water Resources Research Inst. , *Moscow, Idaho* 83843

The food habits of mayflies will be studied in northern Idaho, principally in the St. Maries and St. Joe River drainages. Both polluted and unpolluted waters will be investigated representing streams, ponds, and reservoirs. Gut analyses will be performed on the digestive tracts of immature mayflies to determine their food habits and preferences and to evaluate the role of food as a limiting factor in regulating the distribution and abundance of this aquatic group. In addition, the physical and chemical characteristics of the water will be studied, the substrate will be critically evaluated to understand microhabitat requirements and an attempt will be made to study the interrelationships of mayflies with other components of the biota in the aquatic ecosystem.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Idaho

5.0324, BEHAVIOR AND HABITAT INTERACTION OF BROOK TROUT AND CUTTHROAT TROUT

J.S. GRIFFITH, Univ. of Idaho, Cooperative Fishery Unit, *Moscow, Idaho* 83843

Objectives: 1) To study interaction in habitat selection between cutthroat and brook trout. 2) To study the comparative behavior of the two species, both intra- and interspecifically, and its role in habitat selection and maintenance.

Methods: 1) Sections have been chosen in each of three northern Idaho streams - one stream has only cutthroat present, one with brook trout only, the third with both species. 2) Map and physical parameters of each section. 3) Periodically during summer 1968 mark locations of fish in each section by skin diving. 4) Analyze habitat data by multiple regression technique to assess interaction. 5) Remove all members of one species in sections with sympatric populations to collect microhabitat data, and observe if remaining fish move to vacated areas. 6) Observe behavior in laboratory stream tank and in field.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
University of Idaho

5.0325, SOILS, PESTICIDES AND THE QUALITY OF WATER

G.C. LEWIS, Univ. of Idaho, Agricultural Experiment Sta. , *Moscow, Idaho* 83843

Emphasis of the project will be placed on the following objectives: (1) to establish whether movement through the soil constitutes a significant source of the pesticides found in surface and ground water. (2) To identify the properties of pesticides and of soils that control the extent of movement of pesticides in and through soils. (3) To ascertain the effects of management of pesticides and land on the transport, by all means, of pesticides to water supplies.

Organic phosphate compounds will be the class of pesticides studied. Leaching columns in the laboratory and field plots will be used to study the following variables in relation to pesticide movement: (1) soils of different texture, cation exchange status, and organic matter content. (2) Different moisture regimes-continuous leaching and adding solution in increments after equilibrium has been established. (3) Different ratios of calcium, magnesium, and sodium in the leaching solution.

SUPPORTED BY U.S. Dept. of Agriculture
Idaho State Government

5.0326, BIOLOGICAL PRODUCTIVITY OF THE COEUR D'ALENE RIVER AS RELATED TO WATER QUALITY

F.W. RABE, Univ. of Idaho, Water Resources Research Inst. , *Moscow, Idaho* 83843

The objectives of this study are (1) to collect and analyze certain physical and chemical data from the South Fork and North Fork of the Coeur d'Alene River, Idaho; (2) to measure primary production in various zones of the river and to estimate standing crop of herbivore and carnivore levels over a yearly period; and (3) to determine the median tolerance limits (tlm) of rainvow trout, Salmo gairdneri, to various concentrations and combinations of heavy metals from the river. Field collections will consist of collecting data from various locations in the river which typify clean water and water treated with mine wastes and domestic sewage. Periphyton will be collected to assess production. Laboratory studies will involve bioassays of fish under both static and running water conditions.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Idaho

5.0327, THE FEASIBILITY OF REUSE OF CHLORINATED SEWAGE EFFLUENT FOR FERTILIZATION AND IRRIGATION IN IDAHO (ABBREV)

R.E. WILLIAMS, Univ. of Idaho, Graduate School, *Moscow, Idaho* 83843

The objective of this study is the evaluation of the feasibility of statewide reuse of sewage effluent. The steps to be taken consist of: 1. Location of communities in Idaho producing sufficient volumes of effluent to merit construction. 2. Determination of average annual volume of effluent of reuse facilities produced by each community -- minimum usable volume will have to be determined during the course of the study. 3. Determination of type of treatment employed by each community. 4. Determination of type and thickness of soils and geologic formations in each community. 5. Determination of distance from each community to irrigated crop land or to a forested area which might receive effluent. 6. Determination of types of crop grown in each irrigated area. 7. Determination of type of irrigation system employed in each area. 8. Estimation of cost of introducing sewage effluent from each locality into the existing irrigation system. 9. Estimation of cost of chlorination of effluent. 10. An analysis of existing devices in each locality which may be used for the monitoring of the quality of waters moving downward toward the ground-water table. 11. Determination of distance from ground surface to ground-water table in each locality. 12. When possible an interpretation of the direction of movement of ground water at each locality. 13. Determination of annual volume of phosphate and nitrate currently applied to the irrigated land in each locality investigated -- the volume of effluent required to duplicate this application rate can subsequently be estimated.

Once these data have been collected and analyzed, it will be possible to define those areas in Idaho wherein the addition of sewage effluent to streams can be eliminated and safely and beneficially applied as fertilizer and irrigation waters to crop or forest lands.

SUPPORTED BY Idaho State Government

5.0328, AN INVESTIGATION OF FACTORS INFLUENCING WATER QUALITY IN SOUTH FORK, COEUR DALENE RIVER

R.E. WILLIAMS, Univ. of Idaho, State Bureau of Mines & Geol. , *Moscow, Idaho* 83843

The quality of the South Fork of the Coeur d'Alene River, Idaho, reportedly has been degraded by various users. However, little study of the river, its quality or the sources of its pollution has been undertaken. This study is designed to define the pollutants, determine their concentrations, their sources, and to recommend corrective measures.

SUPPORTED BY Idaho State Government

5.0329, AEROBIC SECONDARY TREATMENT OF POTATO PROCESSING WASTES WITH MECHANICAL AERATION

W.M. SWANSON, R.T. French Company, *Shelly, Idaho*

The objective of this project is to demonstrate the aerobic biological treatment for potato processing wastes, to establish design criteria and to develop construction and operating costs. The following systems will be studied: 1. Extended aeration with sludge return; 2. Flow through aeration without sludge return; and 3. Intermittent aeration with intermittent effluent withdrawal.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
R.T. French Company

5.0330, REAGENTS FOR DETERMINATIONS OF TRACE IMPURITIES IN WATER

A.L. CASKEY, Southern Illinois University, Graduate School, *Carbondale, Illinois* 62903

The proposed research plan involves laboratory investigations in the design of reagents for determinations of trace impurities in water. The first family of reagents involved will be sulfonated ortho nitrosonaphthols.

Problems proposed to receive early attention are: A. The Spectrophotometric determination of Nitrate in Water Using 2-Nitroso- 1-naphthol-4-sulfonic Acid. B. The Spectrophotometric Determination of Nitrite in Water Using 1-Naphthol-4-sulfonic Acid. C. Effect of the Position of the Sulfonic Acid Substituent on Acidity of the Naphtholic Hydrogen. D. Sodium 2-Nitroso-1-Naphthol-5-Sulfonate as a Reagent for Cobalt in Water. E. 2-Nitroso-1-Naphthol-7-Sulfonic Acid. F. Sodium 2-Nitroso-1-Naphthol-8-Sulfonic Acid.

The long term objective of this proposed research is to develop ideal reagents; sensitive, specific, stable, water soluble reagents for rapid, spectrophotometric determinations of trace impurities in water.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Southern Illinois University

5.0331, LOW ENERGY MECHANICAL OXYGENATION OF WATER

W.M. LEWIS, Southern Illinois University, Graduate School, *Carbondale, Illinois* 62903

A preliminary investigation of the principles involved in a new method of oxygenation was carried out. The results indicate the method to be more efficient than any technique now in use. This preliminary work was used by Mr. Gleen Kaffenberger as his master's thesis. During the summer it will be prepared for publication and a revision of an earlier grant proposal will be made in an attempt to obtain federal financing.

SUPPORTED BY Southern Illinois University

5.0332, CATALYTIC OXIDATION OF ORGANIC COMPOUNDS IN WASTE WATERS

G.V. SMITH, Southern Illinois University, Graduate School, *Carbondale, Illinois* 62903

It is proposed to examine the oxidation of organic compounds (especially water pollutants and related model compounds) in dilute aqueous solutions by heterogeneous catalytic and/or electrocatalytic techniques.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Southern Illinois University

5.0333, BIOLOGICAL SURVEY OF STREAMS OF COLES COUNTY, ILLINOIS

L. DURHAM, Eastern Illinois University, Graduate School, *Charleston, Illinois* 61920

This project's purposes are: 1. To determine the present species of fishes, macroinvertebrates and plankton in the streams of

Coles County, Illinois. 2. To determine the present environmental conditions in the streams with respect to pollutants (organic materials, silt loads, chemicals and others). 3. To compare the existing fish populations and environmental conditions with those present approximately 53 years ago as reported by Hankinson (1913).

This information will be useful in many forms of fresh water biology, including fisheries management and pollution control. Also, a planned flood control reservoir which is to be built near Charleston, Illinois will undoubtedly have considerable effect on many of these streams. This study will provide a good record of conditions prior to the influence of the reservoir.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0334, WHITE WATER CLARIFICATION AND REUSE

E.G. FOCHTMAN, I I T Research Institute, *Chicago, Illinois*

Work is directed toward the determination of preferred methods of using retention aids in the paperboard process. Flocculation of cellulose fibers is being monitored by electrokinetic measurements. The many retention aids which are currently commercially available are being evaluated to determine their cost-effectiveness and the conditions for optimum use.

SUPPORTED BY Boxboard Research & Development Assn.

5.0335, PHOTOLYSIS MECHANISMS FOR POLLUTION ABATEMENT

L.C. KINNEY, I I T Research Institute, *Chicago, Illinois* (14-12-443)

To determine the feasibility of oxidizing the soluble organic materials in wastewater by contacting the water with photoreactive materials. The photoreactive materials for this application would be those capable of producing active oxidizing species upon exposure to sunlight or the light from inexpensive artificial sources.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0336, MARINE OIL-WATER MONITORING INSTRUMENTATION SYSTEM SUBGROUP V

J.H. SEELINGER, I I T Research Institute, *Chicago, Illinois*

The Contractor has developed an IR absorption oil detection instrument which will report and record oil concentrations in water of 30 to 1500 ppm plus or minus 1%. A prototype instrument has completed extensive field evaluation and an improved second generation instrument is scheduled for field testing in Fall, 1968.

SUPPORTED BY U.S. Dept. of Commerce - Maritime Admin.

5.0337, AMMONIA STRIPPING MATHEMATICAL MODEL FOR WASTE WATER TREATMENT

R.H. SNOW, I I T Research Institute, *Chicago, Illinois* (14-12-193)

To develop a mathematical model of air stripping of ammonia from waster water. Variables to be considered are: pH, post-precipitation, operating temperature ranges, distribution of capital and operating costs. The model will be written in a FORTRAN language applicable to an IBM 360/65 computer.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0338, USE OF COAGULATION IN THE FLOTATION OF WASTEWATER

C.F. GURNHAM, Illinois Institute of Technol. , School of Engineering, *Chicago, Illinois* 60616

'Gross flotation' is the removal from a water medium of all species of particulate matter, including oily droplets, by attachment to the particles of freshly nucleated gas bubbles, followed by gravity separation and skimming. This process is currently in use for the treatment of industrial and municipal wastewaters, and serves to remove suspended matter including much that is not removable by the more conventional operations of primary treatment. Along with the suspended matter removal, the biochemical oxygen demand and other parameters of stream pollution are simultaneously reduced.

The process of gross flotation would be more widely used, to the benefit of the nation's waterways, if some of the present operating difficulties were better understood and could be removed, and if the operating efficiency of the process could be improved. The use of chemical coagulation in conjunction with gross flotation is an obvious means for improvement. Some waste treatment facilities have successfully employed this technique; other attempts have failed completely. Recycle ratio is undoubtly a significant variable; zero recycle gives the maximum yield of bubbles and the opportunity for nucleation on the dispersed particles, but damages or destroys the coagulant floc by the necessity of passing it through a pump and other constrictions. Increasing recycle ratios can eliminate the latter problem, and may still produce an adequate bubble yield. Nucleation, however, is an essential and little understood aspect. The hypotheses of time lag in nucleation and of a possible very significant distinction between nucleation in homogeneous and heterogeneous fluid media are to be investigated in the project.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0339, ISOLATION AND TAXONOMY OF YEASTS IN LAKES AND SEWAGE

L.R. HEDRICK, Illinois Institute of Technol. , Graduate School, *Chicago, Illinois* 60616

To date, 13 different sites in the Calumet River area on the Illinois-Indiana border have been sampled for yeasts. The two genera most often encountered were Candida and Rhodotorula. In an effort to determine just what aspects of pollution were affecting the yeast population, data on chemical and physical pollution indicators were fed along with the numbers of yeasts into an IBM 360 computer. At every station, it was found that two parameters which gave the highest regression values were the nitrite-nitrate nitrogen and dissolved oxygen content of the water.

Currently, a survey of changes in yeast populations with the seasons is being conducted. The following pathogenic yeasts have been isolated: Cryptococcus neoformans, Torulopsis glabrata, Candida tropicalis, Candida Parapsilosis, and Trichosporon cutaneum.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0340, EFFECTS OF SURFACTANTS ON FIBROUS BED COALESCENCE

R.C. KINTNER, Illinois Institute of Technol. , School of Engineering, *Chicago, Illinois* 60616

The efficacy of close-packed beds of a mixture of fibers of cotton and a supporting material has been demonstrated and the results published (Sareen, et. al., A.I.Ch.E. Journal, 12, 1045 - 1966). The effects of Surface Active agents were shown to be unpredictable by ordinary criteria. In the current work, it is proposed to characterize the various types of SA agents as to solubility, hydrolysis, polarity, ionic condition, etc., in such a way that their effect on coalescence of oil droplets in an aqueous liquid field can be predicted. The use of an emulsion 'break-time' test seems to be the best criterion to date. Surface phenomena are of paramount importance and the manner in which SA agents produce such interfacial conditions is a prime subject of this inquiry. The relation between these factors and coalescence is a final objective.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0341, ECOLOGY OF SPHAEROTILUS IN ACTIVATED SLUDGE

W.O. PIPES, Northwestern University, School of Engineering, *Evanston, Illinois* 60201

This project is a survey of activated sludge plants to determine 1) what types of filamentous organisms are present when the sludge has poor compaction characteristics, 2) the extent to which the compaction characteristics of the sludge depends upon the presence of filamentous organisms, and 3) environmental factors which encourage the growth of filamentous organisms in activated sludge. The research plan consists of collecting samples of sludge from a number of activated sludge plants; physical, chemical, and biological analyses of the sludge samples; and statistical analysis of the data to find correlations between the various parameters. Loss of sludge in the effluent due to poor compaction in the secondary settling tank or for other reasons is the most common operating problem with the activated sludge process and delineation of the factors which contribute to this condition should result in significant improvements in process operation.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0342, ULTIMATE DISPOSAL OF PHOSPHATE FROM WASTEWATER BY RECOVERY AS FERTILIZER

K.M. RIES, W.R. Grace & Company, *Lake Geneva, Illinois* 60047 (14-12-171)

A method will be developed for removing nutrients, i.e., phosphates and ammonia nitrogen, from wastewaters and converting them into a fertilizer material. The phosphates, which are concentrated in the aerobic step of the activated sludge process, will react with the ammonia present in the waste stream and added magnesia to form magnesium-ammonium-phosphate. This compound is of low solubility in water and can be separated by the use of flotation or other separation techniques. The separated magnesium-ammonium-phosphate sludge will be converted by further processing into a fertilizac material.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0343, DEVELOPMENT OF A MATHEMATICAL MODEL FOR SEPARATION COAGULATION AND SEDIMENTATION PROCESS USING ADDITION OF CHEMICALS

W.A. JASIONOWSKI, General American Trans Corp. , *Niles, Illinois* (14-12-416)

The contractor shall develop a mathematical model for coagulation and sedimentation of activated sludge process effluent using lime or alum as an additive. The emphasis shall be placed, first, on establishing the current state of design procedures for predicting the performance of existing equipment such as the Infilco Densator or Accelator. Next, limitations of current design procedure should be delineated by comparison with data from existing installations.

The limitations of existing design procedures should then be used as a basis for developing improved design procedures or, if necessary, recommending additional experimental programs.

The model shall consist of a set of preliminary design relationships for computing the size of the equipment required, the amount of chemicals and power required, and estimates of both capital and operating and maintenance cost. The performance of the process as expressed by the volume flow and concentration of all important species in the effluent streams from the process as a function of the characteristics of the influent stream and the operating and design conditions should be expressed in mathematical terms.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0344, DEVELOPMENT OF MATHEMATICAL MODEL OF SEWAGE SLUDGE FLUIDIZED BED INCINERATORS

J.D. ZEFF, General American Trans Corp. , *Niles, Illinois* (14-12-415)

To develop a mathematical model of the incineration of sewage sludge in a fluidized bed furnace. The model will be written in FORTRAN language applicable to an IBM 360/65 computer.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0345, SYSTEMS APPROACH TO COMBINED SEWER-STORMWATER OVERFLOW POLLUTION ABATEMENT

J. FINK, Shelbyville Government, *Shelbyville, Illinois* 62565

This project is a full-scale demonstration of the application of several control and treatment methods applied in a coordinated manner to abate pollution of surface waters caused by overflows of untreated wastes from combined storm and sanitary sewers.

The effectiveness of treating combined sewer overflows from small drainage areas utilizing three types of detention and treatment units will be evaluated. The individual units will be incorporated into a total control system for the community.

Units to be installed and evaluated include: 1. lagoon designed for 5-day detention of a 10-year storm, followed by primary and secondary stabilization lagoons--receiving flow from 95% of the drainage area. 2. A storm overflow holding tank for 600% of dry-weather flow. 3. weather flow with 2-hour detention. The tank will be equipped with a chlorinator, comminuter, solids collecting facilities and lift station to pump sludge to the municipal sewage treatment plant.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Shelbyville City Government - Illinois

5.0346, COOK STREET STORM WATER OXIDATION POND

P. TROEMPER, Springfield San. Dist. No. 5, *Springfield, Illinois*

Springfield, like many older cities, has an extensive system of combined sewers. Separation of these sewers is economically impractical at the present time. Conventional treatment of the combined sewer overflow is not considered feasible since it would be difficult to keep available a supply of organisms sufficient to treat the storm volumes. The oxidation pond seems to provide the most likely possibilities for a solution. Tributary to this project contains approximately 12.5 square miles of separate sewered area and 3.25 square miles of combined sewered area. It is proposed to investigate feasibility of the oxidation pond to treat combined sewer overflows by measuring flow from the pond, and 24 hour composite sampling of both pond influent and effluent for BOD, suspended solids, and coliform counts. Daily grab samples will be taken at 3 points in the receiving stream for D.O., BOD, suspended solids and coliform count. Biological sampling of the pond and stream will be done at monthly intervals. A fish assay of the stream will be run before the start and at the completion of the investigation.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Springfield City Government - Illinois

5.0347, HYDROGEOLOGY OF SOLID WASTE DISPOSAL SITES

G.M. HUGHES, State Geol. Survey, *Urbana, Illinois*

The objectives of this project are to investigate, in northeastern Illinois, hydrogeologic environments which are currently being used for shallow solid waste disposal, and to evaluate the factors which control ground-water movement of refuse leachate in these environments. Criteria are sought to judge the suitability of proposed disposal sites not only in glaciated areas, such as northeastern Illinois, but in many other areas as well.

Existing landfills are being studied, and the investigation is proceeding by: (a) drilling by wash boring or with hollow stem augers to determine the character and sequence of deposits, (b) installation of piezometers to define fluid potential distribution and the ground- water flow system, (c) sampling of the ground water for chemical analysis, (d) a monitoring program of the piezometers to determine seasonal variations of the flow system.

SUPPORTED BY Illinois State Government
University of Illinois
U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0348, EFFECTS OF POSSIBLE POLLUTANTS ON ENERGY PRODUCTION BY BLUEGILL LIVER MITOCHONDRIA

R.C. HILTIBRAN, State Natural History Survey, *Urbana, Illinois*

In 30 Warburg experiments, data indicate that of the four metals, cadmium, zinc, manganese and calcium, cadmium, zinc and manganese altered oxygen uptake more than phosphate uptake whereas calcium altered phosphate metabolism more than oxygen uptake. Less extensive data on other metals indicated that divalent and monovalent copper, trivalent and divalent iron, cobalt and aluminum severely inhibited oxygen uptake over a wide concentration range but did not alter phosphate metabolism at any level. Chromium and barium inhibited oxygen uptake only at high levels, but did not alter phosphate uptake.

The ultimate objective of these investigations is to attempt to correlate the effect of these metals on oxygen and phosphate uptake with the recorded toxicity data of these metals to bluegills.

SUPPORTED BY Illinois State Government

5.0349, CHEMICAL CONTROL OF AQUATIC VEGETATION

R.C. HILTIBRAN, State Natural History Survey, *Urbana, Illinois*

Seven new herbicide preparations were used for the first time during 1967. A total of 36 herbicide preparations were applied to 13 aquatic plant species in 119 test areas in 14 bodies of water. Preemergent herbicides were tested in 69 test areas. Most of the preemergent applications were made in late December 1966 and the remainder in April of 1967. The recent development of leafy pondweed, Potamogeton foliosus, in Allerton Lake has given us an opportunity to test the effect of preemergent herbicides against that species. The results indicated that rates of 20 lbs/acre of dichlobenil and fenac did not give season-long control of leafy pondweed and new approaches will be tried in attempts to obtain season-long control. Recently it was brought to my attention that spatterdock, Nuphar advena, and waterstargrass, Heteranthera dubia, were not controlled in Illinois by herbicides suggested for their control. It was found that granular silvex and 2,4,5-T at a rate of 80 lbs/acre substantially reduced stands of spatterdock within the treated area. Liquid applications of silvex and 2,4,5-T were not effective. Waterstargrass was eliminated from the treated areas by diquat cation at a rate of 1 ppm. The effect of other herbicides on waterstargrass was not determined.

Most of the herbicides tested for the first time were not as effective on the species treated as are the currently available herbicides.

SUPPORTED BY Illinois State Government

5.0350, INORGANIC ADDITIONS RESULTING FROM WATER USE

R.L. EVANS, State Water Survey, *Urbana, Illinois*

Normal waste treatment systems are designed to remove only the suspended and biodegradable organics. Therefore, the general character and concentration of the mineral constituents in 'one use water' are being studied as a means of assessing the reuse potential of such waters for agricultural and industrial practices or other uses.

In the initial phase of the study, five residential areas were selected, and analyses were performed on samples collected at weekly intervals from water taps and from sewers in each area. The second phase of the study will involve the collection of composited samples in the same areas to obtain an estimate of the additions of refractory organics to a water subjected to a domestic use of one cycle. Projection of the study will involve determining that proportion of common ions contributed by industrial usage of water in municipalities.

SUPPORTED BY Illinois State Government

5.0351, ILLINOIS RIVER STUDY

R.L. EVANS, State Water Survey, *Urbana, Illinois*

The principal purpose of the study is to determine the waste assimilative capacity of a 77-mile sector of the Illinois River from Pekin to LaGrange, Illinois. Since in this particular investigation the capacity is considered contingent upon the oxygen resources of the stream, field work is limited to critical periods of high temperature with low flow. An evaluation of existing data would appear to preclude the use of conventional analytical techniques for making an intelligent appraisal of the stream's capacity. Proper analysis will permit reasonable decisions regarding the degree of waste treatment required.

SUPPORTED BY Illinois State Government

5.0352, BIOLOGICAL ASPECTS OF TERTIARY PONDS

R.L. EVANS, State Water Survey, *Urbana, Illinois*

Tertiary ponds of relatively short detention periods (2-5 days) have successfully demonstrated their value in improving the effluent from secondary units of sewage treatment works. Field observations of a 23-acre pond complex, with depths varying from 10-16 feet receiving treated sewage at an average flow of 25 mgd revealed the major biological organisms, other than bacteria, to be protozoa. An investigation has been undertaken to monitor the phytoplankton population in the ponds and associated environmental conditions for an 18-month period.

SUPPORTED BY Illinois State Government

5.0353, DIATOM REMOVAL BY FLOCCULATION

R.L. EVANS, State Water Survey, *Urbana, Illinois*

Plankton examinations suggest the principal forms of algae in Peoria Lake (on Illinois River) are diatoms. Recent studies indicate that some of the abundant genera are those associated with sand filter clogging. An existing water treatment plant pumping mgd from Peoria Lake provides a means for determining the removal efficiency of plankton in a clarifier preceded by a flocculation unit. Data to be evaluated will include flow, detention, chemical dosages, temperature, chemical characteristics of raw water, floc formation, and plankton reduction.

SUPPORTED BY Illinois State Government

5.0354, LIMNOLOGICAL STUDY OF PEORIA LAKE

R.L. EVANS, State Water Survey, *Urbana, Illinois*

A short-term study of Peoria Lake (on Illinois River), commencing in March 1967, was undertaken to gain some insight on the dynamics of phosphorus, nitrogen, iron, turbidity, and silica as related to phytoplankton productivity in natural waters. Two hundred and twenty- five water samples have been collected and subjected to chemical and biological examination. Evaluation has been substantially completed and a report is being prepared.

SUPPORTED BY Illinois State Government

5.0355, NUTRIENT REMOVAL IN A WATER TREATMENT PLANT

R.L. EVANS, State Water Survey, *Urbana, Illinois*

The Illinois River with a total phosphorus concentration ranging from 0.5 - 3.0 mg/l (as P) serves as a source of water for the city of Peoria. Treatment units consisting principally of a flocculator, clarifiers, and sand filters produce potable water. The uses of chemical coagulants, filtration, and biological stripping have been demonstrated as possible avenues for phosphorus removal. This study involves the collection and analyses of water samples for the purpose of determining the extent of phosphorous and ammonia-N removal as well as changes in COD, BOD, total residue, and others and the role each treatment unit contributes to such removal or changes in concentration.

SUPPORTED BY Illinois State Government

5.0356, HYDRAULICS OF STORM SEWER JUNCTIONS

H.W. HUMPHREYS, State Water Survey, *Urbana, Illinois*

The growth of new urban areas has made urban storm drainage a major problem in the country today. There is an urgent need to improve designs for the several parts of a storm drainage system. As one facet of the needed research, a model test program is planned to study the hydraulics of storm sewer junctions. At the present time, storm sewer junctions are designed by 'rules of thumb,' developed through the years in engineering practice. The model tests should indicate the validity of these 'rules.' If better design criteria can be developed, the design procedures then can be modified, which could result in more economical structures.

SUPPORTED BY Illinois State Government

5.0357, OXYGEN RELATIONSHIPS IN SMALL STREAMS

J.H. AUSTIN, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

The relative importance of atmospheric reaeration, photosynthesis, biological oxidation, sedimentation and benthal deposits by detailed mass balance studies of sections of a small stream are underway. An attempt is being made to correlate the magnitude of these sources and demands upon the oxygen level in the stream with the various factors that may influence them. These would include stream loading, flow, velocity, depth, temperature, light, and possibly others. Experimental equipment for these measurements has been constructed.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0358, REVIEW OF ALGALCIDES

J.H. AUSTIN, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

This study consists of a literature search for algicides or potential algicides that can be used for the control of nuisance algae in domestic water supplies. Preliminary screening of potential algicides will be discussed as well as the necessary data that must be obtained before an algicide can be used in domestic water supplies. Reference material will be included in a comprehensive bibliography.

SUPPORTED BY University of Illinois
U.S. Dept. of Interior - F. Water Pol. Ctl

5.0359, REDUCTION OF HAZARDS ASSOCIATED WITH INSECTICIDAL CHEMICALS IN THE ENVIRONMENT

W.N. BRUCE, Univ. of Illinois, Agricultural Experiment Sta., *Urbana, Illinois*

Objectives: 1. Determine the fundamental physical, biochemical, an biological factors influencing occurrence, magnitude, interaction, and persistence of insecticidal chemical residues in soils and raw agricultural commodities. 2. Identify and evluate fundamental factors influencing the magnitude and mechanism of air and water pollution by insecticidal chemical residues. 3. Develop basic studies related to the metabolism and detoxication of insecticidal chemical residues in animals, plants, soils and water. 4. Identify and evaluate the effects of residues of insecticidal chemicals on eco-systems with special emphasis on fish and wildlife. 5. Explore the reciprocal influences of residues of insecticidal chemicals on soil microflora, microfauna, and non-insect fauna. 6. Develop and improve analytical techniques essential to the pursuit of this research.

Procedures: To study the persistence, metabolism and detoxication of insecticide chemical residues in soils, plants, animals and water and study the effects of toxicant residue on ecosystems in soils and water.

SUPPORTED BY U.S. Dept. of Agriculture
Illinois State Government

5.0360, LIVESTOCK WASTE MANAGEMENT AND SANITATION

D.L. DAY, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

Field testing the oxidation ditch method of treating manure collected beneath slotted floors in hog finishing buildings is in progress. A second partially slotted floor building has been equipped with a rotor. Data including D.O., B.O.D., C.O.D., pH., temp., solids, and fertilizer value are being collected and analyzed by a digital computer program. Foaming has continued to be somewhat of a nuisance, but the material in the gutter has been maintained in an odorless condition. Complete biological stabilization has not been achieved without subsequent treatment.

An investigation of aerating cattle manure was performed by D. D. Jones for his M.S. degree thesis research. The objective was to determine the aerobic-digestion characteristics of beef and dairy cattle on high-concentrate rations. Significant reductions of biodegradable organic-matter were obtained without odor problems.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0361, MECHANISMS OF SLUDGE THICKENING

R.I. DICK, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

It is proposed to continue previous work which has shown present criteria for evaluating the solids loading capabilities of settling tanks to be inadequate when applied to activated sludge because of their failure to consider the rheological properties of the material. Attempts will be made to define the fundamental mechanisms which control the behavior of the sludge. The techniques for examining the thickening properties of activated sludge will be extended to other suspensions which are troublesome in water and wastewater treatment because of their failure to consolidate into compact masses. Results of laboratory batch settling tests will be compared to the performance of continuous processes in the laboratory and the field. Knowledge of the basic properties of the suspensions will be employed to evaluate possible chemical, physical or biological processes or alterations of conventional processes which might improve the effectiveness of sludge thickening. Rational bases of design of the thickening portion of settling basins, as suggested by results of the fundamental studies, will be proposed.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0362, SECONDARY EFFLUENT POLISHING BY RAPID SAND FILTRATION

R.I. DICK, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

The suitability of rapid sand filtration as a means of advanced treatment of effluent from secondary biological waste treatment plants is being investigated. Two pilot models of rapid sand filters have been installed and operated at an activated sludge waste treatment plant. Final effluent from the plant has been used. Changes in suspended solids, biochemical oxygen demand, chemical oxygen demand, dissolved oxygen, and nitrogen compunds have been noted.

SUPPORTED BY University of Illinois

5.0363, APPLICATION OF SEWAGE SLUDGE TO FIELD CROPS

R.I. DICK, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

Investigations are being carried out to evaluate the effect of digested sludge constituents on crops, land, and on ground and surface water. A few of the potential sources of concern are heavy metals, nitrates, and pathogenic microorganisms. Other information needed to permit a rational approach to the design of new systems involving liquid application of sludge to land is being sought. Examples of such information are the optimum dosage intensities and frequency for various climates, crops, and soil types and the effect of various sludge application methods such as flooding and spraying.

SUPPORTED BY Chicago City Government - Illinois

5.0364, VIRUS REMOVAL BY CHEMICAL FLOCCULATION

R.S. ENGELBRECHT, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

The purpose of the proposed research is to delineate the basic mechanisms involved in the removal of viruses by alum flocculation. The first stage in the removal of viruses by coagulation and flocculation appears to be the formation of a virus-aluminum complex, followed by subsequent precipitation and flocculation of the complex. The first phase of the study will investigate the interaction of the virus with the metal ion by (a) demonstrating the complex formation between aluminum and viruses and (b) determining the nature of the 'complex' and virus inactivation by aluminum. The second phase will be directed towards a quantitative investigation of virus removal by alum flocculation under controlled laboratory conditions, studying such variables as pH, organic matter, bivalent metal ions like calcium and magnesium, and synthetic polyelectrolytes. Throughout the study, a bacterial virus will be used as a model. The results with the bacterial virus will be confirmed using an animal virus so as to be able to interpret the data in terms of viruses which may be significant in water supplies.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Illinois

5.0365, UPTAKE AND RELEASE OF SOLUBLE ORTHOPHOSPHATE BY ACTIVATED SLUDGE

R.S. ENGELBRECHT, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

A laboratory study of the effectiveness of the activated sludge process to remove phosphorus from liquid wastes has been carried out. The overall objective of the investigation was to examine the parameters that are involved in optimizing the uptake of soluble orthophosphate, and minimizing the release of soluble orthophosphate by activated sludge mixed liquor suspended solids. The variables considered were temperature, pH, food to microorganisms (F/M) ratio, contact time, aeration rate, concentrations of orthophosphate, dissolved oxygen, and degree of mixing.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
University of Illinois

5.0366, ACCLIMATION OF HIGH RATE ANAEROBIC DIGESTION

R.S. ENGELBRECHT, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

An investigation of the properites of methane-forming organisms, capable of utilizing acetate, is important for a better understanding of the basic mechanism of methane fermentation. Laboratory experimental digesters which are fed acetate do not show a normal rate of gas production, but the addition of certain complex organic materials to the digesters does stimulate gas production, which indicates a greater rate of methane fermentation. Methane production can be stimulated by yeast extract.

SUPPORTED BY University of Illinois

5.0367, CHLORINATION OF WASTE WATER EFFLUENTS

R.S. ENGELBRECHT, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

The objective of this study is to investigate the effect of a chlorinated waste effluent on the bacteria population of a small, receiving stream. The effluent from the activated sludge treatment plant at Paxton,, Illinois, discharges into a small stream which is being sampled above and below the outfall. Effluent and the stream samples are being analyzed for total coliform, fecal coliform, and enterococcus bacteria in the absence of and during chlorination of the waste effluent.

SUPPORTED BY University of Illinois

5.0368, FACTORS INFLUENCING FREE-LIVING NEMATODES IN WATER SUPPLIES

R.S. ENGLEBRECHT, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

It has been observed that nematodes can be removed effectively by rapid sand filtration if their motility can be reduced. The use of various chemical agents, e.g., chlorine, bromine, copper sulfate and silver nitrate, on nematode motility is being evaluated in terms of nematode removal by subsequent water treatment processes. Results indicate that 3mg/l of free available residual chlorine, prior to coagulation, sedimentation and filtration, can eliminate more than 99 percent of the nematodes in the finished water as compared to about 66 percent in systems without chlorine. Copper sulfate was effective only when the hardness of water was low. Studies are being continued, using tap water, sewage treatment effluent, and stream water to determine the efficiency of different chemicals under various conditions, e.g., pH, organic and inorganic composition of the water.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0369, EFFECTS OF OXYGEN DEMAND ON SURFACE REAERATION RATES

E.R. HOLLEY, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

For turbulent water flow with no oxygen demanding materials in the vicinity of the air-water interface, the surface reaeration rate has been shown to be proportional to the rate of turbulent energy dissipation. When oxygen demand is present, dissolved oxygen may be 'consumed' near the water surface and allow a more rapid reaeration. In this research, it is proposed to experimentally investigate the extent of the increase in reaeration rate due to the presence of different amounts and different types of oxygen demand. The experiments will be conducted both in a vessel with no throughflow where turbulence is generated by oscillating screens and in open channel flows with various roughness. The laboratory results will be compared with available field data.

SUPPORTED BY University of Illinois

5.0370, TRANSPORT PROCESSES OF PARTICLES IN DILUTE SUSPENSIONS IN TURBULENT WATER FLOW

B.G. JONES, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

An experimental and analytical study of the behavior of small particles in dilute suspension in turbulent water flow in a circular tube is being conducted. Individual particle trajectories are examined by recording analog signals of the motion on magnetic tape, converting these into digital form and processing them with high-speed digital computers. The detailed characteristics of the turbulent fluid field are determined by using hot-film anemometer techniques. The macroscopic and microscopic characteristics of the particle motion are determined directly from the trajectory information. The former are compared with analytical predictions of dispersion and sedimentation. The latter provide insight into the detailed structure of the particle motion which is necessary to determine the validity of analytical models.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Illinois

5.0371, INVESTIGATION OF THE TURBULENT TRANSPORT MECHANISMS FOR HEAT AND MOMENTUM TRANSFER IN PIPE FLOW

B.G. JONES, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

Detailed turbulence characteristics are measured in fully developed pipe flow of water in which a temperature field, due to uniform heating of the pipe wall, is present. It is proposed to investigate, (i) the coupling of the turbulent velocity and temperature fields, (ii) the influence of molecular properties on the turbulence characteristics, (iii) the validity of turbulent diffusion models, and (iv) the characteristic parameterization of turbulence. Instantaneous fluctuations of fluid velocities (3 components) and temperature are monitored simultaneously by three hot-film aneometer sensors and a fast response thermocouple respectively. Analog-to-digital conversion is employed with statistical analyses subsequently performed by a digital computer. The detailed structure is studied in this manner.

SUPPORTED BY University of Illinois

5.0372, (U) DETERMINATION OF FREE BROMINE IN WATER (US 14)

T.E. LARSON, Univ. of Illinois, State Water Survey Division, *Urbana, Illinois* (DA-49-193-MD-2909)

CHEMISTRY OF BROMINE, TO DEVELOP A SUITABLE ANALYTICAL METHOD FOR FREE BROMINE AND BROMAMINES IN WATER, AND TO EXAMINE THE REACTION OF CHLORINE WITH AMMONIA IN THE PRESENCE OF BROMIDE ION.

TECHNIQUES USEFUL FOR CHLORINE AND IODINE SPECIES IN WATER WILL BE EXPLORED AND MODIFIED WHERE NECESSARY. COLORIMETRIC AND AMPEROMETRIC METHODS WILL BE EMPHASIZED.

COLORIMETRIC REAGENTS WERE EVALUATED ON THE BASIS OF THEIR REACTIONS WITH BROMINE, CHLORINE, CHLORAMINES AND BROMAMINES. AT THE PRESENT TIME METHYL ORANGE AND PHENOL RED ARE THE BEST AVAILABLE REAGENTS FOR TOTAL BROMINE AND ARE IN GOOD AGREEMENT. BROM CRESOL PURPLE IS THE BEST AVAILABLE REAGENT FOR FREE BROMINE. . PHENOSAFRANIN GIVES REASONABLY GOOD RESULTS FOR FREE BROMINE, BUT ITS PRIMARY APPLICATION MAY BE IN DETERMINING HIGH CONCENTRATION OF BROMINE /UP TO 10 MILLIGRAMS PER LITER/. BREAKPOINT CURVES WITH BROMINE AND AMMONIA HAVE BEEN DETERMINED FOR VARIED CONTACT TIMES AND AT DIFFERENT PH VALUES. THE BROMAMINES ARE FAR LESS STABLE THAN THE CHLORAMINES. STUDIES OF THE STABILITY UNDER VARYING AMMONIA-TO BROMINE RATIOS AND VARYING PH VALUES HAVE BEEN MADE. A STUDY WAS MADE OF THE REACTION OF CHLORAMINES WITH BROMINE ION. NO EVIDENCE OF BROMAMINE FORMATION WAS FOUND BY ULTRA-VIOLET ABSORPTION, BUT STABILITY OF THE CHLORAMINE SOLUTION WAS DECREASED, AND IT APPEARS THAT UNSTABLE BROMAMINE WAS FORMED SLOWLY. THE CHLORAMINEBROMIDE ION SOLUTIONS EXHIBITED CHARACTERISTICS SIMILAR TO THOSE OF BROMINE SOLUTIONS. AS WITH BROMAMINE SOLUTIONS, THE STABILITY OF CHLORAMINEBROMIDE SOLUTIONS MAY BE IMPROVED BY INCREASING THE AMMONIA BROMINE /OR BROMIDE ION/ RATIO OR BY INCREASING PH.

SUPPORTED BY U.S. Dept. of Defense - Army

5.0373, CORROSION AND TUBERCULATION IN DISTRIBUTION SYSTEMS

T.E. LARSON, Univ. of Illinois, State Water Survey Division, *Urbana, Illinois*

This study is designed to determine the relative effect of the various factors which cause or inhibit the corrosion of cast iron in water distribution systems. The variables of water quality being evaluated are calciums, alkalinity, chlorides, and pH, as well as various inhibitors. A study is also in progress on the rapid deposition of thin coatings of calcium carbonate as a protective measure after cleaning of water mains.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0374, DISINFECTION OF SMALL QUANTITIES OF DRINKING WATER

J.T. OCONNOR, Univ. of Illinois, School of Engineering, *Urbana, Illinois* (DADA-17-67-C-7062)

Tech. Objective - A feasibility study. Attempts will be made to formulate a disinfectant in tablet or other form for the disinfection of small quantities (canteens) of drinking water.

Approach - Study will explore alternative methods of disinfection for use by individual soldiers in the field. Convenience and effectiveness of the method will be stressed. Consideration will be given to an effervescent tablet containing chlorine or iodine plus a buffer and to disinfection employing oxidizing agents other than the halogens.

Progress - (Jan 67 - Jun 68) As part of the effort to prepare a comprehensive literature review, the important literature on the subject of disinfection is being abstracted or reproduced. Ultimately, this information will be synthesized into what is hoped will be a comprehensive and readable summary of the state of water disinfection. Prominent authors and laboratories are being contacted for internal, unpublished or pre-publication copies of documents pertaining to disinfection. In addition to chemical manufacturers and suppliers, we have contacted the Chlorine Institute and Chilean Iodine Institute in a search for new products for disinfection.

SUPPORTED BY U.S. Dept. of Defense - Army

5.0375, INVESTIGATIONS OF THE REMOVAL OF IRON FROM GROUNDWATER SUPPLIES IN ILLINOIS

J.T. OCONNOR, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

A new process for iron removal results in the more rapid and complete precipitation of iron from ground waters. In addition, precipitated iron is readily removed from suspension by diatomaceous earth filters. The research study was primarily aimed at the determination of the rates of iron removal and the mechanisms through which calcined magnesite promotes more rapid and complete precipitation of iron.

SUPPORTED BY University of Illinois
Johns Manville Products Corporation

5.0376, CALCULATION OF CHEMICAL DOSAGES IN LIME-SODA SOFTENING

J.T. OCONNOR, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

The effect of the incremental addition of lime and soda on chemical equilibrium in a hard water is being determined using fundamental equilibrium expressions. A simplified technique for the solution of chemical softening problems is sought.

SUPPORTED BY University of Illinois

5.0377, CONTROL OF BIOLOGICAL GROWTHS IN RAPID SAND FILTERS AS RELATED TO IRON REMOVAL

J.T. OCONNOR, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

Problems with the reduction of iron from the ferric to the ferrous form in sand filters have been associated with the consumption of dissolved oxygen dure to nitrification. In addition to the leakage of iron through the filter, nitrified filter effluents are found to have lowered oxidation-reduction potentials, lowered pH, and high total bacterial counts. It is proposed that studies be conducted to test practical remedial measures for the inhibition of biological growths in rapid sand filters being used for the removal of iron. Inhibition of nitrifying organisms would prevent nitrification in filters treating ground waters which contain ammonia. Remedial measures to be evaluated for the control of biological growths will include periodic chemical disinfection of the filter media at the time of the filter backwash. In addition, the effect of more efficient backwash procedures, employing physical methods such as surface or air wash, will be observed.

SUPPORTED BY University of Illinois

5.0378, DIFFUSION AND FLOW IN INTERPHASE TRANSPORT

J.A. QUINN, Univ. of Illinois, Graduate School, *Urbana, Illinois*

In elucidating interphase transport, whether encountered in conventional engineering operations or in the many and varied problems involved, in the supply and efficient usage of our water resources, the coupled problems of diffusion, convection, and interfacial phenomena invariably appear. This research program is concerned with the analysis and systematic exploration of these various problems as they apply to transfer through fluid interfaces, through structured liquids, and through model membranes. Current and proposed studies are in the following areas: (1) Convective instability in thin fluid layers, (2) Permeation through multimolecular films or model membranes, (3) Diffusion in structured fluids, (4) Transient diffusion through the liquid-liquid interface, (5) Rates of spreading and migration in a fluid interface, (6) The effect of surface-active agents on absorption rates.

Our objective in this work is to provide fundamental information on the overall subject of interphase transport, to carry out original experiments which will augment existing theories and which will increase our knowledge of the physical and chemical factors involved.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

5.0379, EFFECT OF CHLORINATION ON CILIATE PROTOZOA AND THEIR ROLE AS A BARRIER TO STREAM POLLUTION

E.B. SMALL, Univ. of Illinois, Graduate School, *Urbana, Illinois*

This investigation will study two significant relationships of the ciliate protozoa present in a heavily, biologically polluted portion of the Saline Ditch in Champaign County, Illinois. One relationship is the role played by the ciliates as a natural barrier to the biological pollutants of the Champaign-Urban sewage effluent. To be investigated here will be (1) the nature of the ciliate flocculating process and (2) the chemical and physical factors (e.g. Dissolved Oxygen and temperature) which may control the density of the protozoan population. The second relationship is the effect, either direct or indirect, that chlorine in various representative dilutions may have upon the protozoan populations. In the laboratory, field samples of controlled temperature circulating growth chambers where the ciliate population as well as temperature, dissolved oxygen and other factors will be monitored by electronic sensors and time lapse microcinematography. These results will be compared to the chlorine effects noted when this chemical sterilant is added to the effluent.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Illinois

5.0380, DISINFECTION OF SEWAGE EFFLUENTS

F.W. SOLLO, Univ. of Illinois, State Water Survey Division, *Urbana, Illinois*

A study is being made of the effectiveness of bromine as a disinfectant for treated sewage effluents under varied conditions of temperature, pH, and bromine concentration in parallel with a study with chlorine as the disinfectant. Disinfection is being measured in terms of coliform, fecal coliform, and total bacterial numbers.

In addition, two streams receiving treated effluents, one chlorinated and the other to be chlorinated in the near future, are being surveyed to determine the effect of chlorination on both bacterial counts and general stream chemistry.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0381, WATER QUALITY CRITERIA FOR SELECTED RECREATION USES

E.H. STOREY, Univ. of Illinois, Graduate School, *Urbana, Illinois*

The proposed research plan involves laboratory and field investigations directed at the determination of water quality criteria for selected recreation uses. The objectives of the project are: I. To survey the types and extents of water pollution which are, or are considered to be, detrimental to selected water-oriented recreation activities of the residents of a six county area in East Central Illinois. A. To determine the beliefs and attitudes toward different types and extents of pollution for different activities (questions about what types and extents of pollution bother the respondents). B. To determine if choice of location for particular activities is related to physical measures of water quality. C. To determine types of pollution that users believe to affect their choices of sites for particular activities, and how the users conceptualize these pollutants. These problems are to be investigated for both on-site and off-site users. II. water quality criteria for water oriented recreation, based on a combination of information from the survey and from existing quality standards; and to develop a rating scale, for selected recreation uses of water, based on the quality criteria.

The research will be conducted by survey questionnaires and interviews of users at recreation sites and at off-site locations. Statistical analysis may include Kendall's coefficient of concordance, differences in the mean or the number of cases, bivariate frequency tables, chi square analysis, and multiple regression techniques. Both chemical and biological tests of water quality will be made.

The survey method and methods for developing the water quality criteria and rating scale, if successful, will provide states, regions, other agencies and the national with a tool to survey their residents, test their waters and develop comprehensive water quality criteria for recreation.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Illinois

5.0382, USE OF PURE STRAINS OF ALGAE AND MIXED ALGAE-PROTOZOA, AND ALGAE-BACTERIA CULTURES IN SEWAGE TREATMENT

S.V. GANAPATI, Univ. of Baroda, *Baroda, India*

Object: To reduce costs involved in treatment and disposal of sewage from small rural communities through determination and application of optimum algal-protozoal and algal-bacterial symbiotic balances.

Plan of Work: Various species of photosynthetic algae growing in sewage from different locations will be gathered, and evaluated as to their oxygen-liberating capacity and ability to withstand attack by zoo-plankton predators. The most suitable for cultivation in sewage liquors will be selected and the optimum conditions determined for their growth, devleopment, and sewage purification ability. Some algae species will be further treated with ultraviolet, colchicine solution, etc. in varying concentrations, to get mutants and the resulting changes in physical and physiological properties studied and evaluated with respect to liberation of oxygen in a sewage liquor environment and consequent capacity for purification of sewage. Selected species of algae will be grown along with Vorticella, Epistylis, and perhaps other types of protozoa in a sewage liquor environment, with environment varied to determine the optimum for algal --protozoal growth and for purification of the sewage. Similar studies will be made of algal bacterial symbiosis. If laboratory results indicate promise, a pilot plant with a number of small, outdoor tanks will be constructed and its performance studied.

SUPPORTED BY U.S. Dept. of Agriculture

5.0383, EFFECT OF HEATED WATER DISCHARGE FROM IPALCO'S PETERSBURG PLANT ON THE WATERS OF WHITE RIVER, INDIANA

A.F. AGNEW, Indiana University, Water Resources Research Ctr., *Bloomington, Indiana* 47405

The project area is in southwestern Indiana, just below the junction of the East Fork and West Fork of the White River, Pike County, Indiana.

A thorough investigation of the physical, biological, and chemical characteristics of the river will be made over a three-year period, including one year before construction of the new steam-electric generating plant, and one year after, in order to determine the effects of thermal pollution.

It is anticipated that this investigation will result in information that will be useful not only to the power-producing company but also to the power-regulating State agency.

The investigation of several parameters, such as temperature, dissolved oxygen, fishes, BOD, plankton, turbidity, and bottom fauna has produced significant data in the past three years. The continuation of the project for another three years will permit us to continue to assess the effect of Unit No. 1, and the added effect of Unit No. beginning in 1969.

This project will also include a microbiologic study by Thomas D. Brock and Warren Silver as part of an AEC contract.

SUPPORTED BY Indiana University
Indianapolis Power & Light Company
U.S. Atomic Energy Commission

5.0384, HYDROLOGY AND WATER QUALITY OF SURFACE MINING FOR COAL IN PIKE COUNTY, INDIANA

A.F. AGNEW, Indiana University, Water Resources Research Ctr., *Bloomington, Indiana* 47405

The project area is in southwestern Indiana, in the area where Coals No.

Two automatic recording steam gaging stations have been established, and partial flow measurements will be taken at 6-8 sites; water quality samples will be taken at these and perhaps 50 other locations, particularly in the South Fork Patoka River.

The project was begun in September 1964, and a report (Indiana University Water Resources Research Center Report of Investigations No. 1, 1965) was published; the project was expanded to include a detailed study of quantity and quality of water in the Busseron Creek Watershed of Sullivan County (Report of Investigations No. in September, 1968), and to include reconnaissance investigations in fringe areas. The current project will continue the reconnaissance in a few of the fringe areas.

SUPPORTED BY Indiana University
Ayrshire Collieries Corporation
Enos Coal Corporation
Peabody Coal Company

5.0385, MICROBIOLOGICAL ASPECTS OF ACID MINE-DRAINAGE

R.M. RAMALEY, Indiana University, Graduate School, ***Bloomington, Indiana*** 47405

The high concentrations of sulfuric acid and ferric ion found in streams draining coal mining regions are due almost entirely to the biological oxidation of the pyritic minerals associated with coal, chiefly by autotrophic bacteria in the Thiobacillus-Ferrobacillus group.

The present investigation will emphasize the quantitation of both the iron-oxidizing and sulfur-oxidizing bacteria in several Indiana localities, according to the method of Silverman and Lundgren (J. Bacteriol. 77:642, 1959); in addition, chemical data will be obtained from each of the sites visited. (All dilutions, etc. will be conducted in the field to minimize errors that may occur during transport back to the laboratory.)

Some attention will also be given to the development of a rapid field test for the biological rate of sulfur or iron oxidation (present tests require 15 days).

It is hoped that this study will indicate methods of strip mine operation that show the most promise in preventing the microbiological oxidation of sulfur and iron, and will supplement recent investigations on the chemical aspects of acid mine-drainage in other areas (Barnes and Romberger, J. Water Pollution Control Fed., 40:371 (1968)).

SUPPORTED BY Indiana University
Indiana University Foundation

5.0386, HYDROLOGY STUDY IN U. S. GYPSUM MINE, SHOALS, INDIANA

Y.M. STERNBERG, Indiana University, Graduate School, ***Bloomington, Indiana*** 47405

An artesian water system appears to be actively dissolving gypsum and associated rocks in the lower part of the St. Louis Limestone near Shoals, Indiana and probably elsewhere along a line running about N 20 degrees W from near Alton on the Ohio River to Freedom in Owen County. The source of the water is not known but is presumed to be up the dip of the rocks to the east of areas of known gypsum. It may be that the ultimate source of the water in the Shoals region is the extensive sinkhole area near Mitchell. The system discharges through a line of sulphate-water springs that includes those at French Lick and West Baden plus several others less widely known. Most of these springs flow into the East Fork of White River or into the lower part of Lost River.

In the first phase of the study the source direction of movement and the quantity of water involved will be determined using trace studies and water level elevations of wells and nearby streams.

SUPPORTED BY Indiana University
U.S. Gypsum Company

5.0387, TERTIARY TREATMENT OF COMBINED STORM WATER, SANITARY RELIEF DISCHARGE AND SEWAGE TREATMENT PLANT EFFLUENT

F. GURNHAM, East Chicago Sanitary District, ***East Chicago, Indiana***

The objective of this project is to develop and verify, on a small pilot scale, the preliminary design and operating conditions for chemical coagulation, sedimentation, dual media filtration, and granular activated carbon adsorption for treatment of combined municipal industrial wastes mixed with storm run-off. This pilot-plant unit will be operated for approximately 4 months. In addition, the aim is to design and construct a minimum 1-MGD pilot plant to include the operation of the above process steps.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
East Chicago City Government - Indiana

5.0388, THE EFFECT OF INORGANIC SEDIMENT ON STREAM BIOTA

J.R. GAMMON, Depauw University, Graduate School, ***Greencastle, Indiana*** 46135

The basic purpose of this research is to quantify the effect of inorganic pollution in the form of stonedust on certain biotic components of the stream. Thus far a deleterious effect on macro invertebrate populations of riffles and fish populations of pools has been noted in pools and riffles immediately downstream from the point of pollution. No major reorganization of species composition has occurred, although some species of fish appear to be scarce below the point of sediment entry. The populations of these biotic components approach normal farther downstream.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0389, A STUDY OF THE QUALITY OF INDIANA SURFACE WATERS

J.M. BELL, Purdue University, School of Engineering, ***Lafayette - West Lafayette, Indiana*** 47907

Data collected during an 8 year period from 24 Indiana streams, Lake Michigan, and the Ohio River was analyzed.

A quality index was calculated for 63 sampling stations. The quality characteristics used in the calculation were: dissolved oxygen, B.O.D., Temperature, coliforms, specific conductance, pH, and chlorides. The project is a continuing study.

SUPPORTED BY Purdue University

5.0390, WATER POLLUTION STUDY OF THE WABASH RIVER

J.M. BELL, Purdue University, School of Engineering, ***Lafayette - West Lafayette, Indiana*** 47907

Studies were initiated to develop a comprehensive surveillance program on the quality of the Wabash River between Lafayette and Covington, Indiana. Data is collected ata critical time of the day throughout the summer months of low flow.

An attempt is being made to obtain a mathematical model(s) which may be used to predict the response of the dissolved oxygen concentration in the river to the waste discharges resulting from municipalities, industries, and agriculture sources in the Greater Lafayette Area.

SUPPORTED BY Purdue University

5.0391, WASTE TREATMENT FOR AN INDIVIDUAL HOME WITH REUSE OF THE WATER

D.E. BLOODGOOD, Purdue University, School of Engineering, ***Lafayette - West Lafayette, Indiana*** 47907

A system consists of a 300 gallon spherical fiber glass tank with nylon bag occupying about 2/3 of the tank volume. Aeration of the bag contents is continuous. Water from the tank is put under pressure, passed through an activated carbon filter and used to supply a conventional flush toilet.

SUPPORTED BY Purdue University

5.0392, EFFECT OF PESTICIDE RESIDUES AND OTHER ORGANO-TOXICANTS ON THE QUALITY OF SURFACE AND GROUND WATER RESOURCES

L. CHANDLER, Purdue University, Agricultural Experiment Sta. , ***Lafayette - West Lafayette, Indiana*** 47907

1. To study the mechanisms by which organo-toxicant materials are held by the mineral and organic fractions in the soil. 2. To determine the fate of organo-toxicant materials in water storage reservoirs. 3. To evaluate effects of organo-toxicants on terrestri-

al and farm pond invertebrates. 4. To determine the role of microorganisms in the elimination of organo-toxicants from surface and ground waters. 5. To effect control and removal methods for reducing or eliminating organo-toxicant residues from reservoir water supplies.

SUPPORTED BY Indiana State Government

5.0393, REDUCTION OF INSECTICIDAL HAZARDS

J. FAHEY, Purdue University, Agricultural Experiment Sta. , *Lafayette - West Lafayette, Indiana* 47907

1. Determine the fundamental physical, biochemical, and biological factors influencing occurrence, magnitude, interaction, and persistence of insecticidal chemical residues in soils and raw agricultural commodities. 2. Identify and evaluate fundamental factors influencing the magnitude and mechanism of air and water pollution by insecticidal chemical residues. 3. Develop basic studies related to the metabolism and detoxication of insecticidal chemical residues in animals, plants, soils and water. 5. Explore the reciprocal influences of residues of insecticidal chemicals on soil microflora, microfauna, and non insect fauna. 7. Develop and improve analytical techniques essential to the pursuit of this research.

DESCRIPTION OF WORK PROPOSED: Study the effect of cultural practices such as methods of application and tillage on the deposition, distribution and persistence of residues of insecticidal chemicals in soils. Investigate chain of contamination such as the translocation of insecticidal chemical residues from soils into mint hay and their occurrence in mint oil. Study the dislocation of insecticidal residues from soils through water movement and the accumulation of insecticidal chemicals in ponds and drainage water. Investigate the effect of chemical and physical composition of soil on the persistence and resistance to leaching of insecticidal residues. Study the effects of insecticidal chemicals on the non-insect fauna of the soil. Improve instrumentation and procedures for the analysis of insecticidal chemical residues.

SUPPORTED BY U.S. Dept. of Agriculture
Indiana State Government

5.0394, DISPERSION DURING FLOW IN HETEROGENEOUS POROUS MEDIA

R.A. GREENKORN, Purdue University, School of Engineering, *Lafayette - West Lafayette, Indiana* 47907

The immediate objective of this project is to study the theory and measurement of dispersion in heterogeneous anisotropic porous media. A better understanding of dispersion phenomena is necessary to obtain useful flow models of real porous media. Initially, we will study the differential equations associated with dispersion. Present statistical models will be extended to include heterogeneity and anisotropy. Dispersion coefficients will be measured in linear and radial flow in heterogeneous anisotropic media using tracer techniques and these data will be used to determine the statistical range of the dispersion coefficient in view of microscopic and macroscopic heterogeneity, fluid properties, and anisotropy. A better understanding of the fundamental nature and description of disperson will allow better calculation of miscible flow in porous media. This study of effects of heterogeneity and anisotropy on disperson has immediate practical application: in tracing seepage of contaminates into underground fresh water; in reclamation of waste water; in underground disposal of chemical, bacterial, and radioactive wastes; in ion exchange; in filtration theory; in the movement of fluids in the human body; and in the flooding of oil reservoirs.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0395, MICROBIAL INTERACTIONS IN WASTE TREATMENT SYSTEMS

E.J. KIRSCH, Purdue University, School of Engineering, *Lafayette - West Lafayette, Indiana* 47907

The growth and metabolic activity of methane-producing bacteria grown in association with both selected pure and mixed cultures of predominant bacterial types isolated from anaerobic digesters are being evaluated. A simulated mixed culture digestion system is being used; it employs semi-permeable membranes to effect physical separation of the cultures under investigation.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0396, EFFECT OF PESTICIDE RESIDUES AND OTHER ORGANO-TOXICANTS ON THE QUALITY OF SURFACE AND GROUNDWATER RESOURCES

E.J. MONKE, Purdue University, School of Agriculture, *Lafayette - West Lafayette, Indiana* 47907

Laboratory experiments will be utilized to study sorption mechanisms of organo-toxicant materials to mineral and organic fractions in the soil and the movement of these substances through soil profiles. Incubation studies using enrichment culture techniques will be used to isolate microorganisms capable of decomposing those materials which offer the greatest water pollution hazards. Special studies will be made to determine relationships between molecular structure and decomposability of specific toxic substances to determine the feasibility of altering molecular structures. The feasibility of treating reservoirs with special adsorbing or chelating materials in order to flocculate, precipitate, or otherwise deactivate the organo- toxicant materials or their residual decomposition products will be studied using radiological tracer techniques with model filters. Accompanying biological experiments with similar organo-toxicant materials will be conducted in laboratory aquaria to determine the effects of different concentrations and synergisms.

Field studies will be conducted on well characterized, controlled watersheds and associated reservoirs to determine the effects of application practices on pollution hazards. The rate of the applied organo-toxicant materials both on the watershed and subsequently in the small reservoir will be determined possibly using radioisotope tracer techniques. Attention will be given to the development of ready means of detecting the toxic substances or its residue in water storages. Both aquatic and terrestrial indicator organisms will be used to assess the movement and concentration of the organo-toxicant, soil-borne organo-toxicant, or organo-toxicant residue on the watershed and in associated small reservoirs. Samples of water, bottom muds and watershed soils will be subjected to chemical, biological and physical analyses during pretreatment, treatment, and post-treatment periods for possible organo-toxicant residue and pertinent fauna.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Purdue University

5.0397, TREATMENT OF WATER FROM SMALL RESERVOIRS FOR DOMESTIC CONSUMPTION

E.J. MONKE, Purdue University, Agricultural Experiment Sta. , *Lafayette - West Lafayette, Indiana* 47907

(1) To study electrophoretic control as an aid for filtration of raw water supplies; (2) To investigate methods for reducing the adverse effects of aquatic weed residues on water treatment processes and water quality.

Model water filters will be established in which the amounts and kinds of colloidal particles, type, gradating and depth of filter material, operating head, pH, and type and rate of coagulant aid may be varied. Efficiencies will be measured using concepts of streaming potential and electrophoresis. Also the effects of organic residues on water treatment processes principally filtration will be studied. Control methods for modifying the adverse effects of these residues will be devised and evaluated in terms of treatment efficiency and subsequent water quality.

SUPPORTED BY U.S. Dept. of Agriculture
Indiana State Government

5.0398, EXTRACTION OF ALGAE BY FLOCCULATIVE TECHNIQUES

M.W. TENNEY, Purdue University, School of Engineering, *Lafayette - West Lafayette, Indiana* 47907

The extraction of nuisance causing algae from various types of water, such as public water supplies and effluents from algal wastewater treatment systems, is of extreme importance if continued maintenance of high level water quality is to be ensured. This research proposes to investigate the feasibility of applying flocculative techniques to algal extraction. The primary objective is to study the basic mechanisms related to algal auto-flocculation and flocculation with added chemicals in order to obtain the necessary quantitative information to ensure the effective application of these techniques.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0399, REMOVAL OF ORGANIC AND EUTROPHYING POLLUTANTS BY COMBINED CHEMICAL AND BIOLOGICAL TREATMENT

M.W. TENNEY, Univ. of Notre Dame, School of Engineering, *Notre Dame, Indiana* 46556

The object of this project is to demonstrate by pilot plant techniques the operational feasibility and economic aspects of a combined biological and chemical treatment scheme for the removal of organic, nitrogenous and phosphatic pollutants from industrial and municipal wastewater. The project was started in fiscal year 1968 and it is anticipated that it will be completed in fiscal year 1970.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
University of Notre Dame

5.0400, APPLICATIONS OF POWDERED MAGNETIC IRON OXIDE FOR THE REMOVAL OF PATHOGENIC MICROORGANISMS

J. WARREN, Charles Pfizer & Company Inc. , *Terre Haute, Indiana* (14-12-418)

Concentration of viruses on powdered iron oxide will be studied as a means for detecting small quantities of viruses in large volumes of water, and for removal of viruses from water. After separation of the iron oxide (carrying adsorbed viruses) in a magnetic field, elution of the viruses from the oxide with high concentrations of sulfate, carbonate, or phosphate ion will be done. Adsorption and elution of viruses to and from the oxide with electrical current will also be studied.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0401, FEASABILITY OF FISH PRODUCTION IN TERTIARY WASTE TREATMENT PONDS

R.W. BACHMANN, Iowa State University, Graduate School, *Ames, Iowa* 50010

As a means of upgrading the quality of effluents from municipal waste treatment plants, there is much current interest in the use of tertiary treatment ponds where plant nutrients can be removed by algae and organic materials can be further oxidized. We propose to explore the feasibility of raising fish in these ponds. If successful, the returns from the fish culture operation would help to pay for the ponds and at the same time channel some of the waste nutrients inno a usable form.

Our objectives are to determine if tertiary treatment ponds are suitable for fish production, to determine the potential production of fish on a pounds per acre basis, to evaluate the economic feasibility of raising fish in these ponds and to determine the role fish have in the dynamics of the ponds.

In the initial experiments channel catfish (Ictalurus punctatus) will be stacked in tertiary treatment ponds at Ames, Iowa. Fingerling fish will be used in the early spring and will be harvested in the late fall. Data will be collected on the costs attributable to the fish cultural operation and the marketable value of the fish harvest. Data will also be collected on various physical, chemical, and biological parameters of the ponds.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Iowa State University

5.0402, USING SOIL FILTRATION TO REDUCE POLLUTION POTENTIAL OF LAGOON EFFLUENT ENTERING GROUND WATER SYSTEM

C.E. BEER, Iowa State University, School of Engineering, *Ames, Iowa* 50010

The practice of disposal of animal manure and collection of feedlot runoff in lagoons is being widely used. In most cases Pollution Control Commissions will not permit the direct release of lagoon effluent into surface water streams.

The objectives of this research are to develop land application criteria for the lagoon effluent whereby the quality will be such that pollution potential will be minimal, and the effluent may enter the ground water system. The change in the soil structure, soil chemistry and biological environment will be also studied.

The experimental procedure will involve the sprinkling of lagoon effluent (swine wastes) at controlled rates and frequencies on the experimental area. A tile network will intercept the effluent after infiltration and filtering through the soil and permit the change in quality of the effluent to be evaluated. The soil samples to be studied will be taken directly from the experimental areas.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Iowa State University

5.0403, EMPIRICAL PREDICTION OF SAND FILTER PERFORMANCE

J.L. CLEASBY, Iowa State University, School of Engineering, *Ames, Iowa* 50010

In recent years, there has been a trend to higher filtration rates for sand filters used in municipal water treatment. However, no acceptable rational method has been developed to predict quantitatively the filtering characteristics of a given suspension of solids using a granular filter media. Previous attempts at developing a filtrability index were done with thin filters which measure only surface removal effects and are thus not indicative of the depth removal obtained in a sand filter. Equations currently under study for prediction of the filter behavior have limitations that restrict seriously their usefulness. Data collected in this study should permit proper evaluation of such equations.

The objectives of this study are to develop a standard filtrability index to quantify the filtering characteristics of suspended solids on granular media. A device has been developed consisting of 3 shallow filters of increasing depth to measure both surface and depth removal tendency. Hopefully, a measured index can be correlated to full depth filter performance. Typical filtrability measurements are being made with the device in the laboratory, and at various plants treating waters of different types to test whether a measured index can be used for prediction of plant scale performance. If satisfactory correlation is evident, the device will be suggested as a standard means of measuring filtrability for granular filters.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0404, REDUCTION OF HAZARDS ASSOCIATED WITH THE PRESENCE OF RESIDUES OF INSECTICIDAL CHEMICALS IN THE ENVIRONMENT

P.A. DAHM, Iowa State University, Agricultural Experiment Sta. , *Ames, Iowa* 50010

1. Determine the fundamental physical, biochemical, and biological factors influencing occurrence, magnitude, interaction and persistence of insecticidal chemical residues in soils and raw agricultural commodities. 2. Develop basic studies related to the metabolism and detoxication of insecticidal chemical residues in animals, plants, soils, and water. 3. Seek methods of removing or reducing residues of insecticidal chemicals from the environment. 4. Develop and improve analytical techniques essential to the pursuit of this research.

Greatest emphasis will be placed on objective 2, by studying the metabolism of organophosphorus, carbamate, and chlorinated hydrocarbon insecticides in animals, plants, soils, and water. Differences between closely and distantly related species of animals and plants will be investigated as well as intra-specific factors such as age, physiological conditions, and environmental influences. The interaction of insecticides with other synthetic chemicals in our environment will also be explored.

SUPPORTED BY U.S. Dept. of Agriculture
Iowa State Government

5.0405, AN ECONOMIC ANALYSIS OF ORGANIZATIONS OF WATER USERS

J.R. DAVIS, Iowa State University, Graduate School, *Ames, Iowa* 50010

Users of water resources often generate 'spillover effects' that affect the cost and/or benefits accruing to other water users. The purpose of this study is to examine ways in which spillover effects that raise the cost or reduce the benefits of affected parties might be reduced or eliminated.

In some cases legislation can force offenders to reduce spillover effects, but since this raises their costs they often successfully resist regulation. We plan to use established methods of estimating costs and benefits to determine when the following types of spillovers are likely to be present. (1) Cases where those who benefit from reduction of spillovers find it worthwhile to pay those creating the spillover to reduce or eliminate it. (2) Cases where all parties to an agreement can gain net benefits that are unattainable if they act individually.

The problems of organizing water users when spillover effects of the variety cited are present will then be examined. At least one pilot study involving water users along a major river in Iowa is anticipated.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Iowa State University

5.0406, ECOLOGY OF DIATOMS IN HARDWATER HABITATS

J.D. DODD, Iowa State University, Graduate School, *Ames, Iowa* 50010

1. This is a continuing study of diatoms in a region with moderately hard waters. Collections by various methods, including diatometers, are made from large and small streams, ponds, lakes, reservoirs, groundwater seeps, etc. Chemical properties of the water are evaluated with field testing equipment as well as in the laboratory.

2. Core samples of post-glacial sediments are being analyzed simultaneously for pollen and diatoms. Correlations between observed results and diatoms. Correlations between observed results and climatic changes will be sought.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0407, FARM ANIMAL WASTE DISPOSAL

T.E. HAZEN, Iowa State University, Agricultural Experiment Sta. , *Ames, Iowa* 50010

The objectives are to determine the properties of animal manures and to test and evaluate one or more promising procedures which can be used in the handling, treatment and safe disposal of the farm animal wastes.

Qualitative and quantitative measurements of the physical, chemical and biological properties of swine, poultry and cattle wastes from confinement production units will be taken. Both University and private production units will be studied in this study. Methods of manure treatment and disposal presently under consideration (some already under test) are one- and two-cell lagoons, oxidation ditch and sludge digestion. The effect of waste management in a hog confinement unit will be studied so as to evaluate ventilation and structural design requirements in confinement rearing.

SUPPORTED BY U.S. Dept. of Agriculture
Iowa State Government

5.0408, DEVELOPMENT OF PULSATING ADSORPTION FILTER FOR TERTIARY TREATMENT OF WASTE WATERS

R.L. JOHNSON, Iowa State University, School of Engineering, *Ames, Iowa* 50010

In the near future, many of the effluents from conventional sewage treatment facilities will need further tertiary treatment to reduce the organic pollution load entering our waterways. The proposed research will determine the design and operating parameters for a new type of tertiary treatment process, first through laboratory scale investigations using synthetic sewage and second by pilot plant operation of the process on actual secondary sewage plant effluent.

The new process will utilize the adsorption phenomenon of the organic materials onto sand, coal and other media, with the adsorption providing a concentration effect. This concentration of the organic material in the presence of oxygen and biological life allows further bio-degradation of the organic material. The air supply to the process provides the required oxygen for the biological life as well as the pulsating effect needed to prevent clogging of the media beds.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Iowa State University

5.0409, INFLUENCE OF GEOHYDROLOGY ON LANDSCAPE AND SOIL FORMATION

R.V. RUHE, Iowa State University, School of Agriculture, *Ames, Iowa* 50010

The research objectives are: to determine the effect of water in the evolution of first- or second-order subwatersheds that ascend from tributary streams to upland summits in parts of 4-Mile Creek watersheds, Tama County, Iowa; to evaluate the effect of water in formation of the hillslopes, in deposition of sediment in subwatershed bottoms and lower hillslope positions; to evaluate the surface and subsurface water regimen and the effect of water in the genesis of the soils; and to determine the effect of water in the formation of soils on the floodplain of 4-Mile Creek. Field survey, instrumentation, and measurement will be coordinated with physico-chemical laboratory studies. Principles will be developed regarding the influence of the geohydrologic system on landscape evolution, weathering, and soil formation. Personnel will be trained in the integrated approach of geomorphology, pedology, and hydrology.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Iowa State University

5.0410, TREATMENT OF AQUEOUS AGRICULTURAL WASTES FOR CLEAN WATER AND FOR MICROBIAL PROTEIN PRODUCTION

G.T. TSAO, Iowa State University, School of Engineering, *Ames, Iowa* 50010

The present proposal concerns a study of a biological engineering process for treating extremely high BOD (biological oxygen demand), heavily contaminated, aqueous agricultural wastes to produce microbial cells, in an unusual culturing vessel known as the Waldhof fermentor. Because of their content of surface active agents, agricultural wastes usually foam excessively when bubbled with air for oxygen supply. Ordinary sparger-agitator type of culturing vessels cannot be used for this purpose due to the high antifoaming demand. The Waldhof fermentor actually makes a virtue of extreme foaming properties and accomplishes high degree of aeration by making use of foam which has a large air- liquid contacting interface. The foam is continuously recycled in the system.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Iowa State University

5.0411, THE EFFECTS OF DREDGING AND SILTATION ON DIVING DUCK FOODS AND FEEDING HABITS ON THE MISSISSIPPI RIVER

M.W. WELLER, State Conservation Commission, *Des Moines, Iowa*

Gather information on population size and feeding behavior of ducks in the Keokuk-Fort Madison Pool.

Populations data will be gathered by counts from shore and boat transect. Aerial censuses will be made during migration periods.

Feeding behavior will be observed from duck blinds and from shore to determine choice feeding areas, depth of water preferred, age and sex composition of flocks and methods of feeding.

Gizzards and proventriculi will be collected and examined for food utilization analysis. Food will be analyzed in the laboratory as to species, volume, percent occurrence and size.

Data on the composition and size of hunter harvest of this Pool will be collected by direct hunter contact. Sexing and ageing of all ducks will be recorded and gizzards removed from birds for laboratory when possible on these contacts.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Iowa State Government

5.0412, MANAGEMENT OF CATTLE FEEDLOT WASTES

R.R. DAGUE, Univ. of Iowa, School of Engineering, *Iowa City, Iowa* 52240

Previous research has shown that cattle feedlots represent a significant source of water pollution. Anaerobic lagoons have been proposed as a means of accomplishing a reduction in the polluting strength of cattle feedlot wastes through biological decomposition. Fundamental theory indicates that it may not be possible to accomplish a significant improvement in the quality of feedlot runoff by the use of anaerobic lagoons. The supernatant in an anaerobic lagoon is the effluent from the lagoon when additional wastes are added. This research is designed to determine whether or not any significant improvement in the quality of the supernatant liquid occurs after an initial improvement as a result of solids separation.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Iowa

5.0413, RECESSION CHARACTERISTICS OF IOWA STREAMS

J.W. HOWE, Univ. of Iowa, School of Engineering, *Iowa City, Iowa* 52240

The behavior of Iowa streams in low-water periods during the crop- growing season, May to September inclusive, is herein determined. The flow records in all such periods of ten days or more in length were first analyzed to determine the recession constants. The results of this part of the investigation are shown on a map of the State and indicate a considerable uniformity of behavior during each of the summer months. In the second part, the flow at the beginning of the periods was related to the area and soil permeability of the drainage basin and to the antecedent temperature and precipitation by means of correlation techniques.

Regression equations of the form Q equals A to 0.71 power times I to the 2.01 power times P to the 0.22 power times T to the minus 0.67 power, in which A is the area in square miles; I an infiltration index; P the antecedent temperature are determined for each month and for the season as a whole.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Iowa

5.0414, DISPERSION OF WATER POLLUTANTS IN CURVILINEAR FLOWS

E.O. MACAGNO, Univ. of Iowa, School of Engineering, *Iowa City, Iowa* 52240

In a modern, technologically sophisticated society, many rivers are assigned in addition to their natural functions the conflicting roles of serving as sources of fresh water supplies and recipients of the water-borne wastes of urban and industrial areas along their courses. Due to their turbulence and irregular velocity distributions, river flows have a certain capability to disperse and/or oxidize the contaminants that they receive; on the other hand, it is obvious that excessive concentrations of pollutants are intolerable. Hence the increasing interest in recent years in obtaining a better understanding of turbulent mixing in open channel flows.

Two important aspects of the dilution processes have not yet been extensively investigated: the effects of channel curvature and the attendant secondary currents on lateral mixing and longitudinal dispersion, of density differences between the pollutant and the polluted liquids. The first of these is presumed to be the dominant factor responsible for the divergence between laboratory and field values of dispersion coefficients; it is of great practical significance because natural rivers are never straight for more than a few channel widths. Density stratification must play a significant role in cases where the density of the contaminating fluid is different from that of the diluting fluid; this can be inferred from earlier basic research on the effects of density stratification on turbulent mixing.

The proposed research would consist of an experimental and analytical study of the separate and joint effects of channel curvature and pollutant buoyancy (positive and negative) on dispersion in open channel flows, with the goal of developing predictors to enable engineers to estimate better the temporal and spatial dilution that will occur when a particular waste is introduced into a given natural stream.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0415, EFFECTS OF LIMNOLOGICAL FACTORS ON WATER TREATMENT

D.B. MCDONALD, Univ. of Iowa, School of Engineering, *Iowa City, Iowa* 52240

Limnological studies of the Coralville Reservoir, Johnson County, Iowa, and the Iowa River above and below the impoundment are currently being conducted. Additional studies of the reservoir and river will be conducted under the proposed project to determine the effects of various chemical and biological conditions within the reservoir and the river on the quality of water utilized by the University of Iowa Water Treatment plant, located on the Iowa River about five miles below the Coralville Dam. Inplant studies, involving modification of treatment methods, chemicals used, points of application of chemicals and rates of treatment, will be conducted to determine the best treatment methods under varying conditions of water quality.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Iowa

5.0416, LIMNOLOGICAL FACTORS AFFECTING PESTICIDE RESIDUES IN SURFACE WATERS

D.B. MCDONALD, Univ. of Iowa, School of Engineering, *Iowa City, Iowa* 52240

Studies will be conducted to determine the relationship between runoff, plankton blooms and other chemical and biological factors on the concentration of various chlorinated hydrocarbon pesticides in the Coralville Reservoir and Iowa River, Iowa.

Additional studies will be conducted to determine the role of various aquatic organisms in the uptake and concentration of these pesticides.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Iowa

5.0417, REOXYGENATION OF IOWA STREAMS

W.L. PAULSON, Univ. of Iowa, School of Engineering, *Iowa City, Iowa* 52240

Evaluation of biological and limnological factors affecting reoxygenation of typical Iowa streams for purpose of more accurately predicting their pollution assimilation capacity. Special attention to effect of algal photosynthesis and death on stream oxygen resources.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Iowa

5.0418, AEROBIC TREATMENT OF PACKINGHOUSE WASTES

W.L. BROWN, John Morrell & Company, *Ottumwa, Iowa* 52501

The objective of this project is the construction and study of a demonstration plant using the aerobic oxidation channel method to treat packinghouse waste. The project will be based on results of pilot scale studies which have indicated that the method is efficient for treating packinghouse wastes, and the project will attempt to extend these findings to the demonstration scale.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
John Morrell & Company

5.0419, LIMNOLOGY OF THE JOHN REDMOND RESERVOIR

C.W. PROPHET, Kansas State Teachers College, Graduate School, *Emporia, Kansas* 66801

Primary objectives. The primary objectives of this study are to provide information relating the effects of large impoundments on the limnology of rivers and to determine variations in the limnological conditions of newly formed impoundments during their early history.

Immediate objectives. (1) To record seasonal variations in the physical-chemical conditions in the Cottonwood River prior to its impoundment by the Marion Dam, and to determine changes in the physical- chemical conditions in the reservoir after impoundment. (2) To measure and record various limnological conditions in the newly impounded Council Grove Reservoir on the Upper Neosho River during its early history. (3) To determine whether the impoundments of the upstream Council Grove and Marion reservoirs have a significant effect on the limnological features of the John Redmond Reservoir located below the confluence of the Neosho and Cottonwood rivers.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0420, REMOVAL OF INORGANIC MATERIAL FROM SALINE WATER BY PRECIPITATION PROCESSES

C.E. BRICKER, Univ. of Kansas, Graduate School, *Lawrence, Kansas* 66045

Precipitation is one technique that may be used to remove certain dissolved ions from saline water. Before practical methods can be developed for this process, a more thorough understanding of the factors that control precipitation must be obtained. This study will endeavor to evaluate the parameters that influence and control nucleation and the growth of substances such as alkaline earth carbonates. The effect of transition-metal ions on the rate of nucleation as well as the degree to which these ions are coprecipitated either in the nucleation step or in the subsequent growth process will be explored.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Kansas

5.0421, ACTIVITY PATTERNS OF FISH EXPOSED TO TOXIC MATERIALS

J. CAIRNS, Univ. of Kansas, Graduate School, *Lawrence, Kansas* 66045

Fish will be exposed to sublethal concentrations of various toxic substances and the activity of these fish compared to unexposed control fish. Experiments will be carried out under controlled environmental conditions in small aquaria. Sensors will be used which do not interfere with movement. It is hoped that a technique may be developed that will permit relatively simple assessment of the effects of industrial wastes upon the ability of fish to function normally. Most industrial fish bioassays now use death as an end point.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Kansas

5.0422, CATTLE FEED LOT WASTE WATER TREATMENT

R.C. LOEHR, Univ. of Kansas, School of Engineering, *Lawrence, Kansas* 66045

The objective of the project is to evaluate a system that will treat the wastes from beef cattle feed lot operation. Evaluation will be made of treatment efficiency, ability of the system to reduce pollution from runoff and on the potential reuse of the treated wastewater. A system consisting of anaerobic lagoons will be constructed at a commercial feed lot. The influent and effluent from the lagoons will be routinely analyzed, rate of solids buildup will be determined and possible ground water pollution evaluated.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
University of Kansas

5.0423, CHEMICAL REMOVAL OF NITRATE FROM POTABLE WATER SUPPLIES

W.J. OBRIEN, Univ. of Kansas, Water Resources Institute, *Lawrence, Kansas* 66045

High concentrations of nitrate in potable water supplies are both medically and economically undesirable. At the present time controlled removal of nitrate from potable waters is not considered economically feasible. The usual procedure upon discovering high nitrate contamination in a supply has been to seek another source or to simply warn those who might be adversely effected. These approaches are inadequate at the present time and will become even more deficient in the future.

The purpose of this project will be to investigate the removal of nitrate by chemical reduction with air stripping and by ion exchange. Nitrate reduction will be carried out in conjunction with lime-soda softening in suspended solids contact units. Air stripping of the ammonia produced by reduction will be facilitated by the high pH inherent in the lime-soda process.

The nitrate removal characteristics of Type 1 anion exchange resins operated on the chloride cycle will also be evaluated.

An economic evaluation of both techniques will be conducted.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Kansas State University

5.0424, OXYGEN CONSUMPTION IN CONTINUOUS BIOLOGICAL CULTURE

W.J. OBRIEN, Univ. of Kansas, School of Engineering, *Lawrence, Kansas* 66045

The objectives of this research are to measure the rate of oxygen consumption of nutrient limited, completely mixed, activated sludge systems and to utilize these measurements to develop a theroetical basis for the response of these systems to abrupt changes in the influent nutrient concentration.

Hydraulic means residence times in the aeration basin of from three to twenty-four hours are being investigated. Both aeration only and aeration with sludge return systems will be considered.

Preliminary results indicate the existence of a peak rate of oxygen consumption during transition growth periods following an increase in the influent nutrient concentration in aeration only systems. This peak will be of critical importance in establishing aeration design criteria for the recently proposed plants using biological compartmentalization of the influent nutrients followed by chemical flocculation to remove the micro-organisms from solution.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0425, EFFECT OF URBANIZATION ON WATER QUALITY

W.J. OBRIEN, Univ. of Kansas, School of Engineering, *Lawrence, Kansas* 66045

The problem of water quality and contamination by the environment is one of the most challenging areas for research in our society. However, the more specific problem of the effect of urbanization on water quality has been essentially ignored. We propose to examine this problem by investigating the quality of runoff water draining the south part of the campus (U. of Kansas) and exiting down the Naismith channel. The study will include an investigation of seasonal, sudden storm, and dry period effects as reflected in the 10 water quality parameters: Biological oxygen demand, chemical oxygen demand, coliform count (total and fecal), solids content (total, dissolved, and volatile), nitrate, phosphate, pH, temperature, and chloride. Our objectives are: (1) to determine time-distribution of water quality both on a seasonal basis and in response to runoff following a heavy rainstorm, (2) to determine the feasibility of using urban runoff as a supplemental municipal water source from a water quality standpoint, (3) to compare runoff quality between an open residential area (Lawrence) and a mixed-industrial-city urban area (1 paper in literature), (4) to ascertain whether climatic differences are evident in quality of runoff water (literature presents data for Cincinnati and Leningrad).

SUPPORTED BY Kansas State Government
University of Kansas

5.0426, OPTIMIZATION OF STEP AERATION WASTE TREATMENT PROCESSES

L.T. FAN, Kansas State University, School of Engineering, *Manhattan, Kansas* 66504

This research involves an analysis, optimization, and process design study of step aeration waste treatment processes. The primary purpose of this investigation is to develop optimal designs and methods that lead to optimal designs for step aeration waste treatment systems.

For each system that is considered, the procedure to be used will involve a definition of objectives, the development of system equations or mathematical model the application of optimization theory to optimize the design variables in the mathematical model, the compilation of solutions, and the definition of the method of attack recommended for that particular system.

A number of types of problems related to step aeration waste treatment process will be approached considering all available optimization techniques, but with special emphasis on the dynamic optimization techniques which include dynamic programming, a discrete version of the generalized maximum principle, a continuous version of the generalized maximum principle and combinations of these.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Kansas State University

5.0427, APPLICATION OF OPTIMIZATION TECHNIQUES TO PROBLEMS TO AGRICULTURE

L.T. FRAN, Kansas State University, Agricultural Experiment Sta., *Manhattan, Kansas* 66504

We propose to apply modern optimization techniques to such agriculturally related processes as the design of biochemical reactor systems, food processing systems, grain drying systems water treatment, distribution and storage, waste treatment, and solid waste disposal. As an example, the optimal handling of solid wastes generated in a cattle feed-lot could be considered from a systems engineering point of view.

Analog a digital computers will be employed to carry out the calculations. Analog simulation and/or digital simulation of the systems to be studied will also be used.

SUPPORTED BY Kansas State Government

5.0428, ECOLOGICAL RELATIONSHIPS OF ORGANIC MATTER AND BACTERIA IN TUTTLE CREEK RESERVOIR

J.O. HARRIS, Kansas State University, Graduate School, *Manhattan, Kansas* 66504

It is the objective of the investigation to evaluate the variation in the quantity of dissolved and particulate organic matter in Tuttle Creek Reservoir, and to ascertain the relation of these parameters to the bacterial populations existing in the reservoir.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Kansas State University

5.0429, FACTORS INFLUENCING INSECTICIDE RESIDUES ON OR IN FOOD AND FORAGE CROPS

T.L. HOPKINS, Kansas State University, Agricultural Experiment Sta., *Manhattan, Kansas* 66504

Objectives: (1) Determine fundamental physical, biochemical, and biological factors influencing occurrence, magnitude, interaction, and persistence of insecticidal chemical residues in soils and raw agricultural commodities; (2) identify and evaluate fundamental factors influencing the magnitude and mechanism of air and water pollution by insecticidal chemical residues; (3) develop basic studies related to the metabolism and detoxication of insecticidal chemical residues in animals, plants, soils and water; (4) identify and evaluate the effects of residues of insecticidal chemicals on ecosystems with special emphasis on fish and wildlife; (5) develop and improve analytical techniques essential to the pursuit of this research.

Description of Work: The degradation and metabolism of organophosphorus insecticides are studied with reference to environmental effects of solar radiation, temperature, and humidity.

Field studies are in progress to determine potential buildup of insecticide residues in a newly established irrigation district with little previous insecticide exposure. Soil and filiar applications of selected insecticides at recommended rates are applied yearly to corn, sorghum and alfalfa. Soil, water, foliage and certain wildlife species are analyzed at intervals for residues.

SUPPORTED BY U.S. Dept. of Agriculture
Kansas State Government

5.0430, RELATIONSHIPS BETWEEN PESTICIDAL APPLICATION AND WATER CONTAMINATION UNDER IRRIGATION IN THE GREAT PLAINS

H. KNUTSON, Kansas State University, Graduate School, *Manhattan, Kansas* 66504

The pesticides to be most commonly used in irrigated areas in the Central Great Plains are applied on a 20 acre experimental field in the Cedar Bluff irrigation District in Ellis Co., Kansas. Various rates of pesticides are applied, along with certain water application rates. Terraces and subdivided terraces constitute individual treatment plots.

Water is analyzed in the residue analysis laboratory of the Department of Entomology at Kansas State University for pesticidal residues taken in wells of various depths within and surrounding the experimental field, in the irrigation ditch as it flows into the field; and in any overflow water resulting from heavy rains.

Soil analysis determines rate of penetration into the soil; *toward the well bottoms.*

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Kansas State University

5.0431, LIGAND EXCHANGE REAGENTS

J.L. LAMBERT, Kansas State University, Graduate School, *Manhattan, Kansas* 66504

Present emphasis is on ligand exchange involving ion association compounds of very low solubility, which are formed between large cations and anions of low charge. When one of the ions is a complex ion and is altered chemically by ligand exchange with an ion from solution, the colored counter ion is released into solution for spectrophotometric determination. A method that has been submitted for publication involves the determination of cyanide ion in the 0 to 8.0 p.p.m. range by reaction of the cyanide ion with triiodide ion of the insoluble tris(1,10-phenanthroline) iron (II) triiodide compound. The released red tris(1,10-phenanthroline)iron(II) cation is determined from its absorbance at 514 millimicrons. A reagent consisting of the insoluble compound between tetraphenylarsonium cation and the complex thorium- Alizarin Red S (1,2-dihydroxyanthraquinone-3-sulfonate) anion shows promise as a direct colorimetric method for small concentrations of fluoride ion. Several reagents for the determination of sulfite ion are under study. Use is made of the selective complexing ability of sulfite ion for mercury (II) complexes to release colored anions from insoluble monoiodomercury(II)-dye anion compounds, to release a dye cation from insoluble Methylene Blue-tetrabromomercurate(II) compound, and to release mercury dibromofluorescein from its insoluble compound with trimethylamine ligand.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0432, WATER QUALITY MODELING AND PREDICTION

E.S. LEE, Kansas State University, School of Engineering, *Manhattan, Kansas* 66504

The primary objective of this research is to apply the recently developed modeling and prediction techniques such as the quasilinearization technique, invariant imbedding, and nonlinear filtering and estimation to establish realistic mathematical models. It will be shown that by the use of these modeling techniques, computational requirements can be reduced and certain experimental difficulties in obtaining the data can be eliminated.

Another objective of this study is to develop and improve the above mentioned techniques for water quality modeling. Since all the modeling techniques to be used are fairly new, further developments and improvements which are especially suited for water quality modeling will be made.

The modeling and parameter estimation of (1) the amount of pollutants in a water stream or river with and without longitudinal dispersion, (2) the estimation of rate constants in waste treatment systems, and (3) dynamic modeling will be studied. Only plug flow situation will be studied in the dynamic modeling.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Kansas State University

5.0433, BIOLOGICAL TREATMENT OF BEEF ANIMAL WASTES TO REDUCE WATER POLLUTION

***R.I. LIPPER*, Kansas State University, School of Engineering, *Manhattan, Kansas* 66504**

Water pollution resulting from cattle feeding operations could be reduced greatly if cattle were reared in confinement on concrete so that wastes could be readily collected for biological treatment. Poultry and swine producers have already demonstrated that confinement rearing is practical on a large scale. Confinement systems for beef production are being investigated. This research proposes to evaluate two systems for the biological treatment of beef cattle wastes. A recirculating oxidation ditch will be operated under a slotted floor for pens holding twenty beef animals in an open front shed. Another shed with capacity for twenty animals will have a solid concrete floor. Manure from the second shed will be pushed into a waste collection hopper at weekly intervals. Waste from the hopper will be fed into a mixed, *anaerobic treatment system. Total and volatile solids, BOD* and COD will be determined for material fed to each system. The efficiencies and operating characteristics will be determined for each system. The adaptability of the system to cattle management schemes will be evaluated.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Kansas State University

5.0434, NITRATE ACCUMULATION IN KANSAS GROUND WATER

***L.S. MURPHY*, Kansas State University, School of Agriculture, *Manhattan, Kansas* 66504**

The project is designed to study the nitrate content of Kansas water supplies and to determine the role of nitrogen fertilization in this accumulation. Special attempts will be made to evaluate the effect of varying rates of nitrogen fertilization on the accumulation of nitrate by various soils and the aquifers beneath. Nitrate movement into the aquifers will be monitored by means of observation wells in the immediate vicinity of the plots.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Kansas State University

5.0435, MECHANICS AND PRINCIPLES OF WATER EROSION AND THEIR APPLICATION FOR EROSION CONTROL IN THE SOUTHERN PLAINS

***N.P. WOODRUFF*, Kansas State University, Agricultural Experiment Sta., *Manhattan, Kansas* 66504**

Object: To determine erosion causes, processes and study methods; and the relations between various soil conditions and properties, climate and erosion; to improve erosion prediction methods; to determine soil erosion tolerances; and to develop methods to control erosion and accelerate soil renewal.

Plan of Wsork: Use will be made of (a) a tower to simulate rain with and without wind, (b) a rain simulator to test erodibility of various soil and cover conditions, and (c) runoff and erosion records for individual storms. Major research techniques will be developed. Results obtained with rain simulators will be supplemented, compared, and coordinated with comparable field conditions. Study will be made of promising cropping and tillage practices; physical and chemical soil properties; permeability as it relates to erodibility of different soil types; relations between soil conditions, erosion-control structures, vegetative cover, topography, etc., under different climatic conditions, and integration into an improved water erosion equation; new and improved structures (terraces, furrows, crop rows) to control erosion under dryland and irrigated systems; climatic factors and runoff at various locations; and soil erosion tolerances and soil renewal methods.

SUPPORTED BY U.S. Dept. of Agriculture

5.0436, COMPLETE TREATMENT OF TANNERY INDUSTRIAL WASTE FOR CHROME TANNING, ALUM TANNING AND VEGETABLE TANNING

***J.R. HOWLETT*, Caldwell Lace Leather Company, *Auburn, Kentucky* 42206**

No completely satisfactory method has been devised for treating tannery industrial waste. Since tanneries use large volumes of water, containing organic and inorganic matter, suitable treatment methods must be found.

The objectives of the project are to demonstrate the feasibility of completely treating tannery waste from the only plant in U.S. that tans all three types of leather tannages - Chrome, Vegetable and Alum - and to obtain basic data to design full-scale treatment plants usuable for any tannery.

The basic plan is to develop methods to pre-treat the three present leather tannages, to combine their streams, and to completely treat tannery industrial waste. The high alkaline content of beam house waste will be neutralized with high acid made up of various tannages. The organic solids will be reduced in an anaerobic-aerobic lagoon.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Caldwell Lace Leather Company

5.0437, FISH POPULATION STUDIES. (DEWEY RESERVOIR)

B. LAFLIN*, State Dept. of Fish & Wildlife, *Frankfort, Kentucky

Objectives: To determine the changes in the fish population in Dewey Reservoir as a result of fertilization.

Procedures: Rotenone cove samples of approximately two acres in area will be made in May, June, July, August and September. These studies will be conducted according to the procedures outlined by Charles (1967) attached. Special emphasis will be placed on the length frequency distribution of the crappies and the bluegill in the samples to determine whether or not the expected increase in shad production as a result of artificial fertilization is accompanied by increased growth of bluegill and crappie.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Kentucky State Government

5.0438, METABOLIC ROLE OF SULFATES AND SULFIDES PRODUCING BACTERIA IN THE POLLUTION OF WATERS

***W.I. ALEEM*, Univ. of Kentucky, Water Resources Institute, *Lexington, Kentucky* 40506**

The proposed investigations involve laboratory and field studies directed at an attempt to determine the effects of metabolic activities of microflora involved in sulfur, iron and nitrogen transformations in the pollution of waters. The work is concerned with the studies of the biochemistry of such processes. The prime sites for initiating such investigations will be creeks receiving run-off from strip mined areas as well as the spoil banks. Any imbalance in the 'normal' sulfur and nitrogen cycle will be equated with the altered environment (either biologically or chemically), in an attempt to shift the environment back to the normal.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Kentucky

5.0439, ANALYSIS OF SOLUTIONS FOR SURFACE-ACTIVE CONSTITUENTS

H.H. BAUER, Univ. of Kentucky, Water Resources Institute, *Lexington, Kentucky* 40506

The behavior of surface-active substances at electrodes will be investigated in order to identify the effects due to the nature of the surfactant, the nature of the electrolytes present, and the relation between these two factors at different concentrations of both types of substances. These studies will be made by the tensammetric method which is well established.

The results will indicate the extent to which such methods can serve for the determination of surfactants in the presence of the wide variety of other substances that one expects to be present in samples of water that will need to be monitored for possible pollution. In addition, it may become possible to treat adsorption processes on a theoretical basis that includes the effect of the presence of electrolytes at the surface; present theories do not take this effect into account.

The applicability of a new technique of greater sensitivity and precision than the tensammetric method will be explored after the main features of the phenomena occurring have been elucidated by the tensammetric technique.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Kentucky

5.0440, ELECTROANALYTICAL CHEMISTRY - STUDIES OF ADSORPTION AND REDOX PROCESSES AT ELECTRODES

H.H. BAUER, Univ. of Kentucky, Graduate School, *Lexington, Kentucky* 40506

1. Studies of adsorption processes; primarily at adsorption-desorption (tensammetric-peak) potentials, by measurements of distortion induced in applied sinusoidal currents. 2. Influence of so-called inert electrolytes on characteristics of redox processes, to elucidate effects of electrical double-layer. 3. A.C. polarography in aqueous- alcoholic solutions: fundamental studies; decreased sensitivity to small amounts of contaminants.

Applications are foreseen to the monitoring of constituents of natural and polluted waters, both electroactive species and surface- active ones. Tensammetry may provide an empirical overall index of surfactant impurities since this technique detects the presence of the major surfactant independently (or usually nearly so) of the specific chemical nature of the surfactants present.

SUPPORTED BY University of Kentucky

5.0441, DETECTION AND IDENTIFICATION OF MOLECULAR WATER POLLUTANTS BY LASER RAMAN SPECTROSCOPY

E.B. BRADLEY, Univ. of Kentucky, Water Resources Institute, *Lexington, Kentucky* 40506

The proposed research is a study of the application of laser Raman spectroscopy in the detection and identification of molecular water pollutants. The primary advantages in such an approach are (1) laser Raman spectroscopy offers a direct method of detection and identification of molecules in water solution or suspension, and (2) the ability to detect and identify high-molecular-weight pollutants.

Laboratory and field investigations will include the following: (a) preparation of standard samples of various industrial and agricultural molecular water pollutants to which Raman spectroscopy is uniquely applicable, (b) use to standard samples to establish levels of detectability, sensitivity limits, and numbers of compounds in representative polluted water samples from industrial effluents that can feasibly be detected and identified by laser Raman spectroscopy at one time without separation techniques, (c) construction and testing of internal-beam-condensing cells, multiple-entrance cells, and laser- cavity cells, (d) sensititivity enhancement of Raman spectra by beam ratioing, (e) development of a catalog of standardized Raman spectra of a wide variety of water-soluble industrial waste products divided into the following categories: 1. organic pesticides, 2. petroleum products, 3. detergents, 4. inorganics.

The data will be employed to develop practical applications of laser Raman spectroscopy for the extension of analytical techniques of molecular identification outside the normal capability of GLC and mass spectroscopy.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Kentucky

5.0442, PROCEDURES FOR TRACE ANALYSIS OF DISSOLVED INORGANIC AND ORGANIC CONSTITUENTS IN WATER

G.D. CHRISTIAN, Univ. of Kentucky, Water Resources Institute, *Lexington, Kentucky* 40506

Various analytical techniques will be exploited for the determination of trace constituents in water.

1. Atomic Absorption Spectroscopy - Methods will be investigated to improve existing sensitivities. A systematic study of organic solvent systems will be conducted to determine the best solvent for each particular metal; acetone appears to offer generally high sensitivity. Thus, methods will be investigated for separating acetone from aqueous solutions via salting-out techniques and for performing solvent extractions with this system. Formation constants and metal/liqand ratios of metal ion complexes with ammonium pyrrolidine dithiocarbatate will be investigated by polarographic techniques. The use of atomic absorption spectroscopy for determining nonmetals in water by indirect methods will be studied.

2. Coulometric Titrations - The feasibility of electrogenerating hydrogen ions in concentrated salt solutions will be studied. Some concentrated neutral salts enhance the activity of the hydrogen ion with the result of certain nonaqueous solvent properties. Variables to be studied include: type of salt and concentration, current efficiency, endpoint detection, types of bases which can be titrated. This system may prove useful for titrating certain trace weak bases in water and bine solujtions without the necessity of obtaining them in a non-aqueous solvent.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Kentucky

5.0443, ALGAL GROWTH AND DECOMPOSITION - EFFECTS ON WATER QUALITY

E.G. FOREE, Univ. of Kentucky, School of Engineering, *Lexington, Kentucky* 40506

The proposed study will be basically an extension of a previous study conducted by the principal investigator. The objectives of the proposed study are as follows: l. To further evaluate a model for calculating the organic composition of algae as a function of the COD/weight ration and the nitrogen content. This will be accomplished by growing algal cultures of varying compositions and comparing directly measured values for the protein, carbohydrate and lipid contents with calculated values. 2. To further evaluate a model describing the regeneration of nutrients (nitrogen and phosphorus) during the decomposition of algae. Specifically, studies will be conducted to extend the model to aerobic as well as anaerobic conditions and to predict the kinetics as well as the extent of nutrient regeneration. 3. To relate the magnitude of the refactory organic fraction (that portion which is resistant to degradation) of a particular algal culture to initially measurable parameters such as DOD/weight ratio and nitrogen content.

Experimental methods will consist primarily of periodic sampling and analysis of algal cultures growing and decomposing under controlled laboratory conditions.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Kentucky

5.0444, FOAM SEPARATION FOR FIELD WATER TREATMENT

R.B. GRIEVES, Univ. of Kentucky, School of Engineering, *Lexington, Kentucky* 40506 (DADA)

Tech. Objective: Final establishment of and testing of design criteria for a field, water clarification unit to be used by the individual soldier are to be carried out. Criteria include column size and geometry, aerator size and porosity, aeration system, air pressure and air rate, aeration time, surfactant(s), surfactant dosage, and mode of operation.

Approach: Utilizing actual raw waters sampled from a variety of sources with highly variable quality, an actual-size prototype of the field unit is used to establish the ability of the foam separation process to clarify readily any water. The measures of success of the process are the turbidity of the clarified water, the volume of the raw water carried into the foam, and the residual surfactant concentration. Criteria, applicable to the field, are determined to minimize all of these measures.

Progress: Approximately 100 individual experiments have been conducted during the past six months utilizing waters sampled from six different sources in the Central Kentucky area. Using both Cetol (Fine Organics, Inc.) and Adogen 471 (Archer Midland Daniels), surfactants, all samples have been clarified readily and successfully, most within a 20 minute aeration time. Currently, modification of the aeration system to a hand-driven compressor is being initiated, and concurrent disinfection and foam separation are being investigated. Of the eleven final criteria listed in Technical Objective, all but three have been determined.

SUPPORTED BY U.S. Dept. of Defense - Army

5.0445, FOAM SEPARATION FLOTATION OF COLLOID ORGANIC SYSTEMS

R.B. GRIEVES, Univ. of Kentucky, School of Engineering, *Lexington, Kentucky* 40506

The overall objective of this investigation is the establishment of definite design criteria for specific, continuous foam separation processes. The processes will include the foam fractionation-flotation of colloidal and soluble iron from water supplies, the ion flotation of hexavalent chromium from plating wastes, the foam fractionation of sulfate, sulfite, and lignin-containing wastes from pulp and paper mills, the ion flotation of free and complexed cyanide, and several additional processes, involving specific industrial waste constituents. The processes will be conducted on a batch and *on a continuous-flow basis, establishing* the efficiencies on the basis of effluent contaminant concentration, and on the quantity of influent lost into the foam stream. For each process an economic evaluation will be carried out, and definite recommendations on the applicability of each process will be made.

Based on previous work and on work currently being conducted, foam separation processes can become a vital part of industrial waste treatment systems. They have excellent potential for water clarification and for iron and manganese removal. This research will enable the design of full-scale processes for specific contaminants.

An additional phase of the investigation will be a feasibility study of the addition of low concentrations of colloidal particulates to wastewaters to enable the foam separation of weakly-surface-active organics.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0446, A STUDY OF INHIBITORY COMPOUNDS PRODUCED BY FRESH-WATER ALGAE

D.O. HARRIS, Univ. of Kentucky, Water Resources Institute, *Lexington, Kentucky* 40506

The purpose of this study is to examine the biological and chemical properties of inhibitory compounds produced by freshwater algae (Volvocales). Past experiments by the author have shown a substance produced by Platydorina caudata to be: heat labile, non-dialyzable, dilutable several times with no loss in activity, specific for Platydorina, unstable at both acid and base conditions and unaffected by short periods of freezing and exposure to bacterial contamination. Studies here will be expanded to include Sephadex, DEAE cellulose, proteolytic enzymes, electrophoresis, etc. in an attempt to isolate and completely characterize these substances.

The study here will be three-fold in nature: (1) a study of substances which are auto-inhibitory in nature, (2) an examination of substances which are not specific for any one organism but effect a wide range of both animals and plants, and (3) a characterization of the substance and an attempt to learn how they work in order to gain insight as to a method for controlling non-desirous algal blooms. Perhaps this line of investigation will eventually provide clues to a method of controlling algae in water supplies, etc.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Kentucky

5.0447, ACIDITY OF SPOIL BANKS

H.F. MASSEY, Univ. of Kentucky, Agricultural Experiment Sta., *Lexington, Kentucky* 40506

Objective: To determine the reactions which occur when soil materials are subjected to acids produced on oxidation of pyritic minerals in strip-mine spoil banks.

Work Proposed: Several spoil-bank materials will be selected on the basis of their acid-producing capacities. The principal chemical, mineralogical and physical properties of these materials will be determined. The extent of acid production and the rate of acid production will be determined for each material. Based on the above preliminary work individual minerals and combinations of minerals will be subjected to conditions similar to those occurring during spoil bank weathering and the weathering products determined.

SUPPORTED BY U.S. Dept. of Agriculture
Kentucky State Government

5.0448, IDENTIFICATION AND REMOVAL OF PESTICIDES FROM RURAL WATER SUPPLIES

G.M. WHITE, Univ. of Kentucky, Agricultural Experiment Sta., *Lexington, Kentucky* 40506

Project Objectives: (1) to determine the extent and the state in which pesticides occur in farm water supplies, (2) to evaluate the effectiveness of presently recommended farmstead treatment systems in removing pesticide residues, (3) to investigate the possible application of new techniques and system arrangements to remove pesticide residues from rural water supplies.

Description of Work: Selected farm water supplies will be tested using standard chemical analysis techniques to ascertain the degree of pesticide contamination in these locations. Results will be correlated to the pesticide history of the watershed. The effectiveness of conventional rural water treatment and filtering methods in removing different pesticides will be studied. New or potential methods of removing pesticide residues from water supplies will be studied and evaluated for possible application on the farmstead.

SUPPORTED BY U.S. Dept. of Agriculture
Kentucky State Government

5.0449, OIL CONTAMINATION OF OYSTER FROM OIL WELL DRILLING MUDS

A.L. BERTRAND, Louisiana State University, Agricultural Experiment Sta., *Baton Rouge, Louisiana* 70803

Objectives: 1. To determine the amount of diesel oil present in contaminated oysters. 2. To determine the threshold amount of oil which can be detected by taste or organoleptically. 3. In what areas or organs of oysters the oil is concentrated. 4. The relationship between concentration of drilling mud in sea water to the oil concentration in the oysters.

At times drilling mud has been released into the surrounding areas. If oyster beds are in the vicinity where drilling muds are released such material can slowly settle over the oyster beds. This may cause the osyters to have an oily taste or if the concentration is high enough death of the oysters.

Oysters will be placed in tanks containing bottom mud mixed with oil drilling mud containing tagged hexadecane C14. Samples of oysters will be removed at regular intervals and the amount of oil from the drilling mud will be determined by liquid scintillation spectrometry. This is a cooperative project with the La. Wild Life and Fisheries Commission. The Grand Terre Laboratory will conduct the biological work. The extraction of the oil will be conducted in this Dept. The spectrometry will be carried out in the Nuclear Science Center at La. State University.

5. WATER QUALITY MANAGEMENT AND PROTECTION

SUPPORTED BY Louisiana State Government

5.0450, SEDIMENT TRANSPORTATION AND BOTTOM CONFIGURATION, AMITE RIVER

V.E. GWINN, Louisiana State University, Graduate School, *Baton Rouge, Louisiana* 70803

This is the second year of a two-year project. The periods in the annual discharge cycle when maximum depth of scour occurs in bends and crossings will be determined together with gross patterns of scour and aggradation in the channel. Predictions based on the results of current (1967-68) work will be tested by observing the patterns of distribution of clay-organic sediment beneath point bars inside the bends and comparing the facts with forecasts. Data on the scour-and- fill pattern during floods will be used to select optimum periods for installation of channel stabilizing structures, and optimum periods for installation of such structures in bends. On the basis of field work to date, the point bar terrains, clayey at the surface, are predicted to comprise largely sand and gravel in the subsurface.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Louisiana State University

5.0451, PESTICIDE CONTAMINATION OF THE ENVIRONMENT AND ITS SIGNIFICANCE

L.D. NEWSOM, Louisiana State University, Agricultural Experiment Sta., *Baton Rouge, Louisiana* 70803

Objectives: (1) To determine the extent to which the environment is contaminated and to develop a continuing monitoring system. (2) To develop more satisfactory analytical techniques and methodology than those which presently exist for residues of some insecticides. (3) To furnish pesticide analytical services to cooperating departments.

Description of Work Proposed. Amounts of insecticide residues currently present will be determined in representative samples of soil, water, bottom sediments, aquatic and terrestrial animals, and plants from five areas differing in ecology and land use. Data obtained will be used as a base line with which all subsequent data may be compared to determine changes resulting from changes in insecticide use paggern. Particular attention will be devoted to developing more satisfactory techniques for determining levels of organophosphorus and carbamate residues as well as any new materials which come into widespread use. Capability for performing analytical work will be increased to the point that pesticide analyses can be done for all cooperating departments.

SUPPORTED BY U.S. Dept. of Agriculture
Louisiana State Government

5.0452, LAGOONS FOR DISPOSAL OF BARN YARD WASTES

B.A. TOWER, Louisiana State University, Agricultural Experiment Sta., *Baton Rouge, Louisiana* 70803

To determine feasibility of disposing of animal waste by lagoon method under La. climatic conditions. To determine if lagoon method can be used for (a) Milking parlor and milk room; (b) Feeding floors for dairy, beef, hogs and chickens. To determine what size should be used in order to get satisfactory sedimentation, elimination of odors and to meet the demands of the State Board of Health.

Make survey and collect data on efficiency of operation on lagoons now in use.

Help install additional lagoons and obtain accurate data for 2- 3 year period during operation.

Summarize data and calculate correct size and operation for future recommendations on lagoons in Louisiana.

SUPPORTED BY U.S. Dept. of Agriculture
Louisiana State Government

5.0453, EFFECTS OF WATER QUALITY ON HATCHING SUCCESS

J.S. HUGHES, State Wildlife & Fish Comm., *Baton Rouge, Louisiana*

Objectives: (1) To determine the effect of water quality on hatching success of striped bass eggs. (2) To determine the effect of water quality on the hatching time and survival of striped bass fry.

Procedure: This job is contingent upon availability of striped bass eggs in Louisiana. When striped bass eggs are obtained, approximately 100 eggs each will be placed directly into one pint hatching jars. Waters of known quality will be used for hatching. As necessary, reference waters will be formulated. Duplicate hatching jars will be used with each water type. Studies will include but not be limited to the effects of temperature, pH, hardness, iron and zinc. Combinations of various chemicals will be evaluated as well as individual parameters. The temperature variations will be from 50 degrees Farenheit to 80 degrees Farenheit at 5 degree intervals. The pH will be varied from 5 to 9 among the hatching jars. A Hach Colorimeter will be used to determine the concentrations of most chemicals. The percent hatch, time of hatching and five day survival in all jars will be recorded. The various stages of egg development will be examined microscopically to determine when development is affected by the different water qualities.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Louisiana State Government

5.0454, EFFECTS OF CHANGES IN WATER QUALITY ON FRY AND FINGERLINGS

J.S. HUGHES, State Wildlife & Fish Comm., *Baton Rouge, Louisiana*

Objectives: (1) To determine tolerance limits of striped bass to changes in chemical constituents in water.

Procedures: Striped bass ranging in size from fry to six inches in length will be used for this study. Both gradual and rapid chemical changes and combinations of chemical changes will be tested. These will include but not be limited to hardness, pH, zinc, iron, sulfate, copper, chloride and turbidity.

Standard bioassay techniques will be used. Tests will be run with reconstituted water held at 22 degrees Centigrade. Graduated concentrations of a chemical will be placed in a series of aquaria. The fish will be observed for 96 hours or until death occurs. Concentrations where all fish die, all live and fifty percent live will be reported for each 24 hour period when applicable.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Louisiana State Government

5.0455, A COLOR REMOVAL AND FIBROUS SLUDGE DISPOSAL PROCESS FOR THE KRAFT PAPER INDUSTRY

F. JOHNSON, Continental Can Company Inc., *Hodge, Louisiana* 71247

The two year project will develop economical design and operation data applicable to the Kraft pulp and paper industry in removal of color in mill effluents, and disposing of fibrous sludges. Color removal will be accomplished by lime precipitation of the color bodies and fibers, with subsequent regeneration of the lime by sludge combustion in a kiln.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Continental Can Company, Inc.

5.0456, ENZYMES FOR ANALYSIS AND PURIFICATION OF SALINE WATER SYSTEMS

G.G. GUILBAULT, Louisiana State University, Graduate School, *New Orleans, Louisiana* 70112

Research will be conducted on (1) the use of enzymes systems for determination of inorganic and organic pollutants in saline water and (2) purification of water by selective enzymatic degradation of toxic materials. The approach involves the investigation by means of electrical and fluorimetric techniques, of a number of enzyme systems for analysis of impurities such as heavy metals, hydrocarbons, phenols and pesticides. In another phase of the work, the efficiency of enzymatic conversion of amines, acids, alcohols and hydrocarbons will be investigated.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

5.0457, A LIMNOLOGICAL STUDY OF LAKE PONTCHARTRAIN, LOUISIANA, IN THE SUMMER OF 1968

D.H. STERN, Louisiana State University, Graduate School, *New Orleans, Louisiana* 70112

A limnological reconniassance of Lake Pontchartrain, emphasizing chemical and physical dynamics, will be carried out during the summer of 1968. Four cruises (four or five stations per cruise) will be run successively. The cruise stations will be selected so as to sample the summer variability in physico-chemical parameters in the Lake waters. Stations will be established in such locales as river or bayou mouths, canal and sewer outfalls, and offshore lake waters. As soon as one cruise cycle (four cruises) is completed, the next one will be initiated.

Shipboard analyses will include surface, mid-depth and bottom measurements of the following: salinity, dissolved oxygen, light extinction, pH, and alkalinity. Laboratory analyses of surface, mid- depth and bottom water samples will include the following: turbidity, specific conductance, total phosphate, hardness, anionic detergents, nitrate nitrogen, ammonia nitrogen, silica, coliform bacteria presence, chlorophyll a and suspended matter. Additional tests which may be included are those for barium, chromate, cyanide, nitrite, nitrogen, total biomass per liter and plankton per liter. Finally, there will be an attempt to make preliminary determinations of the direction and rate of flow of water currents through the Lake during the summer period.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Louisiana State University

5.0458, CHLORINATION AND HYPOCHLORINATION OF POLLUTED STORM WATER PUMPAGE

C.J. POWELL, New Orleans Sewrge. & Wat. Bd. , *New Orleans, Louisiana*

To control bacteriological pollution in Lake Pontchartrain the project will demonstrate the effectiveness, efficiency, and economics of using open drainage ccanals as treatment facilities; the effectiveness of chlorine and hypochlorite disinfection on intermittent high flow discharges; and the optimization of various feeding rates, multiple points of application; and control times. Facilities for disinfection will be placed and operated in the St. Charles Canal, the London avenue Canal and the Orleans Avenue Canal. A sodium hypochlorite blending plant will be constructed and a chlorine alarm system installed. The project will include the provision of appropriate instrumentation for the generation of quantitative and qualitative data necessary for a comprehensive evaluation.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
New Orleans City Government - Louisiana

5.0459, COMPILATION OF WATER QUALITY DATA

J.T. DAVIS, State Wildlife & Fish Comm. , *New Orleans, Louisiana*

Objectives: 1. Secure all water quality data previously collected by all investigators. 2. Compile water quality data secured. 3. Analyze data to determine possible factors limiting striped bass in this area.

Procedures: 1. Contact all agencies taking water quality data on these lakes and their tributaries and secure data. 2. Compile data using ADP equipment presently owned. 3. Compare and analyze data based on reports of striped bass in other areas.

Several components in the instrumentation console for use with the modulated sub-carrier attenuation calibration systems in the frequency range 8.2 - 18 GHz have been constructed. These include an improved 1000 Hz constant-amplitude phase shifter and associated circuitry, a redesigned and improved null amplifier, a 1000 Hz phase detector, and a new driver amplifier for the ferrite modulator.

A new 30 MHz cut-off attenuator has been constructed for the parallel IF-substitution attenuation system. A longer precision lead screw is used and the input impedance-matching network was redesigned.

Approximately 45 waveguide items have been constructed for the attenuation calibration systems including sliding short-circuits, waveguide tuners, precision waveguide sections, sliding terminations, and a variable attenuator.

Two high-resolution gear trains have been constructed for use with the rotary-vane attenuators.

The period reported upon above is from approximately the starting date of the project given in Box 13 to 311267.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Louisiana State Government

5.0460, REPOPULATION OF EXPERIMENTALLY DECIMATED AREAS BY STREAM FISHES

G.E. GUNNING, Tulane University of Louisiana, Graduate School, *New Orleans, Louisiana* 70118

An alternative to restocking a stream artificially with fishes following natural decimation by pollution is to allow natural movement of the animals to repopulate a decimated area. The time for this to occur can be expected to vary depending upon environmental conditions and the species of fish in question.

The principal goal of the proposed study is to consider the rate of repopulation of experimentally decimated areas by stream fishes. The proposed study would utilize basic information on five species of fishes already obtained by the writer during the past seven years from three study areas in Louisiana which will be used again.

Segments of streams will be decimated by removing all fish possible in a given stretch. The movement of fishes marked upstream into the center area as well as the samples marked downstream from the central area in each stream will enable us to see the extent of repopulation under natural conditions.

SUPPORTED BY U.S. National Science Foundation

5.0461, BEDDING AND INFILTRATION STUDIES OF SANITARY SEWERS IN THE GULF COAST AREA

F.W. MACDONALD, Tulane University of Louisiana, School of Engineering, *New Orleans, Louisiana* 70118

The purpose of this project is to determine the best types of bedding arrangements and the most suitable materials to be used in laying sewer pipes in the Gulf Coast areas, including studies on manholes, teir and other appurtenances of sewer systems. A major portion of the project will be infiltration studies using various materials of construction. Some of the studies will be with a testing frame in the University laboratory, while other studies will include field studies of sewer lines in the area.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Tulane University

5.0462, CONTAMINATION OF OYSTERS BY PESTICIDES

F.W. MACDONALD, Tulane University of Louisiana, School of Engineering, *New Orleans, Louisiana* 70118

The objectives of this project are to determine the concentration factors, the rate of uptake, and rate of decontamination of oysters exposed to radiolabelled dieldrin and endrin; to examine the pesticide interaction with bottom sediments from Wilkinson Bay; to determine the amounts of dieldrin and endrin in Wilkinson Bay Oysters, to compare these amounts with the water, suspended material and bottom sediments in Wilkinson Bay, and to evaluate the environmental effects upon uptake. Data obtained should indicate whether the pesticide concentration in the oysters poses a health hazard to consumers, affects oyster growth, and will provide a base line for future samplings.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0463, THE ENGINEERING AND ECONOMIC ASPECTS OF USING SEWAGE EFFLUENT FOR IRRIGATION

C.W. WILSON, Louisiana Polytechnic Inst. , School of Agriculture, *Ruston, Louisiana* 71270

This research project is to investigate the technical and economic feasibility of using sewage plant effluent as irrigation water and will be conducted in Lincoln, Jackson, and Ouachita Parishes.

A review of literature will be made to determine the previous work, the city officials will be contacted and visits to treatment plants will be made. The treatment process at the plants and rate of discharge will be examined and records kept. The physical, chemical, and bacteriological conditions of effluent will be determined. The location of land that could be irrigated with the effluent will be determined. The cost of delivering the effluent to the point of use will be determined and the value of chemicals will be calculated. The cost of irrigation water from alternate sources will be determined and the economic feasibility of each project calculated.

From the references mentioned it is anticipated that this effluent will provide a low cost source of irrigation water. Field use of this resource should improve the economy of Louisiana. Public laboratory facilities, office space, and personal transportation are available to conduct this research.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Louisiana Polytechnic Institute

5.0464, EVOLUTION OF ALLOPATRIC POPULATIONS

W.H. EVERHART, State Inland Fish & Game Dept. , *Augusta, Maine* 04330

Beginning third year of work on this project.

Fertilized brook trout (Salvelinus fontinalis) eggs representing all possible crosses among seven distinctive trout populations in Maine were obtained during fall 1966, and are being reared at a local State fish hatchery. Rearing of the resultant young trout will continue through their second summer of life. During this time, studies of egg size, egg development rate, growth and condition of the resulting fry and parr, mortality of fry and parr, morphology and coloration, socio- territorial behavior, stamina, and resistance to unfavorable chemical features of the environment will be or have been carried out. Differences among lots can most probably be attributed to differences in genotype, and the 7 x 7 design of the experiment will allow evaluation of the heritability of the differences found.

An ecological-systematics study of three additional populations of wild brook trout is in progress. This study may show the magnitude of the differences to be expected among trout from deep, cold trout lakes; shallow, warm lakes; and cold, mountain streams.

General morphological and serological investigations of Maine's wild trout populations continue, along with experimental transfers.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0465, TREATMENT OF ALKALINE WASTES FROM POTATO PROCESSING

C. BRUCE, Vahlsing Incorporated, *Easton, Maine* 04740

The objectives of this project are to demonstrate the feasibility of: treating potato processing waste using the activated sludge system; combining potato processing waste with sugar beet refining waste; and the feasibility of three in-plant closed waste water systems in the sugar beet plant.

The project will provide extremely valuable data to both the potato processing and beet sugar industry. The aim is also to determine if a $30 million industrial complex, composed of potato and sugar beet processing and a residential community, can exist on a small stream, as is proposed, and have clean water.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Vahlsing, Inc.

5.0466, PHASE II-STUDY OF A RIVER SYSTEM AS A CHEMICAL REACTOR

E.G. BOBALEK, Univ. of Maine, School of Engineering, *Orono, Maine* 04473

The objective of the proposed work is to develop a mathematical model of an actual river system. This model will be developed and treated from the point of view of the river as a chemical reactor. A total systems concept will be applied in hopes of developing a practical control scheme which will ultimately optimize the manipulation of the river variables such that optimal water quality control will be attained. The river chosen is the Penobscot river between Bangor, Maine and the Atlantic ocean. While this work considers a typical paper industry river, it is hoped that the resultant model will be extensible to other rivers polluted by industrial and sewage wastes. The means of implementing and manipulating the model is analog, digital and hybrid simulation and control.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Maine

5.0467, HYDROGRAPHY OF THE PENOBSCOT RIVER ESTUARY

P.A. HAEFNER, Univ. of Maine, Graduate School, *Orono, Maine* 04473

A long range program of studies on the ecology of the Penobscot estuary has been established by the Maine Cooperative Fishery Unit. Part I involves a detailed study of the hydrography of 30 miles of estuary from Bangor Dam to Belfast. Salinity, temperature, density and dissolved have been and will continue to be monitored with the view toward detecting changes in the estuarine environment from anticipated pollution abatement in Penobscot River. This project was initiated July, 1963.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
University of Maine

5.0468, WATER QUALITY DEGRADATION BY SEPTIK TANK DRAINAGE

M.W. HALL, Univ. of Maine, School of Engineering, *Orono, Maine* 04473

Both field and laboratory studies will be performed to determine the degree of nitrogen and phosphorus removal that can be expected of septic tank-drainfield wastewater disposal systems. This investigation will provide information relative to the amounts of nitrogen and phosphorus which enter a lake as a result of seepage or drainage from septic tanks located along lake shores. The information obtained will provide authorities with a means for assessing the importance of this form of pollution.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

5.0469, WATER QUALITY ASPECTS OF RECREATIONAL LAKES

M.W. HALL, Univ. of Maine, School of Engineering, *Orono, Maine* 04473

The extent of nitrogen and phosphorous removal afforded by septic tank - drainfield systems - has not been adequately evaluated. Available evidence tends to indicate that such systems convert insoluble organic and inorganic forms of nitrogen and phosphorous to soluble inorganic forms. It is, therefore, highly probable that septic tank systems can not be expected to effect significant removal of these compounds. The goal of this research is to provide pertinent information on the quantities of nitrogenous and phosphatic materials that enter Maine lakes as a result of septic tank - drainfield practices.

SUPPORTED BY Maine State Government

5.0470, STUDY OF STRIPED BASS POPULATIONS IN MAINE COASTAL WATERS

R.W. HATCH, Univ. of Maine, Graduate School, *Orono, Maine* 04473

Striped bass are becoming an increasingly important sport fish in Maine coastal waters and river estuaries. Intelligent management of this source requires knowledge of the population structure of the species. Present indications are that most striped bass caught in Maine come from a large migratory population. Factors influencing the migratory pattern of this population are not clear, but may include temperature of estuarine waters, variable distribution of preferred food organisms, degree of estuarine pollution, and variation in offshore currents. Natural spawning sufficient to maintain the known stocks has not been demonstrated in eastern Maine. Lack of spawning populations may be related to head-of-tide dams that restrict access of striped bass to fresh water on most Maine coastal streams. Future efforts will be directed toward identifying the source of striped bass and the factors which determine annual variations in estuarine abundance.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
University of Maine

5.0471, THE EFFECT OF SALTS APPLIED TO HIGHWAYS ON THE INFILTRATION AND PERCOLATION OF WATER THROUGH THE SOILS BANDING HIGHWAYS

F.E. HUTCHINSON, Univ. of Maine, School of Agriculture, *Orono, Maine* 04473

The application of chloride salts to highways as a means of ice removal in the northeastern United States has become a widespread practice during the past twenty year period. In Maine alone in excess of 100,000 tons of salt were applied for this purpose during the year 1964-65. The fate of these salts with respect to soil and water resources is not adequately known at present. The nature and extent of their accumulation in the soils bordering highways is to be determined by this project.

Soil samples will be collected from specific sites near highways which have been regularly salted and from the same soils at sites away from highways. Analyses for sodium will be made with a Beckman flame photometer and for chloride by a Dohrmann microcoulometric titrating system. Infiltration and percolation rates for salted and unsalted soils will be made in the field. Snow and water samples will be collected and analyzed to determine the salt concentration of the liquid entering and flowing over the soils near major highways. The project will be started in fiscal year 1965 and terminated in 1968.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Maine

5.0472, EFFECTS OF CHRONIC SUBLETHAL DOSAGES OF DDT ON THE SWIMMING PERFORMANCE OF ATLANTIC SALMON PARR

J.D. MCNEISH, Univ. of Maine, Graduate School, *Orono, Maine* 04473

The effects of sublethal dosages of DDT on the swimming performance of Atlantic Salmon parr is being investigated. Performance is measured by the Burrows stamina tunnel which is housed in facilities provided by Craig Brook National Fish Hatchery. The project was initiated July, 1967.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
University of Maine

5.0473, A BENTHIC COMMUNITY OF THE PENOBSCOT RIVER ESTUARY

W.K. SHOREY, Univ. of Maine, Graduate School, *Orono, Maine* 04473

A macrobenthic community inhabiting substrate with relatively high concentrations of sawdust is being studied. Possible effects of sawdust on benthic communities may be brought out as comparisons are made with studies of the areas of similar chemical and physical properties, but free of sawdust. The project was activated in fiscal year 1967 and should be completed in fiscal year 1969.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
University of Maine
U.S. National Science Foundation

5.0474, ADSORPTION OF VIRUSES ON MINERAL SURFACES

O.J. SPROUL, Univ. of Maine, School of Engineering, *Orono, Maine* 04473

At the present time it is known that most small soil particles will adsorb virus particles. There does not exist, however, a rational method for predicting the capacity of soils for viruses.

The minerals to be used in the investigation would be quartz, orthoclase, albite, anorthite, muscovite, biotite, augite, hornblende and olivine. The minerals would be further classified as to expected mode of reaction in accordance with their physical and chemical structures. Bench scale experimentation to yield data for adsorption isotherms would be carred out. The effect of particule diameter would be assessed by separate experiments. The T4 bacteriophage would be used in the initial work as a screening virus. Subsequent work with a fewer number of typical minerals would be done with the Type I poliovirus and with either an adenovirus or a reovirus. Isotherms from the desorption of the virus would also be determined through the use of competing adsorbate. Adsorptive behavior in column studies would be carried out to determine virus breakthrough curves.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Maine

5.0475, EFFECTS OF CHEMICAL IONS ON VIRUS INACTIVATION

O.J. SPROUL, Univ. of Maine, School of Engineering, *Orono, Maine* 04473

This project would determine the influence of chemical ions on virus inactivation in certain water and wastewater treatment systems and dieoff in natural water systems. The process to be investigated would be ion exchange, phosphate removal from a secondary effluent and inactivation under high and low pH conditions.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0476, CHEMICAL CONTAMINANTS FOUND IN SURFACE AND SUBSURFACE WATER AS RELATED TO SOIL AND CLIMATIC CONDITIONS

R.A. STRUCHTEMEYER, Univ. of Maine, School of Agriculture, *Orono, Maine* 04473

The quality of stream water is greatly influenced by the amount and contamination of runoff water. Contamination of the runoff waters is primarily a result of chemical applications to soils and plants and through the weathering of minerals. this contamination could effect human, biological or industrial users.

This study will consist of the analysis of surface waters from existing runoff plots as to mineral elements and pesticides. Mineral elements such as iron, manganese, zinc, chloride and others will be determined by spectrographic, colorimetric and other techniques. Residues of insecticides, fungicides and herbicides will be analyzed by gas chromatography, chromatography, and other analytical methods.

An attempt will be made to evaluate the movement of these materials through the soil as a result of leaching.

Interrelations of climatic and soil characteristics such as soil temperature, precipitation, and soil moisture will be studied.

The present runoff plots are located in Presque Isle, Maine. Samples will be brought to the University of Maine for analysis.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Maine

5.0477, INDUCED AIR MIXING OF LARGE BODIES OF POLLUTED WATER

S.A. ZIEMINSKI, Univ. of Maine, School of Engineering, *Orono, Maine* 04473

The Problem: Organic matter of industrial and natural origins tends to settle on the bottom of lakes and other large water reservoirs where it decays depleting the water of dissolved oxygen necessary to ensure normal aquatic life. Although the upper surface of water which is in direct contact with atmosphere may be saturated with oxygen, the mixing resulting from density differences is too small to replenish the oxygen deficiency in the lower layer. The resulting anaerobic conditions lower the water quality. Formation of hydrogen sulfide as well as sulfides of iron and manganese takes place. The carbon dioxide concentration increases and the pH decreases. This anaerobic decomposition can produce undesirable organics, imparting bad taste, odor and occasionally toxicity to the water. The unodidized organic matter piles up on the bottom and gradually the body of water becomes smaller and shallower. Plan of Attack: Introduce compressed air in appropriate places of the body of water. The resulting mixing oxygen supply and improved surface aeration will provide to the whole body of water the oxygen necessary for bio-oxydation of the waste organic matter. In addition to substantial increase in dissolved oxygen the application of this method results in precipitation of iron, reduction in carbon dioxide content, improvement of color, etc. Although this method has a tremendous potential in decreasing pollution of large bodies of water, very little is known about the various factors affecting the efficiency of the system and therefore its optimum design. The Objective: A mathematical analysis has been conducted in our laboratory which resulted in selection of a mathematical model which correlates the rate of mixing, density differences produced by the induced air, depth of immersion of the aerator, etc. A complete experimental procedure has been worked out to check or modify the model. It is expected that this work will allow a successful and efficient design of induced air systems for different shapes, sizes and depths of large bodies of water.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0478, WATER QUALITY - BENTHIC INVERTEBRATE RELATIONSHIPS IN ESTUARIES

D. DEAN, Univ. of Maine, Ira C. Darling Ctr. For Res. , *Walpole, Maine* 04573

This project proposes to investigate the relationships between water quality and benthic invertebrates in Maine estuaries. Studies will be conducted in three estuaries, the Penobscot, the upper reaches of the Damariscotta and the Sheepscot, representing heavily polluted, moderately polluted and unpolluted conditions, respectively. Comparable portions of each estuary will be studied to determine the benthic communities present, the settlement of benthic invertebrate larvae, larval metamorphosis, and the growth and survival of juvenile forms. Hydrographic, chemical and geological parameters of the waters and sediments will be measured and used as guidelines for controlled laboratory experiments on larval settlement.

The results of this project should aid 1) in the interpretation of fish distribution patterns in estuaries subject to different levels of pollution and 2) in predicting biotic changes that would occur in an estuary subjected to increased or decreased pollution loads.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Maine

5.0479, FLUID FRICTION IN THE PRESENCE OF NON-RIGID BOUNDARIES

J.C. GEYER, Johns Hopkins University, School of Engineering, *Baltimore, Maryland* 21218

In the presence of thin biological slime layers at the walls of water transmission systems, frictional losses are often observed that are considerably higher than would be expected from the relative roughness of the interior of the conduits.

It is suspected that the biological slime represents and 'active surface,' i.e. a boundary that can be set in motion under the action of fluid flow. Under certain conditions resonance phenomena between the flexible slime surface and the bulk liquid probably account for the high frictional resistance.

The purpose of the proposed study is to investigate the mechanism responsible for this high frictional resistance in the presence of slime layers. Experiments are outlined to determine the functional relationships between the essential parameters. With this information it should be possible to derive criteria for effective control of aquatic slime layers taking into account chemical as well as physical aspects.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0480, INDUSTRIAL REUSE OF PROCESS WATER

C.E. RENN, Johns Hopkins University, School of Engineering, *Baltimore, Maryland* 21218

This is a cooperative study involving the Federal Water Pollution Control Administration, Black and Decker Manufacturing Company, The Johns Hopkins University, and Maryland State Health Department. It is designed to build the engineering background associated with biological problems -- slimes, fouling, insect and snail nuisance, etc. -- that occur when highly treated sewage is stored in exposed ponds for prolonged periods and reused in industrial processes.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Johns Hopkins University

5.0481, FLOOD FREQUENCY AND LOW-FLOW ANALYSES

P.N. WALKER, Johns Hopkins University, State Geological Survey, *Baltimore, Maryland* 21218

It is planned to prepare statistical summaries of low-flow, high- flow and flow-duration data. Flood frequencies and peak discharge information will be determined. The final product will be a statistical presentation of surface-water data collected in Maryland that will have wide application in the design of water works and sewage disposal plants.

SUPPORTED BY Maryland State Government
U.S. Dept. of Interior - Geological Survey

5.0482, DETERMINATION OF RESIDUES OF INSECT CONTROL CHEMICALS IN PLANT AND ANIMAL PRODUCTS AND IN SOILS

M. BEROZA, U.S. Dept. of Agriculture, *Beltsville, Maryland*

Object: To determine (1) the amount and distribution of residues on or in plants and plant products, soils, animal tissues, milk, eggs or other animal products as a result of insect control chemicals, (2) breakdown products of such insect control chemicals resulting from metabolic processes in plants and animals or from the action of weathering, and (3) the rate of disappearance of insect control agents or their breakdown products from plant and animal tissues and soils.

Plan of work: Data will be obtained on the rate of deposition and the persistence of residues from the appplication of new insecticide chemicals. Included will be a wide variety of crops and soils that have been treated directly or that contain residues of chemicals applied to crops grown in the soils. The accumulation and persistence of residues in the fat, organs, and milk of cattle treated directly, or exposed by treating premises or feed crops will be determined. Occasional analyses will be made of tissues from game animals for pesticide residues. Emphasis will be placed on new insecticides that will not cause residues in food crops or animal tissues. Telodrin, dimethoate, dicapthon, phorate, Di-Syston, diazinon, Imidan, Tedion, Ethion and DDVP residues will be studied.

SUPPORTED BY U.S. Dept. of Agriculture

5.0483, AGRICULTURAL SIGNIFICANCE OF CERTAIN TRANSITIONAL ELEMENTS FROM PESTICIDES AND OTHER AGRICULTURAL CHEMICALS

L.A. DEAN, U.S. Dept. of Agriculture, *Beltsville, Maryland*

Object: To develop methods to detect and determine heavy metals of Group II and transition elements in soils and plants; and to study the chemistry of these elements in soil with emphasis on interactions between environmental characteristics such as soil type, fertilizer, moisture, temparature, aeration, and plant species on the availability of these elements to plants.

Plan of work: Analytical techniques will be developed to extract and determine arsenic, copper, cadmium, cobalt, chromium, nickel, hydrargyrum or mercury, plumbum or lead, tin or stannum, and zinc. An extracting technique must be developed that will remove from the soil an amount of the element that is highly correlated with the concentration of that element in an indicator plant growing in the soil. Several chelating agents will be used and evaluated as extractants. Spectrographic or other instrumental or chemical procedures will be studied as an analytical tool in determining concentrations of the extracted elements. Certain problems dealing with the chemistry of these elements will be studied concurrently with the development of the analytical techniques. Environmental factors associated with fixation and availability will be of primary interest.

SUPPORTED BY U.S. Dept. of Agriculture

5.0484, ACCUMULATION AND MOVEMENT OF FISSION PRODUCTS IN SOILS AND PLANTS

L.A. DEAN, U.S. Dept. of Agriculture, *Beltsville, Maryland*

This project seeks ways to reduce contamination of field-grown crops with radioactive fallout. Particular consideration is given to the soil chemistry and plant uptake of strontium-90.

Uptake of radiostrontium by crops may be sharply reduced by burying it deeply in the soil profile in contact with chemicals that inhibit root development in the contaminated zone. Without chemicals, the uptake of radiostrontium from layers buried 20 inches beneath the soil surface in field plot experiments has averaged about half of that from the normal plow depth. When Na_2CO_3 was applied with the buried layer at the rate of 10 tons per acre, the uptake of radiostrontium was only a few percent of the uptake when no chemical was used. Further tests of uptake by crops with different types of root systems will be made, using a large moldboard plow to bury strontium-85 and Na_2CO_3.

The fixation and exchange reactions of strontium on soil materials are studied for their relevance to uptake. Laboratory studies show that hydrous sesquioxide gels on a kaolinite surface play a role in fixation. The selectivity coefficients of exchange reactions on clay minerals vary somewhat with composition of absorbed cations, whereas the exchange capacities increase with increasing concentration of external solution. Relationships of these effects to an assumed heterogeneous charge density at the clay mineral surface are being investigated.

Absorption of strontium-90 from rain by field crops varies widely between species. In controlled environment, absorption increased with increasing relative humidity and temperature of the air to which the leaves were exposed for 24 hours after an applied radiostrontium solution became dry. Differences between species were related to differences in wettability of the leaves.

SUPPORTED BY U.S. Dept. of Agriculture

5.0485, PESTICIDE POLLUTION OF FARMSTEAD WATER SUPPLIES

R.F. EAGEN, U.S. Dept. of Agriculture, *Beltsville, Maryland*

Object: To assemble information on the use and handling of pesticides on an around the farmstead and to develop methods for preventing entry of pesticide pollutants into farmstead water supplies.

Plan of work: Pertinent information on characteristics of insecticides, rodenticides, herbicides, fungicides, and other such pesticides reaching farmstead domestic water supplies will be collected and assembled by search and monitoring of available literature; correspondence, discussion, and other communication with appropriate Federal and State scientific workers in the health and sanitation disciplines, manufacturers representatives, and others; and by a sampling and analysis program. Field and laboratory studies will be made to trace the routes taken by the pesticides from the point of application, accidental discharge, or waste disposal, to the point of entry into the water source or other point in the supply system. Means for detecting presence of pesticides in water will be studied in an effort to develop equipment, instrumentation, and techniques that would be practical for detection under farm conditions. Exploratory investigations will be made on methods for preventing entry of pesticides into farmstead domestic water supply facilities.

SUPPORTED BY U.S. Dept. of Agriculture

5.0486, ALTERATIONS OF THE PERSISTENCE AND MOVEMENT OF HERBICIDES IN SOIL, WATER, AND PLANTS

J.T. HOLSTON, U.S. Dept. of Agriculture, *Beltsville, Maryland*

Object: To determine the effects of herbicide formulation and placement and of soil management practices in the volatility, decomposition and movement of selected herbicides in soil, water and plants.

Plan of work: Factors influencing the persistence of herbicides will be determined by literature review and laboratory studies; the herbicides will include CIPC, EPTC and TOA. Persistence and movement of herbicides in soil and in growing plants will be determined by field experiments on a range of soil types. Factors affecting persistence and movement to be investigated include: (1) use of soil additives such as fertilizers and carbon sources; (2) soil manipulation; (3) placement of herbicides on and in soils, and (4) changes in granular and liquid formations of herbicides. The use of fungicides and bactericides to increase persistence in soil will be investigated. Granular matrices and accompanying ions or compounds will be selected to give optimum retention times for given purposes. Granular formulations will be used principally to reduce or increase vaporization losses. The effects of granules on detoxification of microorganisms and on leaching losses will be explored. Similar studies will be conducted with liquid formulations. The use of different solvents and chemical additives will be explored. Sensitive quantitative methods for determination of herbicides will be developed if needed.

SUPPORTED BY U.S. Dept. of Agriculture

5.0487, THE MOVEMENT OF HERBICIDES OFF, INTO, AND THROUGH SOILS

P.C. KEARNEY, U.S. Dept. of Agriculture, *Beltsville, Maryland*

Object: To determine the lateral and vertical movement in soils of known physical, chemical, and mineralogical properties of several herbicides differing in physical and chemical properties.

Plan of Work: The presence of herbicides in and on soil surfaces caused by lateral and vertical movement will be determined in a well defined watershed with detailed past information on cropping history, fertilizer treatments, soil physical properties, climatic conditions, and hydrological data. Soil samples will be taken at 0-2, 11-13, 23- 25, and 35-37 inches at least four times a year for chemical analysis to determine the depth of movement of at least six herbicides. Water samples collected from weirs will be taken prior to the application of the chemicals, and at subsequent times thereafter as determined by the amount of precipitation and the amount of runoff. Herbicides in soil and water samples will be assayed using appropriate analytical methods, including colorimetric, spectrophotometric and gas chromatographic procedures. All data will be subjected to appropriate statistical analyses, and correlated with the soil and climatic data pertaining to the areas receiving herbicide applications.

SUPPORTED BY U.S. Dept. of Agriculture

5.0488, CONTROL OF INSECTS ASSOCIATED WITH SWINE PRODUCTION WITHOUT THE USE OF INSECTICIDES

C.M. KINCAID, U.S. Dept. of Agriculture, *Beltsville, Maryland*

Object: To investigate fly and insect propagation under different systems of handling swine wastes and devise effective methods of controlling such insects without the use of insecticides.

Plan of work: Confinement systems of producing swine will utilize methods of handling wastes as follows: (a) an open front, shed-type house with a covered concrete floor, in which manure, bedding and other wastes are scraped and spread on the land at weekly intervals, (b) a completely enclosed, insulated and ventilated housing unit with a partial slotted floor and manure pit for accumulation of waste, which will be spread in liquid state on the land at 30-day intervals, (3) the same type housing as (b) with waste discharged into septic tank and the effluent from the septic tank discharged into an oxidation lagoon, and (d) a confinement unit similar to (b) and (c) above with the waste discharged directly into a lagoon for anaerobic decomposition. Each of the units will be screened. Known numbers of housflies will be introduced and population buildup observed. Larvae and adult mosquitoes in the lagoons will be evaluated. Wastes spread on the land from units (a) and (b) will be monitored for insect propagation at intervals after each spreading. Detailed records will be kept on all animals--weights, feed consumption, and any departures from normal response or behavior.

SUPPORTED BY U.S. Dept. of Agriculture

5.0489, DETERMINATION AND EVALUATION OF FACTORS AFFECTING WATER RUNOFF AND EROSION IN

THE DIFFERENT LAND RESOURCE AREAS OF THE NORTHEAST

J. LUNIN, U.S. Dept. of Agriculture, ***Beltsville, Maryland***

Object: To evaluate the interactive effects of climatic, topographic, vegetative and soil conditions found in the different land resource areas of the Northeast on runoff, soil erosion, and percolation, and to develop and evaluate water management practices for the control of these factors.

Plan of Work: Various soil and crop management practices are being evaluated quantitatively for runoff and erosion losses and their effect on soil physical properties under natural field conditions. Practices such as plow-plant and stubble-mulch seedbeds are being studied along with a more critical evaluation of contouring and the use of diversion terraces. In the glaciated areas of New England, special attention is being given to the effect of rocks and stones on runoff and erosion. Landforming on sloping land is being studied as an aid to contouring for the purpose of eliminating point rows to facilitate mechanization. Rainfall simulators are utilized to permit a more quantitative evaluation of the erosive properties of soils with and without various types of vegetative cover. Results of these various investigations will be utilized to improve existing soil erosion predictive equations so that they will be equally applicable to the various land resource areas.

SUPPORTED BY U.S. Dept. of Agriculture

5.0490, INSECTS ASSOCIATED WITH AQUATIC WEED PESTS OF FOREIGN ORIGIN IN LOUISIANA

R.I. SAILER, U.S. Dept. of Agriculture, ***Beltsville, Maryland***

Object: To discover, collect, preserve representative samples, identify, and study the biology of insects associated with aquatic weeds; and to evaluate their potential for control of such weeds.

Plan of work: The work will consist of the following: (1) conduct surveys throughout the year in major ecological areas of Louisiana, to determine what insects and related arthropods feed on alligatorweed, water hyacinth, and parrot's feather; (2) collect all species of arthropods found associated with the weeds; (3) properly prepare specimens in order that they may be identified; (4) conduct basic biological studies of those insects apparently capable of suppressing the weeds in the field, small concrete or metal tanks, and in aquaria in the laboratory; (5) preserve samples of developmental stages of the insects studied under number 4 above together with a record of the conditions under which the specimens are found.

Grant project with the Louisiana State University and A&M College.

SUPPORTED BY U.S. Dept. of Agriculture

5.0491, METHODS OF ANALYSIS FOR INSECT-CONTROL CHEMICALS

M.S. SCHECHTER, U.S. Dept. of Agriculture, ***Beltsville, Maryland***

Object: To develop methods of analysis for insecticides, attractants, repellents or other insect-control chemicals and for their residues, metabolites, or breakdown products in crops, soils, animal tissues, and milk.

Plan of work: When an insect control chemical has shown sufficient promise so that ENT plans to evaluate it with a view to recommending it for use, a method to analyze the chemical compound and its residues or metabolites will be developed, when necessary. The chemical and physical properties of the compound and the various reactions it can undergo in order to find characteristics that are specific and permit quantitative measurement will be studied. For example, such a characteristic might be reaction with certain reagents to give a colored product measurable by a spectrophotometer at a definite wavelength, quantitative reduction at a specific electric potential, or passage through a gas chromatograph column under definite conditions in a specific time interval. After a suitable colorimetric reaction or other characteristic has been found, the optimum conditions for precise and accurate measurements in the desired concentration range will be established. Suitable procedures also will be developed for the extraction and clelanup of samples, including plants, soils, fat, milk, etc., to be analyzed for residues by a given method.

SUPPORTED BY U.S. Dept. of Agriculture

5.0492, PATHOGENS AS BIOLOGICAL CONTROL AGENTS FOR MOSQUITO LARVAE

C.H. SCHMIDT, U.S. Dept. of Agriculture, ***Beltsville, Maryland***

Object: To search for, identify, and study pathogens including viral, fungal, bacterial, protozoan, and/or nematode infections which affect mosquitoes and study their potentiality as biological control agents for larvae or adults.

Plan of work: The contractor shall be responsible for conducting all of the research outlined in this line project. Surveys of natural mosquito breeding areas will be conducted to locate mosquito populations infected with pathogens. Samples of these populations will be collected and returned to the laboratory to determine: (1) Species of mosquitoes which are infected, (2) types of species of pathogens causing infection, and (3) an estimation of the degree of infection of the natural population of mosquitoes. Studies will be conducted in the laboratory to determine the life cycle of pathogens (virus, fungus, bacterium, protozoa or nematode), the environmental factors influencing their development, and the mechanisms by which these pathogens infect mosquitoes.

SUPPORTED BY U.S. Dept. of Agriculture

5.0493, DISPERSAL OF CONCENTRATED OR UNDILUTED INSECTICIDES FOR IMPROVED MOSQUITO CONTROL

O.H. SCHMIDT, U.S. Dept. of Agriculture, ***Beltsville, Maryland***

Object: To evaluate aerial applications of concentrated or undiluted sprays of insecticides for the control of mosquito larvae and adults, with particular emphasis on the effectiveness of different formulations and the economy of this method of application in irrigated agricultural lands in California.

Plan of Work: The contractor shall be responsible for conducting all the research outlined in this line project. Formulations of insecticides known to be effective in the control of mosquitoes and possessing physical characteristics suitable to low volume dispersal will be developed. Existing aerial spraying equipment will be evaluated for the dispersal of undiluted or highly concentrated insecticides. Modifications of existing equipment or the design of new equipment will be undertaken to obtain the most satisfactory dispersal of this type of formulation. The effectiveness of different formulations in controlling mosquito larvae and adults, which are produced in irrigated agricultural areas, will be evaluated under field conditions in California. Studies will include the effects of air speed, heights, and flight patterns on effectiveness of mosquito control and effects on other insects in the area.

SUPPORTED BY U.S. Dept. of Agriculture

5.0494, COMPARISON OF VARIOUS FORAGES FOR AGRICULTURAL WASTE WATER DISPOSAL

J.H. AXLEY, Univ. of Maryland, School of Agriculture, ***College Park, Maryland***

Various amounts of waste water from an agricultural processing plant will be applied with a sprinkler irrigation system to several forage species. Forages to be compared are pure stands of Kentucky 31 tall fescue, reed canary-grass, orchardgrass, and sudangrass; and a mixture of Alsike clover, Ladine clover, and tall Fescue. A fallow plot will be included. The forages will be harvested several times each year and evaluated for yield and content of N, P. K, and possible waste contaminants. Plant vigor and persistence will be observed. The infiltration rate with which the water enters the soil under the different treatments will be measured. The soil will be analyzed bienially for pH, P, K, organic matter, and soluble salts.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Maryland

5.0495, KINETIC STUDIES OF THE OXIDATIVE DEGRADATION OF DETERGENT, AND RELATED CHEMICAL SPECIES IN AQUEOUS SOLUTION

R.B. BECKMANN, Univ. of Maryland, School of Engineering, ***College Park, Maryland***

This is a joint research effort of the Department of Microbiology and Chemical Engineering to study the fundamental biological, and physical-chemical and engineering aspects of the biodegradation process for LAS detergents and to explore the similar fundamental aspects of alternative oxidation routes. Phase I is to be investigated by utilizing a pure (insofar as is possible) LAS derivative, such as A- Dodecene Benzene Sulfonate (or other alkyl derivative in the C12-C15 linear alkyl range) and investigate the rate of degradation in 'synthezised' systems; the systems being 'synthesized' in that the LAS, bacterial, and dissolved oxygen contents will be controlled and the intermediate products and end products will be continually monitored. Once the specific intermediate products have been identified, rate studies will also be carried out using these intermediates as starting materials. By utilizing the 'synthesized' reaction systems in this initial stage, a 'control' or 'ground state' can be established for extension of the kinetics into the realm of industrial or multicomponent mixtures, and it will also serve as a comparative base for the second (II) and concurrent phase of the project. The las concentration range covered will be that anticipated in normal effluents 10-1000 parts per million with ultimate extension to the more concentrated regions that might be encountered in sludges.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Maryland

5.0496, OXYGENATION KINETICS OF REDUCED SULFUR SPECIES

F.B. BIRKNER, Univ. of Maryland, Graduate School, *College Park, Maryland*

It is anticipated that the proposed investigation will supply much needed kinetic and stoichiometric information concerning the oxidation of reduced sulfur species by molecular oxygen under conditions which exist in natural water environments. The project has been designed to determine the order of the reaction kinetics and the effects of pH, ionic strength, temperature, and specific metal cations on the rate of the oxidation reaction. Preliminary calculations, based on recent polysulfide equilibrium data, indicate a significant change in the distribution of reduced sulfur species with pH when both monosulfides and polysulfides are considered to be present simultaneously in a reaction mixture. This effect has never been considered before but may have an important bearing on the pH dependence of the overall oxidation rate of reduced sulfur species. This hypothesis will be tested experimentally.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0497, TREATMENT OF LIQUID WASTE FROM FOOD PROCESSING PLANTS

A. KRAMER, Univ. of Maryland, School of Agriculture, *College Park, Maryland*

Incoming water, waste effluent, and liquid in the waste disposal systems of six commercial food processing plants will be analyzed for total solids, organic matter, certain cations and anions, pH, gases, and pesticide residues. On the basis of analytical findings, recommendations will be made on the most efficient means of water reuse before discharge, and studies will be conducted on possibilities of neutralizing, salting-out and otherwise eliminating deleterious materials from water in the plant for possible reuse, or from effluent to be collected as solids before entering the waste disposal system or direct release onto land or streams. Minimizing off-odors from waste accumulations will also be considered.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Maryland

5.0498, EFFECTS OF THERMAL POLLUTION ON PRODUCTIVITY AND STABILITY OF ESTUARINE COMMUNITIES

J.A. MIHURSKY, Univ. of Maryland, Natural Resources Institute, *College Park, Maryland*

A multidisciplinary investigation is proposed to study thermal pollution of an estuarine community. Laboratory studies of behavioral, metabolic and growth responses to heat stress will be integrated with field experiments to evaluate the overall impact of thermal pollution on an estuarine ecosystem.

Specifically, the laboratory phase will study representative species from the phytoplankton and planktonic herbivores. Growth of algae and intrinsic rates of increase of copepod populations will be used to evaluate thermal stress separately and when other environmental components are varied. At the same time, survival, behavior and metabolism of vertebrates and macro-invertebrates will be measured in gradients of temperature and salinity.

Field experiments will determine the influence of heat pollution on several trophic levels. Rates of mortality, biomass turnover or production and energy flow will be used to evaluate the impact of pollution. An ideal field situation has been provided by the newly constructed electrical generating plant at Chalk Point on the Patuxent river estuary.

The field experiments may be divided into those which test the direct effect of the passage of a part of the estuary through the power plant. The indirect effect of effluent water on the planktonic community adjacent to the power plant may be determined by correlation and comparison with pre-existing patterns of biomass, production and species structure of the plankton. Similarly, pre-pollution-phase measurements of vertebrate and macro-invertebrate standing stocks may be correlated and compared with those existing under thermal pollution.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Maryland

5.0499, DISPOSAL OF WASTE FROM SWINE FEEDING FLOORS TO MINIMIZE OR ELIMINATE STREAM POLLUTION

W.F. SCHWIESOW, Univ. of Maryland, School of Agriculture, *College Park, Maryland*

A septic tank system will be constructed for disposal of wastes from a swine feeding floor to prevent effluent from such floors polluting streams. The effectiveness of such a system will be evaluated for its ability to reduce the biochemical oxygen demand (BOD) of such wastes and to dispose of the wastes by distribution through an underground tile disposal field. Data to be collected will include sludge buildup in the tanks and the gradients of distribution through the soil and the gradients of BOD reduction. The effectiveness of the septic tank and underground disposal system will be compared to that of a lagoon for which three years' operation history is available and which will be continued in service.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Maryland

5.0500, DISPOSAL OF WASTES FROM SWINE FEEDING FLOORS TO MINIMIZE STREAM POLLUTION

W.F. SCHWIESOW, Univ. of Maryland, School of Agriculture, *College Park, Maryland*

To investigate methods for disposing of waste from swine feeding facilities. To develop guide lines for design of systems to minimize water pollution by swine wastes.

The present research installation is to be modified and improved to provide data on quantity of waste, characteristic properties of the waste, and performance of the system. Analysis of data obtained from this project is expected to establish guide lines for design of commercially installed systems.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0501, WATER QUALITY CRITERIA TO PROTECT THE FISH POPULATION DIRECTLY BELOW SEWAGE OUTFALLS

C. TSAI, Univ. of Maryland, Natural Resources Institute, *College Park, Maryland*

The proposed research plan is to establish water quality criteria to protect fish population directly below the sewage outfalls in streams. The criteria will be used as one measurement of sewage pollution assessment and control.

5. WATER QUALITY MANAGEMENT AND PROTECTION

Field investigation will be made at about 120 secondary sewage treatment plant outfalls throughout the State of Maryland during the summers of 1968, 1969 and 1970. At each plant outfall, two stations (one upstream and one downstream, each 300 yards from the outfall) will be designed for determining the water quality (DO,CO2, ammonia, pH, temperature, turbidity, conductivity, nitrite, nitrate, phosphate, and chloride ions) and the fish population (species diversity and fish abundance). The degree of water quality degradation and the degree fo fish population depletion by sewage effluents in a stream will be determined from their difference between two stations. Water quality criteria will be established from the relationship between the degree of water quality degradation and the degree of fish population depletion at all plant outfalls studied.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Maryland

5.0502, IMPROVEMENT OF QUALITY OF WATER RESOURCES BY A THREE-FOLD ATTACK - ADSORPTION, SEDIMENTATION AND MIXING

W.A. WOCKENFUSS, Univ. of Maryland, School of Engineering, *College Park, Maryland*

The proposal is an effort to get to the general problem of water purification through a three-fold attack. (1) Chemically, we would investigate a method to remove water pollutants by adsorption. (2) Through thermodynamics and study of flow conditions, we would investigate a method of preventing destruction of aquatic life and make a significant contribution to an area of investigation which has had little or no attention given to it as indicated by a lack of publications. (3) Through an investigation of settling velocities and settling characteristics of flocculent and nonflocculent materials, we would evolve design criteria for new improved sedimentation tanks.
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SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Maryland

5.0503, SYSTEM STUDY, DESIGN, AND EVALUATION OF THE LOCAL STORAGE, TREATMENT. AND REUSE OF STORM WATER

C.W. MALLORY, Hittman Associates Inc. , *Ellicott City - Columbia, Maryland* 21043 (14-12-20)

A comprehensive study was made to determine the economic and technical feasibility of using system for the local storage, treatment, and reuse of storm water as a method of providing pollution control. With this concept, storm water runoff is collected in small reservoirs dispersed throughout urban communities, treated to remove pollutants and is either released to receiving bodies of water or further treated for reuse. The benefits derived from the reuse of storm water are used to offset the cost of pollution control.

As part of this study, a synthesized hydrograph using mathematical expressions derived by regression analysis techniques were used to predict the runoff from ungaged watersheds following urban development. A system analysis technique was used to evaluate the various combinations of system components, possible plant locations, and quality and quantity of reuse. The systems were optimized by computer techniques based on a net system cost given local site conditions as constraints. The cost of pollution control by conventional means and the value of the reused water were taken as benefits.

Four systems were considered for application to the Wilde Lake watershed in Columbia, Maryland. Three were based on the local storage concept with (1) potable reuse, (2) sub-potable reuse, and (3) pollution control only. The fourth system was a design for pollution control of the same area using conventional design approaches and methods. For the Wilde Lake watershed, the local storage and treatment system for potable reuse was found to be the most economical system. The local storage system for pollution control would have a slightly greater net cost than the potable reuse system. The sub-potable reuse system and conventional system were found to be considerably more expensive systems.

This program included the development of plans, schedules, and cost data for the demonstration of the local storage, treatment, and reuse of storm water and for the collection and analysis of data on urban hydrology.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0504, MODEL ADVANCED WASTE-TREATMENT PLANT

A. MACHIS, Washington Suburban San. Comm. , *Hyattsville, Maryland*

The objective of this project is to design and construct a 5 mgd advanced waste treatment plant at the Commission's Piscataway Wastewater Treatment Plant to demonstrate the high efficiency removal of phosphorus, BOD, suspended solids and refractory organics. The AWT plant is planned to consist of lime precipitation, lime recovery, recarbonation, filtration, activitated carbon adsorption, and activated carbon regeneration.

Research by the Federal Water Pollution Control Administration and others has shown the feasibility of attaining improved removals of carbon and phosphorus from municipal waste discharges. The work has been primarily in the laboratory and small pilot plants; now it is ready for larger pilot scale or full-scale operation. The Piscataway Plant is a particularly appropriate site because of joint FWPCA-WSSC cooperation in AWT and because of the interest in water pollution problems in the Potomac Estuary.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Washington Suburban Sanitary Commission

5.0505, EFFECT OF EURASIAN WATERMILFOIL CONTROL PROCEDURES ON WILDLIFE AND OTHER ORGANISMS IN AQUATIC ENVIRONMENTS

J.H. STEENIS, U.S. Dept. of Interior, Patuxent Wlife. Res. Ctr. , *Laurel, Maryland*

Evaluations on control of Eurasian watermilfoil with 2,4-D and diquat reveal that native species of plants are not adversely affected in tidal waters. In fact, these treatments have resulted in released growth of native species, including the more desirable duck food plants.

To date investigations of the Chesapeake Biological Laboratory and Virginia Institute of Marine Science reveal no direct adverse effects on commercial shellfish, crabs and fish, or other associated marine life from recommended treatments on Eurasian watermilfoil with 2,4-D or diquat. However, these toxicioogical studies are not complete.

Guide lines on residue studies of commercial fish conducted by the Chesapeake Biological Laboratory are incomplete.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0506, PHYSICAL AND CHEMICAL CHARACTERISTICS OF THE UPPER CHESAPEAKE BAY

W.N. SHAW, U.S. Dept. of Interior, Biological Laboratory, *Oxford, Maryland*

Physical characteristics (temperature, current speed and direction, tidal fluctuations, exchange rates and volumes) of local waters and in large man-made salt water ponds are being and will be determined. Chemical characteristics (salinity, oxygen, phosphate, nitrate, etc.) of local waters and in artificial ponds will also be determined. Information provides baselines to evaluate effects of environmental extremes on commercial shellfish in natural waters and in laboratory experiments.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

5.0507, POTENTIAL OYSTER SETTING CAPACITY - LOCAL AREAS

W.N. SHAW, U.S. Dept. of Interior, Biological Laboratory, *Oxford, Maryland*

This project is concerned with the setting capacity of oysters in local waters, principally the Tred Avon River, Broad Creek, and Harris Creek, on the Eastern Shore of Chesapeake Bay in Maryland. Yearly, stations are established in each area, and during the oyster setting season (June to October) collectors in the form of oyster shells and asbestos flexboards are put out at each station. Total amount of setting and period of setting intensity are measured by counting daily and weekly the number of oyster spat on these collectors. In addition, the amount of fouling competitors for space is studied.

Studies on the rafting of shells to catch seed oysters are being conducted. Rafts are being placed in areas where setting intensity has been high. Shells on strings and in bags are being suspended from the rafts during the setting season. Once the seed is caught they are removed from the rafts and suspended from a rigid structure to grow to market size. The long line method to catch and grow seed oysters is to be tested in several areas.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

5.0508, SOURCE CONTROL OF WATER TREATMENT WASTE SOLIDS

D.D. ADRIAN, Univ. of Massachusetts, School of Engineering, *Amherst, Massachusetts* 01003

Water treatment wastes consisting of filter wash water and sludge are discharged back to the raw water source by over 90 per cent of the nation's water treatment plants. Lagoons are sometimes used for concentration of these wastes, especially sludge. Dewatering and drying beds, while commonly utilized in wastewater treatment, are infrequently employed for water treatment waste solids concentration prior to final disposal.

Characterization of sludge by its solids content, specific resistance and coefficient of compressibility has enabled the researchers to develop a new formulation which describes dewatering. Verification of the model with lab scale tests has been very promising and these tests will continue. Incorporation of evaporation into the model is underway.

The filtration and evaporation processes are both subject to moisture contents and gradients in the accumulated solids, the soil and the atmosphere. The proposed research will relate these factors to the dewatering and drying rate by establishing moisture transport rates. Design criteria for land disposal of water treatment sludge, liquid manure, garbage and other moist or wet wastes will be developed.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0509, THE EFFECTS OF PESTICIDE RESIDUES ON LARVAL AND JUVENILE WINTER FLOUNDER IN THE WEWEANTIC RIVER ESTUARY, MASSACHUSETTS

C.F. COLE, Univ. of Massachusetts, School of Agriculture, *Amherst, Massachusetts* 01003

Saltmarshes and their meandering estuarine streams too often have been considered a biological wasteland and public apathy has allowed these areas to become targets of developers of waterfront properties and uncontrolled use of pesticides. The estuarine environment is breeding ground for commercial and sport fishes and little data are available concerning the influence of pesticides upon their general life history. A program was recently established to obtain detailed data on the interaction of pesticides in the estuarine area of the Weweantic River on the northwestern shore of Buzzards Bay. The pesticide investigation will study the possibility of acute toxic conditions occurring from single instances of pesticide application. As the occurrence of parathion in the estuary is ephemeral at most, and, as parathion is one of the major insecticides now used on cranberry bogs, this study is of major significance. The objectives of this project are to study the larval blackback flounder mortality under controlled laboratory conditions; to study a comparative larval mortality in three widely separated geographical areas; to conduct bioassay studies which will delimit tolerance levels, especially for blackback larval flounder; and to conduct a more critical study of the occurrence of area specificity, as evidenced in previous chromatographic patterns.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
U.S. Dept. of Interior - F. Water Pol. Ctl
University of Massachusetts

5.0510, INVESTIGATION OF THE RELATIONSHIP OF THE AMERICAN SMELT, OSMERUS MORDAX - MITCHILL, TO THE WEWEANTIC RIVER ESTUARY, WAREHAM, MASSACHUSETTS

C.F. COLE, Univ. of Massachusetts, School of Agriculture, *Amherst, Massachusetts* 01003

Saltmarshes and their meandering estuarine streams have too often been considered a biological wasteland and public apathy has allowed these areas to become targets of developers of waterfront properties. The estuarine environment is an important area as spawning grounds for many commercial and sport fishes and a program has been established on the Weweantic River estuary to determine age and growth, feeding habits, fecundity, adult movement, larval and young-of-the-year distribution of the more abundant species. One such species is the American smelt.

More than 750 ripe smelt were taken during the period 10 March - 6 April. The peak of the run -- determined from numbers taken -- occurred during the week of 16-22 March and then rapidly tapered off.

Smelt larvae were taken for the first time on 11 April along the upper four kilometers of the estuary. Water temperatures had reached 10.0 degrees Centigrade at the spawning site and gradually decreased downstream to 7.4 degrees Centigrade where the river flows into Buzzards Bay. Subsequent weekly sampling trips yielded larvae at all seven permanently established stations within the estuary. The more downstream specimens were longer and more developed than those secured at the more upstream sites. Intensive sampling with a variety of equipment failed to provide collections of smelt after they had attained a total length of about 20 mm. Evidently, this problem is a familiar one to many investigators who attempt to follow the development of a particular species within estuarine environments. Perhaps three explanations are adequate to explain this phenomenon: (a) high rate of mortality at this stage of development thus fewer numbers are available; (b) the size of the smelt is such that they may actively avoid capture; (c) the net movement of young smelt is into Buzzards Bay where a constant environment, sufficient food, and deeper water is available for development.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Massachusetts State Government

5.0511, INVESTIGATION OF RELATIONSHIP OF CUNNER, TAUTOGOLABRUS ADSPERSUS -(WALBAUM), TO WEWEANTIC RIVER ESTUARY, WAREHAM, MASSACHUSETTS

C.F. COLE, Univ. of Massachusetts, School of Agriculture, *Amherst, Massachusetts* 01003

Saltmarshes and their meandering estuarine streams have too often been considered a biological wasteland and public apathy has allowed these areas to become targets of developers of waterfront properties. The estuarine environment is an important area as spawning grounds for many commercial and sport fishes and a program has been established on the Weweantic River estuary to determine age and growth, feeding habits, fecundity, adult movement, larval and young-of-the-year distribution of the more abundant species. One such species is the cunner.

Limited data are available for this project because it is the initial field season.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Massachusetts State Government

5.0512, EFFECTS OF CHEMICAL IMPURITIES IN WATER DISINFECTION BY HALOGENS

T.H. FENG, Univ. of Massachusetts, School of Engineering, *Amherst, Massachusetts* 01003 (DA-49-193-MD-3036)

Tech. Objective - To investigate (A) the effect of chemical impurities on the bactericidal activities of halogens in aqueous solutions and (B) the odor and taste produced in the process of halogenation.

Approach - Calcium, iron, phosphate, and one surface active agent will be the chemical impurities to be investigated in the initial phase of the study. E. coli will be used as the test organisms. Temperature will be maintained at 25 degrees C, and pH controlled at 5, 7, and 9. Halogens to be used will be chlorine, bromine and iodine. Odor and taste determinations will be made in parallel with the disinfection experiments.

Progress - Oct 66 - Jun 67 - During this period studies have been of a fourfold nature. In the first place the disinfection efficacy of free chlorine residual alone in water has been established in connection with exposure conditions of temperature, contact time, dosages and pH which would afford reproducible and significant experimentation with chemical additives. Secondly, similar experiments have been initiated with free bromine residual. Thirdly, the effects of calcium bicarbonate on the disinfection efficacy of free chlorine residual have been investigated. Lastly the taste threshold concentration of free chlorine residual in water at pH 5.0, 7.0 and 9.0 has been studied. The basic death kinetics of Escherichia coli under specified conditions using free chlorine residual, and to a lesser extent free bromine residual, as the disinfectants, have been established. Calcium bicarbonate, at a concentration of 610 milligrams per liter as calcium carbonate, was found to affect the bacterial cell resistance to, and the disinfecting properties of free chlorine residual in the destruction of E. coli cells.

SUPPORTED BY U.S. Dept. of Defense - Army

5.0513, CONTROL OF BENTHIC DEPOSITS IN LAKES

T.H. FENG, Univ. of Massachusetts, School of Engineering, *Amherst, Massachusetts* 01003

The objectives of this study are in two major phases: (A) Basic studies and (B) Controlling measures. Basic studies will be devoted to investigating how the benthic deposits are formed and stabilized. These basic studies will provide information needed to develop or evaluate the controlling measures applicable in different environmental conditions.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Massachusetts

5.0514, MICROBIAL DEGRADATION OF ORGANIC POLLUTANTS OF INDUSTRIAL ORIGIN

H.B. GUNNER, Univ. of Massachusetts, School of Agriculture, *Amherst, Massachusetts* 01003

Laboratory and ultimately pilot studies are proposed to establish the basis on which industrial installations may be developed for the removal, by microbiological agents, of toxic organic chemicals prior to effluent discharge into local water courses.

The methods of procedure are as follows: 1. Selection and adaptation of bacteria to specific chemicals in soil profusion columns by primary enrichment of flasks in shake culture and by continuous feed in simulated activated sludge systems. 2. Measurement of chemical degradation, manometrically by means of radioisotope labelling, gas and thin layer chromatography and by autoradiography.

Laboratory data will be employed to provide pilot plant scale units for the controlled degradation of selected organic pollutants.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Massachusetts

5.0515, MICROBIAL INTERVENTION IN THE EUTROPHICATION PROCESS

W. LITSKY, Univ. of Massachusetts, School of Agriculture, *Amherst, Massachusetts* 01003

The objectives of this project are: (1) to relate the microbial decomposition of lake sediments to the release of materials required as nutrient by phytoplankton and (2) to tie-up these nutrient materials in bacterial cells by manipulating the bacterial flora or the aquatic ecosystem.

Further, the purpose of this study is to investigate the processes by which the nutrients that are recycled from the bottom muds are liberated by microbial activity and to find ways whereby these soluble nutrients may be utilized before they become available to algae. In other words competition for the soluble nutrients by a microbial flora other than that involved in the eutrophication process, may be a means of limiting the growth of the undesirable algae species.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Massachusetts

5.0516, REVERSE OSMOSIS TREATMENT OF WASTEWATERS

R.T. SKRINDE, Univ. of Massachusetts, School of Engineering, *Amherst, Massachusetts* 01003

Removal of pollutants from water by reverse osmosis has great potential as a new, efficient, and economically feasible method of wastewater treatment. The process has been investigated primarily as a method of desalination of sea water, and only recently has any attempt been made to apply reverse osmosis to the treatment of municipal and industrial wastewaters.

The purpose of this research is to obtain data needed to evaluate and apply reverse osmosis as a process for the treatment of wastewaters. In particular, an improved understanding of the mechanism of separating organic materials from water is essential to development of more suitable membranes and better geometric design of reverse osmosis cells.

The objectives of this study are to: a. Obtain data essential to development of design parameters, including data on liquid diffusion rates, efficiency of separating organic pollutants, and cell operating characteristics for presently-available membranes utilizing waters containing selected organic and inorganic chemicals. b. Apply the above data in developing membrane separation techniques for advanced treatment of organic industrial wastes and municipal sewage. In addition to the development of membranes and cells specific to wastewater treatment, this phase of the investigation will consider systems in which reverse osmosis may be utilized in conjunction with such chemical additives as activated carbon and polyelectrolyte coagulant aids. The systems developed will be tested on municipal sewages and industrial wastes.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0517, TRANSPORT AND FATE OF POLLUTANTS IN SOIL

H.A. THOMAS, Harvard University, School of Public Health, *Boston, Massachusetts*

Develop mathematical models describing the movement of liquids in unsaturated porous media to delineate the critical factors in design and utilization of soil systems for waste water treatment and disposal or waste water reclamation.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0518, OCCUPATIONAL AND ENVIRONMENTAL HEALTH

J.L. WHITTENBERGER, Harvard University, School of Public Health, *Boston, Massachusetts*

The basic objective of this research program is to gain a better understanding of the relationship of man to his physical and chemical environment. Specific areas of interest include classical problems of barometric and thermal stress, but major attention is focused on pollution problems which have come to the fore in the past decade or so. These include the biological effects of atmospheric pollution, the effects of pesticides and other food residues, and the effects of body burdens of radionuclides and other chemicals.

The methods used in studying the effects of environmental variables emphasize biochemical and physiological approaches rather than those of classical toxicology or pathology. A considerable range of test systems has been used in the past and we intend to expand these. Examples of biological systems already used are microorganisms, cell fractions from various vertebrate species, cultures of human tissues, isolated organs, and whole animals (with particular emphasis on the respiratory, renal, and hepatic systems).

In terms of intensity of environmental stress, we aim to study the concentrations required to induce changes in the most sensitive biochemical and physiologic tests we can devise for the system of interest. Oftentimes such concentrations occur in industry and occasionally in communities. We are equally interested in the possible effects of long-standing low-level exposures, as occur in ordinary atmospheric pollution or water and food contamination. The methods used are those of chronic disease epidemiology, and here we are particulary dependent for advice and assistance on our colleagues in biostatistics. We look to our colleagues in physical science for help in measurement of the environmental exposure.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0519, THE CONSTRUCTION OF THE STORM DETENTION AND CHLORINATION STATION

H. WHITMORE, Metrop. District Commission, *Boston, Massachusetts* 02108

The storm detention and chlorination station is being constructed for the treatment of storm water overflows from the combined sewage system of the cities and towns bordering on the Charles River Basin. The proposed installation will be capable of handling a maximum of 230 million gallons per day of excess flow from the new and old sewerage systems. Consisting of screening and pumping facilities, chlorine dosing and detention facilities and skimming and flushing facilities, this installation will be fully automatic and will become an integral component of the overall sewage control program for Metropolitan Boston. A comprehensive sanitary survey of the Basin is now underway and will be followed up by correlation of operation data with rainfall; frequency and extent of overflows; physical, chemical and bacteriological analyses of influent and effluent; regrowth of coliforms; effectiveness of chlorination and solids removal with measurements of solids returnto sewer; effectiveness of the double-sided overflow weirs in relief conduits; effectiveness of effluent diffusers into Basin and overall unit cost studies relating to operation, utilization and performance of the installation. Scheduled to be under construction in the Fall of 1967, the facility will be in preliminary operation in the Fall of 1969.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Boston City Government - Massachusetts

5.0520, STUDIES IN FOAM SEPARATION AND RELATED TECHNIQUES

B.L. KARGER, Northeastern University, Graduate School, *Boston, Massachusetts* 02115

The distribution factors of several metal ions have been measured as a function of HCl concentration for a foam separation process. Measurements have been performed on a recycling batch foaming apparatus. Using a cationic surfactant, hexadecyltrimethylammonium bromide, maxima in distribution factors have been obtained at 1N HCl for Hg and 8N HCl for Fe. Thus, by adding controlled amounts of HCl selective removals of metallic species can be achieved. It is also worth pointing out that distribution factors have been measured as low as 10 to the minus twelfth power M metal ion concentration, and results indicate that foam separation techniques are effective at this level. These studies can be of value in deciding conditions necessary for use of foam separation techniques as in-plant clean-up procedures for industrial wastes. Studies are also underway in examining the extraction mechanism involved in solvent sublation. The results of this study will be presented at a later date.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0521, GROUND-WATER CONTAMINATION FROM HIGHWAY SALTING IN MASSACHUSETTS

S.J. POLLOCK, U.S. Dept. of Interior, Water Resources Division, *Boston, Massachusetts*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Massachusetts.

Purpose: To define the hydrologic principles relating to the movement of highway salt into and through the ground.

Methods: Ground-water sampling stations will be set up in a variety of geologic and hydrologic environments along several major highways. If possible, sites for sampling stations will be selected where previous studies have described a portion of the hydrology and geology of the area. Also, soil samples will be taken from selected depths above the water table at these sites in order to trace the path and rate of movement of the salt both vertically and horizontally.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Massachusetts State Government

5.0522, THE EFFECT OF SELECTED PESTICIDES ON INTERTIDAL BIOTA

W.J. WALL, State College At Bridgewater, Graduate School, *Bridgewater, Massachusetts* 02324

The applicants propose to conduct a three year appraisal of the restrictive influences imposed on intertidal sand and salt marsh ecosystems by controlled applications of selected pesticides to intertidal plots. Through population counts and appropriate chemical analysis of the biota and physical environment, the investigators will accumulate quantitative data regarding; (1) the insecticide residue distribution, and (2) relative sensitivity of the various biological taxa to the insecticides. It is anticipated that the research will furnish the data to identify those pesticides providing maximum pest control and a minimum of ecological disturbance.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0523, AN ELECTROCHEMICAL METHOD FOR REMOVAL OF PHOSPHATES FROM WASTEWATERS

S. SADEK, Dynatech Corporation, *Cambridge, Massachusetts* (14-12-405)

The technical and economic feasibility of removing phosphate from wastewater by the application of an electrolytic process using expendable metal electrodes will be determined on a laboratory scale.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0524, DEGRADATION OF SEWAGE AND SOIL MICROORGANISMS

R. MITCHELL, Harvard University, Graduate School, *Cambridge, Massachusetts* 02138

It is proposed that a project entitled 'Enzymatic degradation of sewage and soil microorganisms by a marine mocroflora' be initiated. The research would entail a study of predation by the indigenous marine microflora on those microorganisms carried into the sea as sewage or in run-off water. An attempt will be made to evaluate the significance of enzymatic degradation in the eradication of sewage and soil microorganisms from the sea. Speical emphasis will be placed on the decomposition of Escherichia coli.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0525, PHOSPHATE EXCHANGE WITH SEDIMENTS

W. STUMM, Harvard University, Graduate School, *Cambridge, Massachusetts* 02138

The proposed study is a part of a broad investigation on chemical factors in limnological transformations of phosphate. It is proposed specifically to investigate the kinetics of the reaction CaCO3 HPO4- -yields phosphate substituted CaCO3 (Ca-Phosphate Apatite).

A better knowledge on the distribution of phosphate between the sediments and the overlying waters is relevant for interpreting the eutrophying effect of phosphates introduced into a receiving water. The results of such an analysis should also be of predictive value in establishing whether and how fast the process of eutrophication can be reversed by reducing the introduction of phosphate bearing wastes into the receiving waters.

5. WATER QUALITY MANAGEMENT AND PROTECTION

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0526, OPERATIONS RESEARCH IN WATER QUALITY MANAGEMENT

H.A. THOMAS, Harvard University, Graduate School, *Cambridge, Massachusetts* 02138

Development and refinement of methods for evaluating the composite effects of investments in structures for streamflow regulation, waste water treatment and other measures in comprehensive programs to improve and maintain the quality of water in major resources systems.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0527, MOVEMENT AND MIXING OF WATER INJECTED INTO AQUIFERS

D.R. HARLEMAN, Mass. Inst. of Technology, School of Engineering, *Cambridge, Massachusetts* 02139

The research program is concerned with the replenishment of ground water aquifers by injection of water through recharge wells. The injected water may be a treated waste effluent or it may have other water quality characteristics, such as salinity, which differ from the native ground water. The primary objectives are to determine the quality of water pumped from the aquifer after mixing and dilution due to the recharge.

The movement and mixing of the injected water is affected by the natural flow existing in the aquifer and by the flow pattern induced by the injection and pumping wells. A single well may be used both for injection and pumping on an alternating basis. It is desired to develop analytical methods for the prediction of mixing and dilution for various boundary conditions and for both steady and unsteady flow fields. The distribution of concentration of any material introduced into the aquifer by means of the injection well is to be determined by numerical solution of the convective-dispersion equation. Longitudinal and lateral dispersion is considered in addition to the mass transport by the convective motion.

The influence of density variations due to dissolved salts on the mixing of injected water will be studied in the final stage of the research programs.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0528, MECHANICS OF DISPERSION IN ESTUARY POLLUTION

D.R. HARLEMAN, Mass. Inst. of Technology, School of Engineering, *Cambridge, Massachusetts* 02139

A basic study of estuary dispersion in an oscillating flow with fresh water throughflow superimposed. Extension of Taylor analysis of longitudinal mixing in estuary type flows. Study of similitude of distorted estuary models in regard to distribution of pollutants in fresh water region of the estuary. Numerical solution of the dispersion equation in a variable area estuary. Experimental and anlaytical investigations were conducted on longitudinal mixing in a pipeline with a throughflow superimposed on an oscillating flow. Exact solutions to the dispersion equation were found for both instantaneous and continuous injection of pollutants into an estuary -type flow and both were verified experimentally. It was found that the equation representing the concentration distribution of a continuously injected pollutant must include the tidal or oscillating velocity. The similitude of distorted estuary models in which dye is injected as a tracer was investigated. The results indicate that concentration similitude is not obtained in distorted Froude models. Current investigations are concerned with numerical solutions for variable area estuaries which account for non-linear effects in the tidal convective motion.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Massachusetts Institute of Technology

5.0529, GROUND WATER DISPERSION DURING PUMPING AND RECHARGE OPERATIONS

D.R. HARLEMAN, Mass. Inst. of Technology, School of Engineering, *Cambridge, Massachusetts* 02139

Development of a general numerical method for the solution of ground water dispersion problems in a steady, two-dimensional flow field. Emphasis is on the development of an efficient finite difference scheme for digital computer application. Investigation includes dispersion between separate recharge and pumping wells and pumping and recharge operations in the same well at different periods of time. The research programs also include consideration of dispersion in non- homogeneous (layered) media. Applications are in the field of ground water contamination. Approximate analytical solutions have been obtained for dispersion in steady, radial flow from a well and for flow between a recharge and a pumping well. The general finite difference formulation for digital computers has been developed. This program may be used for any steady, two-dimensional dispersion problem. The numerical scheme expresses the convective-dispersion equation in curvilinear coordinates consisting of the streamlines and equipotentials. Analytical results have also been obtained for dispersion in layered, non-homogeneous aquifers. Current research is concerned with cyclic pumping and recharge from the same well and with the effect of small density differences between injected and natural ground water.

SUPPORTED BY Massachusetts Institute of Technology
U.S. Dept. of Interior - F. Water Pol. Ctl

5.0530, OPTIMAL DESIGN OF SEWER AND DRAINAGE SYSTEMS

R.T. MCLAUGHLIN, Mass. Inst. of Technology, School of Engineering, *Cambridge, Massachusetts* 02139

Unsteady flow in systems of open channels is being analyzed numerically using a digital computer and dynamic programming is being applied to the optimal design of such systems.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Massachusetts Institute of Technology

5.0531, MATHEMATICAL MODEL OF THE ELECTRODIALYSIS PROCESS FOR ADVANCED WASTE TREATMENT

J.D. SMITH, Process Research Incorporated, *Cambridge, Massachusetts* (14-12-410)

The objective of this contract is to develop a mathematical model of the electrodialysis process for use in preliminary design and simulation of wastewater treatment processes.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0532, SELECTIVE NITRATE AND PHOSPHATE REMOVAL

J.D. SMITH, Process Research Incorporated, *Cambridge, Massachusetts* (14-12-179)

The objectives of this proposed research program are: 1. To investigate an ion exchange membrane system for selective removal of nitrates and phosphates. 2. To determine the initial feasibility of this system. 3. To develop a preliminary design rationale for the proposed system, and 4. To estimate the potential effectiveness and economics of such a system in waste water nutrient removal applications.

A laboratory scale nitrate and phosphate removal system, using exchange membranes will be constructed. Nitrate and phosphate transport rates will be determined with this system, using commercially available anion exchange membranes. Parameters which will be examined will include: 1. Driving force, or chemical affinity. 2. Concentrations. 3. Flow velocity, and 4. Membrane type.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0533, THE PERSISTENCE, ACCUMULATION AND FATE OF PESTICIDES IN CRANBERRY SOILS AND RESERVOIRS

C.W. MILLER, Univ. of Massachusetts, Agricultural Experiment Sta., *East Wareham, Massachusetts* 02538

The objectives of this project are the study of pesticides in relation to their 1) accumulation and persistence in the area of application, 2) movement from the point of application to the water, and 3) final destination and concentration of pesticide chemicals used on cranberry bogs.

Preliminary investigations will be made on the chlorinated hydrocarbons, since these are known to resist breakdown to a greater degree than organic phosphates and many analytical procedures have been developed and are available. As information on these compounds is accumulated, similar studies will be made on the organic phosphates which may require the development of new techniques for determination.

Soil samples at varying depths will be taken in cranberry bogs, ditches and reservoirs. In addition, perennial vegetation, algae and water animals will be collected and analyzed when possible. This information will provide a base line from which further studies may be made in relation to future chemical application.

SUPPORTED BY U.S. Dept. of Agriculture
Massachusetts State Government

5.0534, (U) BIODEGRADABILITY OF DETERGENT COMPOUNDS

M. ROGERS, U.S. Army, Natick Laboratories, *Natick, Massachusetts*

Technical Objective - Carry out research on biodegradable detergents to support procurement user elements, evaluate unique NLabs synthesized compounds, determine mode of action of biodegradation of experimental detergents and determine suitability of detergents for specific army germicidal items.

Approach - Biodegradability of compounds is determined through activated sludge, river die-away, shake flask and Warburg procedures. Breakdown of the compounds are followed by pertinent chemical analyses. New techniques are developed as required.

Progress - (Apr 65) Nine purified samples of sodium (thia-n dodecyl) benzene sulfonate anionic detergents were evaluated against non-sulfur-containing biodegradable standards in river die-away tests. Four of the nine are highly biodegradable, while the other five are slowly biodegradable. The relationship of chemical structure to biodegradability is being investigated. Newer biodegradable detergents, to be included in the formulation for disinfectant, chlorine, food service, have been evaluated by the activated sludge techniques required by West German law. A series of 26 sulfur substituted dodecyl benzene sulfonates are being studied to establish structure-bio-degradability relationships. Gas chromatographic techniques are being developed to follow the biodegradation of specific compounds. A paper concerning some of the sulfur compounds has been on the program of the Army science conference. A given military standard for biological test procedures for biodegradable detergents has been reviewed. Biodegradability of machine working fluids is under study.

SUPPORTED BY U.S. Dept. of Defense - Army

5.0535, STUDY OF LOCAL WATER CONTAMINATION PROBLEMS

W.J. LACY, Merrimack College, School of Engineering, *North Andover, Massachusetts* 01845

Technical Objectives: Complete the development and programming of a water contamination model for predicting the potential radiological hazard from drinking water, including considerations of fallout solubility, fractionation, induced activity in soil, over-land transport of radioactivity in runoff, water treatment decontamination, biological uptake, and human critical organ radiation doses for different periods of water consumption.

Approach: a. Complete the one-dimensional activity transport model, expand it to two-dimensional transport, and apply the developed models to runoff contamination calculations. b. Investigate the amount of contamination due to erosion, and calculate activities transported in sediment and colloidal suspensions. c. Update previous calculations of water supply contamination by incorporating recently revised values of solubility nuclide contour ratios. d. Applying these contamination calculations to selected water supply systems of interest to OCD.

Progress: January 68-June 68: An analytic solution was obtained for kinematic flow over a plane with time-dependent upstream boundary conditions. The infiltration routine was completed to incorporate ponding and pre-ponding conditions. It is being modified to accept tabular data on soil types. The erosion and sediment transport model was completed. The biological uptake routine was reprogrammed and used to recompute critical organ doses from ingestion of drinking water contaminated by direct fallout deposition in the reservoir system of Providence R.I.

SUPPORTED BY U.S. Dept. of Defense - Army

5.0536, WASTEWATER TREATMENT PILOT PLANT INVESTIGATION, MIXED CHROME TANNERY WASTEWATER

J.A. BASSETT, Swift & Company, *Peabody, Massachusetts*

The objectives of the project are as follows: 1) To determine on a pilot plant scale the primary and secondary treatment, by the activated sludge process, of mixed chrome tannery wastewaters and sanitary sewage. 2) To demonstrate the pre-treatment of the tannery wastewater by carbonation with flue-gas and up-flow sedimentation in order to remove excess calcium, chromium, and sulfides. 3) To determine the benefits of mixing municipal sanitary sewage with tannery wastewaters to provide the biological nutrients lacking in tannery wastes. 4) To determine design criteria for a scale up to a full scale demonstration plant and to provide a basis for estimating the costs of construction and operation of a fullscale plant. 5) To determine optimum methods of dewatering sludge, with primary emphasis on concentration by centrifugation, with aim being to dewater sufficiently to dispose of solids as sanitary land fill.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
A.C. Lawrence Leather Company

5.0537, BASIC SALINOGEN ION EXCHANGE RESINS FOR SELECTIVE NITRATE REMOVAL FROM POTABLE AND EFFLUENT WATER

E. SAUNDERS, Tyco Laboratories Incorporated, *Waltham, Massachusetts* (14-12-439)

This program has as its primary objective development of specific anion exchange resins for removal of nitrate from water at influent levels of 20-100 ppm. The contractor will supply the necessary personnel, materials and facilities, and will perform the research and development studies necessary to establish the technical and economic feasibility of nitrate removal by the method proposed. His best efforts will be exerted to develop practical syntheses for the most effective resins and to evaluate their capacity, specificity, and service life characteristics.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0538, THE ELECTRO-OXIDATION OF AMMONIA IN SEWAGE TO NITROGEN

D.L. BROWN, Ionics Incorporated, *Watertown, Massachusetts* (14-12-432)

Semiconducting electrodes will be studied with the object of finding an electrode for the electro-oxidation of ammonia to nitrogen in wastewater. A large number of materials will be screened under a variety of operating conditions. Tests will be run on a simulated sewage effluent containing ammonia levels in the range of 10 to 30 ppm. Candidate electrode materials will be evaluated by a three step procedure: (1) conduct potential sweep tests; (2) prepare stepped potential curves for materials that look promising; and (3) for the most promising materials, place them in an electro-chemical cell and run a sufficient time to obtain reliable analytical data.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0539, MASSACHUSETTS PESTICIDE MONITORING STUDY

W.A. TOMPKINS, State Div. of Fisheries & Game, *Westboro, Massachusetts*

The objective of the project is to define the pesticide pollutants on the major watersheds of the State of Massachusetts through the operation of 100 monitoring stations which will sample aquatic organisms for pesticide residues.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Massachusetts State Government

5.0540, ENVIRONMENTAL CHANGES IN LAKE ERIE

J.F. CARR, U.S. Dept. of Interior, Biological Laboratory, *Ann Arbor, Michigan*

Lake Erie has experienced major changes in the benthos and fish populations. Analyses of physicochemical data show that concentrations of most major ions have increased significantly, very low dissolved oxygen concentrations occur during the summer, and mean annual water temperatures have increased. Present studies are directed toward documenting the extent of change in the benthos and studying the factors which result in the oxygen depletion of the hypolimnetic waters. Laboratory and field studies are being made of the exchange of nutrients and the oxygen demand at the mud-water interface.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

5.0541, PHYSICAL LIMNOLOGY OF THE GREAT LAKES

J.F. CARR, U.S. Dept. of Interior, Biological Laboratory, *Ann Arbor, Michigan*

The major effort in this project is directed toward an understanding of currents, ambient irradiance, and temperatures and their importance to the distribution and behavior of fish. Drogue studies of surface currents are being carried out in Lakes Erie and Superior. The usefulness of airborne radiometers and infrared scanners for detecting water masses and surface currents is also being investigated. These methods were used in Lake Erie in 1963. Bathythermograph and reversing thermometer temperatures collected during 1954-55 are being used to describe the thermal regime of Lake Michigan. Thermal data are being or have been collected in the other Great Lakes.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

5.0542, CHEMICAL CHARACTERISTICS OF THE GREAT LAKES

J.F. CARR, U.S. Dept. of Interior, Biological Laboratory, *Ann Arbor, Michigan*

The long-range objectives are to gain an understanding of the cycles of the major nutrients in the Great Lakes and connecting waters and their influences on the productivity of the lakes. Objectives are to demonstrate the vertical, horizontal, and seasonal variations in water quality in various habitats of the lakes. Routine determinations are being made on a variety of Great Lakes waters for sodium, calcium, magnesium, potassium, sulfate, chloride, silica, alkalinity, pH, dissolved oxygen, and total phosphorus.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

5.0543, REMOVAL OF PESTICIDES FROM FRESH-WATER FISH

R.H. GNAEDINGER, U.S. Dept. of Interior, Technological Laboratory, *Ann Arbor, Michigan*

Collection of various species of fish and proximate and pesticide analyses is in progress, as well as for a study of their rendering characteristics. Studies on pesticides emphasize the lowering of these materials in fish as a result of processing or rendering. Planned feeding studies on a separate project, to determine the effects of an experimental fish press-cake on mink growth and reproduction, will include pesticide considerations.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

5.0544, MONITORING OF PESTICIDE LEVELS IN THE GREAT LAKES

R. REINERT, U.S. Dept. of Interior, Biological Laboratory, *Ann Arbor, Michigan*

A monitoring program to measure levels of insecticides in various species of fishes and water from each of the five Great Lakes.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

5.0545, RATES OF PESTICIDE BUILDUP IN SALMONIDS RECENTLY INTRODUCED IN THE GREAT LAKES

R. REINERT, U.S. Dept. of Interior, Biological Laboratory, *Ann Arbor, Michigan*

A program to follow the buildup of insecticides in lake trout and coho salmon that have recently been introduced into Lakes Michigan and Superior. The eggs and fry will be studied before the fishes are introduced into the lakes and then as these populations develop they will be sampled periodically. When the fishes reach maturity their eggs and progeny will be examined for insecticide levels.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

5.0546, MECHANISMS OF PESTICIDE ACCUMULATION IN AQUATIC ORGANISMS

R. REINERT, U.S. Dept. of Interior, Biological Laboratory, *Ann Arbor, Michigan*

A laboratory program designed to compare the relative importance which direct uptake of insecticides from water and biological magnification via the food chain have on the buildup of chlorinated hydrocarbon insecticides in aquatic communities.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

5.0547, A COHERENT-AREA STUDY OF SOUTHERN LAKE MICHIGAN

J.C. AYERS, Univ. of Michigan, Institute of Sci. & Technology, *Ann Arbor, Michigan*

The work proposed involves a team-approach to the sedimentary, biological and chemical indications of the eutrophication process in the southern portion of Lake Michigan. This Great Lakes water body is a water resource of present value, and future greater value, within which the effects of man's wastes are becoming evident. The studies would assemble and assess the indications of eutrophic change with the aim of determining the onset of and the present rate of deterioration of water quality.

Related basic studies of the present sedimentary process and present sedimenting materials, along with needed basic studies of the weather-modifying effect of Lake Michigan would also be carried out.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0548, LONG-TERM EFFECTS OF PESTICIDES ON AQUATIC INVERTEBRATES

M.E. BENDER, Univ. of Michigan, School of Public Health, *Ann Arbor, Michigan*

The long-term effects of parathion and endrin exposure to aquatic invertebrates are being studied under continuous flow conditions. Test organisms include: the stonefly Acroneuria, the caddisflies Hydropsyche and Chimarra, the dobsonfly Corydalus and crustaceans Asellus and Gammerus, measurement of effects is being evaluated by: mortality rates, growth, time of molting, success of emergence and reproduction success of crustaceans.

The acute and chronic effects of the hydrolysis products of malathion, parathion, and sevin are also being studied.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Michigan

5.0549, SAND FILTRATION OF DISCRETE SUSPENSIONS

J.A. BORCHARDT, Univ. of Michigan, School of Engineering, *Ann Arbor, Michigan*

This research is a continuation of a laboratory study on sand filtration. New techniques have been developed for media placement which have resulted in extremely reproducible head loss values under similar flow and impurity levels. This had made possible the extention of our work into regions of low turbidity.

The magnitude of the surface charge effects can now be separated from other gross bed response factors and hopefully a better insight into the filtration mechanism will result.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0550, ORGANIC DECOMPOSITION AT POISED O-R POTENTIAL LEVELS

J.A. BORCHARDT, Univ. of Michigan, School of Engineering, *Ann Arbor, Michigan*

This research effort will continue along three major paths, each of which will contribute to the total understanding of the importance of electrode potential measurements to anaerobic digestion.

Two banks of laboratory digesters, consisting of three units in each bank, are being used to study the effects of chemical poising as compared to electrical poising.

Dual compartment digestion units are being used with dialysis membranes separating the acid forming from the methane forming bacteria. In one such unit mixed cultures are being studied, while in the other, pure cultures of methane organisms are being fed through the membrane by mixed cultures of acid formers. Electrode potentials and other parameters are being observed.

The third phase of the study involves the use of a conical head digester to determine the instantaneous response of the unit in terms of gaseous components to perturbations as predicted by the results obtained in phases 1 and 2 of this study.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0551, INTERACTIONS OF PESTICIDES AND SEDIMENTED OILS

R. HARTUNG, Univ. of Michigan, School of Public Health, *Ann Arbor, Michigan*

The major objectives of this proposed study are to investigate interactions of pollutants; specifically, the interactions of chlorinated hydrocarbon insecticides in water with sedimented polluting oils. Sedimented polluting oils have been found to exist in a number of widely separated areas with histories of oil pollution. On a theoretical basis, these oils should be capable of concentrating organic chemicals with low water solubility, e.g. chlorinated hydrocabron insecticides. The specific major goals of this proposed study are: 1) The determination of the physical concentrating capacity of naturally occurring sedimented polluting oils for low concentrations of chlorinated hydrocarbon pesticides in rivers and lakes. 2. The investigation of the biological availability of chlorinated hydrocarbon pesticides once they have been concentrated by sedimented oils.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0552, MINERAL-WATER CHEMISTRY, GREAT LAKES

J.R. KRAMER, Univ. of Michigan, Great Lakes Research Division, *Ann Arbor, Michigan*

Great Lakes chemistry, relative to major ions, is evolved from a time independent invariant chemical equilibrium model(s). The ability to rigorously define these models rests upon knowing free energy expressions for the specific minerals and aqueous ligands, the crystallography and stoichiometry of the minerals, and the in situ chemistry of the Great Lakes.

Solution equilibrium among end member solid phases permits determination of free energy of formation of the common minerals. This procedure is applied to synthetic simple composition minerals and naturally occurring minerals. Equilibration is considered attained when identical results are achieved for different paths of equilibration.

Standard chemical, X-ray diffraction, and optical techniques are used to define solid phases. Knowing specific solid phases allows one to 'equilibrate' the entire specimen and compare results with those predicted by single solid phase equilibrium studies.

Ultimate goodness of fit is achieved by comparing apparent equilibrium expressions obtained from data for the Great Lakes to the above models. Since parts or all of the Great Lakes are not in the same environment as the analytical laboratory, emphasis must be placed upon in situ or pseudo in situ analyses.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0553, DISSOLVED OXYGEN DETERMINATION IN NATURAL AND WASTE WATERS

K.H. MANCY, Univ. of Michigan, School of Public Health, *Ann Arbor, Michigan*

The proposed work is concerned with the development of new electro- chemical techniques using voltammetric membrane electrodes for the trace analysis of dissolved oxygen. Potentiostatic as well as galvanostatic methods are used and evaluated under field conditions. The effect of interferences commonly present in natural and waste waters are being also investigated.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0554, A DETAILED STUDY OF LAKE MICHIGAN PLANKTON DIATOMS

E.F. STOERMER, Univ. of Michigan, Great Lakes Research Division, *Ann Arbor, Michigan*

The major objective of the proposed study is to provide a systematic account of the plankton diatom flora of Lake Michigan. The investigation will be based on both modern collections and historic collections from the period of record. Records of abundance and distribution of the entities will be developed, in so far as is possible, for the period of record. Nomenclature used in previous studies will be reviewed in an attempt to make these records useful to the non-specialist.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0555, EFFECT OF WATER TEMPERATURE AND/OR DISSOLVED OXYGEN REQUIREMENTS ON SELECTED MOLLUSKS

H. VANDERSCHALIE, Univ. of Michigan, Graduate School, *Ann Arbor, Michigan*

Eight species of gastropods representing a variety of habitats, ability to survive within several ecological situations, susceptibility to pollution, and significance in the food chain have been selected for study: Physa gyrina, Lymnaea stagnalis appressa, L. emarginate, Helisoma trivolvis, H. campanulatum, Goniobasis livescons, Pleurocera acuta, Amicola limosa.

The temperature tolerance for short periods of time will be determined for the eight species listed above. Three principal factors of several are involved; tolerance to sudden temperature changes, acclimation rates, and upper physiological limits. These three factors will be tested in a manner to separate their importance. An animal migrating or swimming down a river is subject to sudden temperature change at the mixing zone; sensitivity will be tested in this parameter. Rate of acclimation tests are important for ascertaining how fast a temperature changes without adverse effect on the animal, and upper physiological limit ascertains maximum limit of temperature change without death.

Further growth rate over a wide range of temperature changes, freezing, to barely possible survival limits will be investigated. Thus, rate of growth at optimum temperature will be determined. Finally, studies will include the effects of various elevated temperatures on the reproduction of the snail.

This contract was started Fiscal Year 1968-69 and is scheduled to end 1971-72. Quarterly reports are to be submitted to the contract officer in order to keep him posted on the progress of the study. All raw data will be furnished in a final report so that no data are lost for future reference and study.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0556, FLUIDIZED EXCHANGE SYSTEMS FOR REMOVAL OF NITROGEN AND PHOSPHOROUS FROM WASTEWATER

W.J. WEBER, Univ. of Michigan, School of Engineering, *Ann Arbor, Michigan*

The primary objective of this research is the evaluation of the suitability of fluid-bed ion exchange systems for removal of inorganic nutrients - nitrates and phosphates - from sewage effluents. These materials are largely responsible for acceleration of eutrophication in lakes and reservoirs, and development of ion-exchange methods for their removal from wastes prior to discharge into receiving waters is the subject of the current project.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Michigan

5.0557, INTERACTIONS OF SILICA WITH IRON AND ALUMINUM

W.J. WEBER, Univ. of Michigan, School of Engineering, *Ann Arbor, Michigan*

The proposed research is directed toward the following objectives: (1) To examine in detail the possible interactions between Fe(III) and Al(III) and monomeric and polymeric forms of silica in experimental systems closely representing natural waters in chemical constitution, for the purpose of delineating the nature and character of complexes formed between the metal ions and various dissolved and colloidal silicate ligands. The studies will consider both kinetic and equilibrium aspects of the formation of such complexes. (2) To investigate the effects of major systemic variables such as hydrogen- ion concentration, alkalinity, and concentrations of other multivalent metal ions (e.g. Ca plus 2, Mg plus 2) on the formation of iron-silica and aluminum-silica complexes, both as to the nature of the complex formed and as to the extent of complexation. (3) To relate the findings from studies carried out under phases (1) and (2) to definition of the specific role of silica in the formation of metal complexes in natural waters and to the application of resulting principles to the coagulation and treatment of water. Further, to evaluate conditions under which silica can be most effective in aiding coagulation.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0558, ADSORPTION FROM AQUEOUS SOLUTION

W.J. WEBER, Univ. of Michigan, School of Engineering, *Ann Arbor, Michigan*

The present research is directed toward definition of the characteristics of adsorption of organic materials from dilute aqueous solution. It has direct bearing on the problem of removing biochemically resistant synthetic organic substances from waters and waste waters. The kinetics and equilibria of adsorption in columns of fluidized adsorbent are being investigated in terms of uptake profiles relative to the velocity dimensions, time and length, for selected values of the latter parameters, for various particle sizes of adsorbent, for different adsorbents, and for solutions of varied chemical constitution.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0559, SYSTEM MONITORING AND REMOTE CONTROL

G. REMUS, Detroit Board of Water Comrs., *Detroit, Michigan*

The project consists of installation of new power operated diversionary overflow structures and automatic control instrumentation. The instrumentation includes devices for determination of waste water quality, flow measurement, rainfall data, conduit liquid level sensing, and remote operation diversion gates. Telemetering will be provided to transmit and record data collected by the instruments and to provide feed-back data relative to status of the remote controlled units. Investigations will be made to observe the modifications and additions to the system, to analyze and evaluate the data collected, and to determine the overall effectiveness of the demonstration.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Detroit City Government - Michigan

5.0560, PILOT-SCALE STUDY OF IMPROVED PHOSPHATE REMOVAL BY MODIFIED ACTIVATED SLUDGE PROCESS

G. REMUS, Detroit City Government, *Detroit, Michigan*

The primary objective of this project is to determine the most suitable and economically feasible treatment process for the continuous removal of at least 80% of soluble phosphates from the wastewater of a large municipality. The process must also be compatible with treatment for removing a high percentage of suspended solids, phenols, oils, and bacteria, and reducing BOD. By restricting the supply of phosphates to Lake Erie, the growth of algae in the Lake may be slowed and the life of the Lake lengthened.

The most promising tests will be subjected to large-scale pilot plant studies to determine their suitability for use in large treatment plants. Of importance will be the follow-through on sludge disposal to determine the adequacy of sludge thickening, dewatering, and incinerating devices for delivering the phosphates taken up by the sludge, and to keep them from the plant effluent.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Detroit City Government - Michigan

5.0561, GREAT LAKES RESEARCH - SPOIL DISPOSAL EFFECTS

A.P. PINSAK, U.S. Army, Lake Survey, *Detroit, Michigan* 48226

Physical, chemical and biological factors within the water mass and associated solid material which can be related to dredging and disposal of spoil material are being investigated in order to determine effects of this material on characteristics of the lakes. The study will examine changes in water characteristics, dispersion rates, and areal extent; changes in nature of bottom sediments from dumping and dredging and degree to which characteristics of these sediments are improved; and different effects of various dredging techniques on pollution.

Field investigations during 1967 centered on eleven selected rivers, harbors, and open water and diked disposal areas of different basic types in Lakes Erie, Huron, and Michigan. Inasmuch as data on actual levels of pollution which can be traced to various kinds of dredging is lacking, each area was studied before, during, and for a significant period after dredging and disposal of spoil material.

Interim reports for each study area are being prepared and a comprehensive report is scheduled for completion in 1968.

SUPPORTED BY U.S. Dept. of Defense - Army

5.0562, INDICATOR-PATHOGEN DENSITY RELATIONSHIPS IN TRIBUTARY STREAMS

R.M. TWEDT, Univ. of Detroit, Graduate School, *Detroit, Michigan* 48221

Since 1885 when Escherich described his 'Bacillus coli' as a s species characteristic of human feces, the enlarged coliform group of bacteria has been used as an indicator of fecal pollution. In a continuing effort to improve the sanitary significance of the coliform group, many investigators have developed physical and biochemical procedures which could differentiate coliform strains isolated for the feces of warm-blooded animals from saprophytic strains associated with soil and vegetation. In recent years, researchers have shown the intimate association of certain groups of steptococci with human feces. According to presently accepted interpretation, the parallel determination of both fecal coliform and fecal steptococci concentrations in surface water established the presence and relative degree of pollution. In addition, it has recently been suggested that the ratio of fecal coliform to fecal streptococci concentrations will illuminate the source of nature of the pollution.

The object of the proposed investigation will be to characterize the relationships that exist among bacterial indicators and pathogens in a small , surface tributary. The study will achieve this objective by making an intensive quantitative determination of the densities of coliforms, fecal coliforms, fecal streptococci and Salmonella existing under all nutrient and environmental conditions found along the course of a representative stream and also by studying the survival of these organisms in filtered and unfiltered stream water samples. The resulting data would contribute 'new' information since no previous study has contributed a quantitative characterization of the relationships existing between indicators and pathogens along a flowing water course. The value of this proposed investigation would be derived from the increased sanitary significance imparted to the determination of indicator concentrations as a measure of water quality in natural rivers and streams.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0563, ECOLOGY OF PESTICIDES IN AN AQUATIC ECOSYSTEM

R.C. BALL, Michigan State University, Agricultural Experiment Sta., *East Lansing, Michigan* 48824

Objectives: To develop methods of accurately evaluating the effects of low levels and chronic input of pesticides in an aquatic habitat. This will include a study of the pathways and mechanisms of movement through the aquatic ecosystem, and identification of biotic effects at each trophic level.

The work will be carried out in three locations: (1) the laboratory of Fisheries and Wildlife Department. Here the precision, reliability, and specificity of 'stress' analysis technique will be tested on insecticides in two artificial streams. The criterion will be changes in the mobile fraction of the plasma proteins in the type of fish (and invertebrates) found in both cold and warm-water habitats. (2) A field duplication of the above tests will be made using fish from areas known to be contaminated by pesticides. This will be carried out on the Red Cedar River, Michigan. (3) This phase will be carried out at the Lake City Experiment Station where heavy applications of pesticides have been used for several years. Here in a series of experimental ponds, we will study the movement of the toxic materials from the soil into the ponds and there follow them through the organisms that constitute the food chain leading to game fish eaten by man--with special emphasis on the accumulation at each trophic level.

SUPPORTED BY U.S. Dept. of Agriculture
Michigan State Government

5.0564, FARM ANIMAL WASTE DISPOSAL

J.A. DAVIDSON, Michigan State University, Agricultural Experiment Sta., *East Lansing, Michigan* 48824

Objectives: 1. Characterization of the physical, chemical, and biological properties of livestock and poultry wastes. 2. Improvement in management systems with regard to handling, treatment and disposition of the wastes.

The electro-osmosis principle of drying animal and poultry manure will be investigated. The amount of electrical current and the design of and material used in the electrodes will be studied. The time required to dry the material and the amount of moisture remaining in the material when the system stops operating will be determined. The water removed and the residue will be analyzed. Bulk density of the manures and the orientation of the electrodes will be investigated.

The use of air, mechanical agitation, and pumping (circulating) will be investigated as a means of increasing aerobic digestion. This will be accomplished in small tanks with controlled amounts of the manure added daily. In addition one or more full scale tanks in pens with a high density population will be used.

SUPPORTED BY U.S. Dept. of Agriculture
Michigan State Government

5.0565, TOXIC ACTION OF WATER SOLUBLE POLLUTANTS ON FRESHWATER FISH

P.O. FROMM, Michigan State University, School of Medicine, *East Lansing, Michigan* 48824

Fish subjected to chronic low level sgress (hexavalent chromium and forced exercise exhibited a transitory increase in plasma cortisol which returned to control levels after one week exposure. Animals treated with exogenous cortisol by implanting pellets in the body cavity had plasma cortisol levels of over 100 micrograms. Fasted fish so treated had elevated liver glycogen and excreted more waste nitrogen than controls. Plasma glucose was not elevated. Animals similarly treated but fed during the experimental period had liver glycogen stores and nitrogen excretion rates similar to controls. A seasonal variation in plasma cortisol levels of untreated trout was found.

Rainbow trout were placed in solutions of ammonium chloride containing 0,1,3,5 and 8 micrograms ammonia (total)/ml. After 24 hours' exposure the blood levels for total ammonia showed a direct linear correlation with ambient ammonia and ranged from 38 to 71 micrograms/ml. Expressed in terms of non-ionic ammonia (NH3): fish exposed to 0 to 1 micrograms ml had blood levels which ranged from 0.06 to 1.3 micrograms ml. The daily excretion of total waste nitrogen showed an inverse relationship with starting ambient levels of ammonia as did the data for excretion of ammonia nitrogen. The relatively greater decrease in ammonia nitrogen excretion nitrogen over total nitrogen excretion in fish exposed to the higher concentrations of ammonia suggests that excretion of other nitrogenous compounds occurred to partially compensate for decreased ammonia nitrogen excretion.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0566, BIOCHEMICAL AND ECOLOGICAL RELATIONSHIPS OF PESTICIDES AND THE BIOLOGICAL CONSTITUENTS OF AQUATIC COMMUNITIES

G.E. GUYER, Michigan State University, Agricultural Experiment Sta., *East Lansing, Michigan* 48824

Studies of interdisciplinary nature are proposed to evaluate the amount, storage, build-up and release of pesticides under varying biological and chemical conditions. Studies on methods of contamination and levels needed to produce injury, debility, sterility or mortality will be conducted under controlled conditions. The physiological effects of pesticides on energy exchange will be measured at the cellular level. Direct bioassay and gas chromatography will be employed to follow the movement and monitor the accumulation of pesticides in aquatic systems. A study will be initiated to determine the site of damage and the identification of effects of detergents, metallic ions, BOD and other chemicals. Areas of concentration in the trophic system, rate of transfer, buildup and exchange within the biota of aquatic systems will be determined.

SUPPORTED BY U.S. Dept. of Agriculture
Michigan State Government

5.0567, RELATIONSHIP OF PESTICIDES IN SOIL, WATER AND PLANTS

G.E. GUYER, Michigan State University, Graduate School, *East Lansing, Michigan* 48824
SANCLEMENTE

The identification of real or potential hazards to human health or ultimate human satisfactions has been an essential aspect of this pesticide investigation. Sorption of pesticides by clay minerals, soil microorganisms and soil materials of varying organic matter content were studied to elucidate mechanisms of retention and to evaluate effects of sorption on biological activity.

Degradation of a pesticide may lead to dissipation, alteration or enhancement of its biological activity. Precise knowledge of the nature and properties of degradation products and factors conducive to their formation were evaluated. Studies indicate that significant qualitative changes in composition of the microflora may result from specific effects of pesticides on specialized groups of organisms.

A significant aspect of this research was associated with evaluating pesticides as contaminants in the aquatic environment. These studies involved the evaluation of fresh water clams as indicators of pesticide pollution, a quantification of the contribution of pesticides to the aquatic environment by urban and suburban communities and the effect of waste treatment systems on removal and/or degradation of pesticides. Related studies were associated with metabolism and physiological response of organisms to various pesticide exposures.

The relationship of the structure, sorption activity and role of the waxes associated with cuticular membrane to pesticide uptake and metabolism was studied. Further studies involved the effect of diphemid on plant growth and metabolism and the very significant discovery of the relationship of simazine on protein synthesis.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0568, SPORULATION AND GERMINATION OF CLOSTRIDIUM BOTULINUM

R.V. LECHOWICH, Michigan State University, School of Agriculture, *East Lansing, Michigan* 48824

Conditions required to obtain adequate growth and sporulation of Type E Clostridium botulinum will be further evaluated. Germination studies of spores produced under different conditions will also be continued. Toxin production in complex and defined media will be studied and the nature of the toxin produced by different strains of the same toxin type will be examined. Gas-liquid chromatography pyrolysis (GLCP) techniques will be used to determine the applicability of this method of analysis to distinguish metabolic by-products and the use of GLCP as a means to rapidly identify a specific toxin type of Cl. botulinum. Data gained by GLCP techniques and other data on spore composition should be correlated with other properties of Cl. botulinum spores.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0569, ISOLATION OF VIRUS FROM SEWAGE & DRINKING WATER

W.N. MACK, Michigan State University, School of Medicine, *East Lansing, Michigan* 48824

The objectives to be accomplished are: 1. Make a quantitative study of the viruses present in the various stages of activated sludge sewage treatment. 2. To test the effectiveness of chlorine, holding time, temperature, etc. on the viruses present in the effluent. 3. To determine what happens to the viruses in effluents after being discharged into a river. 4. Attempt to isolate enteroviruses from potable water taken from chlorinated municipal water supply and also private wells known to produce a high incidence of hepatitis in individuals using the water.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0570, AN EVALUATION OF WIDELY USED HERBICIDES ON AQUATIC PLANTS, FISH AND FISH-FOOD ORGANISMS

E.W. ROELOFS, Michigan State University, Agricultural Experiment Sta., *East Lansing, Michigan* 48824

(1) To assess the influence of total alkalinity, pH and temperature of the water on the effectiveness of several widely used herbicides. (2) To test the effect of weed control by chemical means on fish-food organisms. (3) To evaluate fertilization as a method of controlling higher aquatic plants.

Preliminary work in the laboratory will include study of influence of water quality on effectiveness of various herbicides. Toxicity of herbicides to fish will be studied in conjunction with the laboratory experiments. While some fertilization studies can be done in the laboratory, the major effort here will be in farm ponds and small lakes. The effect of weed control by chemical means on fish-food organisms will be studied by direct determination of organism abundance before and after control, and by study of stomach contents of fish.

SUPPORTED BY U.S. Dept. of Agriculture
Michigan State Government

5.0571, OCCURENCE OF PROSTHECATE BACTERIA IN A GRADIENT-POLLUTED RIVER

J.T. STALEY, Michigan State University, School of Veterinary Medicine, *East Lansing, Michigan* 48824

Freshwater contains a group of bacteria which are morphologically distinguishable from other bacteria with the phase contrast microscope. These unusual bacteria have one or a number of appendages extending from the surface of the cell. On the basis of the number, shape, and arrangement of the 'prosthecae' (or appendages) they are assigned to a genus. Poindexter (1964) has described Caulobacter and Asticcacaulis; Ancalomicrobium and Prosthecomicrobium, two additional freshwater forms, have also been isolated and described (Staley, 1967). Little is known of their importance and their numbers in freshwater. There is some indication that they may be significant in the ecology of freshwater.

Consequently, the objective of the proposed research is to determine the concentration of these bacteria along a river course in which the degree of pollution increases from source to outlet, and to correlate these numbers with the total and viable counts of other bacteria (including E. coli, a sewage pollutant).

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Michigan State University

5.0572, THE RELATIONSHIP OF SEWAGE HANDLING PRACTICE TO PESTICIDE RESIDUE LEVELS AND INVERTEBRATE ECOLOGY

M. ZABIK, Michigan State University, Graduate School, *East Lansing, Michigan* 48824

The object of the proposed work is to determine wheather a buildup of insecticide residue will occur in the silt below the new East Lansing waste treatment plant and if so, how far downstream it will extend. It is also hoped to determine the source of the residue, i.e. is it coming from the plant effluent, or does it come from points upstream due to drift and then collect below the plant due to the higher organic content of the effluent. An additional segment of the proposed work is to study its interrelationships among the nutrient source (chemical phase), pesticide residue levels, and invertebrate ecology.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Michigan State University

5.0573, EFFECTS OF VARIOUS FOREST TYPES AND STAND TREATMENTS ON GROUNDWATER RECHARGE AND STREAMBANK EROSION IN AREAS OF DEEP GLACIAL DRIFT

D.H. URIE, U.S. Dept. of Agriculture, *East Lansing, Michigan*

Object: To develop forest management practices to improve water yield by inducing greater recharge of ground water. To develop mechanical and vegetative techniques for stabilizing eroding streambanks, channel bottoms, and adjoining lands.

Plan of work: The project staff is determining the water balance under existing vegetation in areas of glacial drift and sand plains. They are studying streambank erosion to determine its causes and methods of erosion controls by mechanical and vegetative means. The changes in suspended sediment following stabilization are being evaluated. New studies will determine effects of forest management practices on snow accumulation and ground-water yields.

SUPPORTED BY U.S. Dept. of Agriculture

5.0574, DISSOLVED ORGANIC MATTER AND PHOTOSYNTHESIS IN LAKES

R.G. WETZEL, Michigan State University, W.K. Kellogg G. Lk. Biol. Sta., *Hickory Corners, Michigan* 49060 (AT(11-1))

Studies are in progress on the qualitative and quantitative analyses of excretion and utilization of dissolved organic compounds and their role in the nutrition and metabolism of planktonic and sessile producers. Discrimination between bacterial, algal, and macrophytic utilization of organic compounds directly in chemo-organotrophy or indirectly by the complexing of inorganic ions affecting metabolism is being approached experimentally. Both axenic and natural populations are used in distinguishing the significance of the individual mechanisms by which dissolved organic compounds influence photosynthesis at naturally occurring concentrations.

A second area of investigation is centered on the qualitative and quantitative excretion of dissolved organic matter by submerged macrophytes and the relation of such compounds to inorganic nutrition and rates of metabolism. Variations in the composition of extracellular compounds and rates of excretion are being determined with regard to changes in metabolism and a number of environmental parameters. While much of the work is being performed with axenic cultrues of macrophytes, experimentation will be extended to in situ analyses under natural conditions. Detailed cyclic variations of physical, chemical, and biological parameters of a representative marl lake are under intensive investigation to provide information for the integration of all experimental phases.

SUPPORTED BY U.S. Atomic Energy Commission

5.0575, TRANSPORT, STORAGE, AND TOXICITY OF INSECTICIDES IN AQUATIC ENVIRONMENTS

J.W. MERNA, State Dept. of Conserv. , *Lansing, Michigan* 48296

Project and Job Objectives: To learn the pathways and measure the rates of concentration and degradation of insecticides in a pond system, and to evaluate the toxic effects of the insecticides on organisms in the system.

Procedures: In an initial step, DDT was applied to a small natural pond; a second pond served as a control. The study of pathways and degradation was complicated by a varied fauna and rapid degradation of DDT to DDE and DDD. Thus the study was extended and simplified, in a physical set-up with four vinyl-plastic tanks, 10 feet in diameter x 4 feet deep, submerged in a farm pond to insure temperature uniformity. The food chain was simplified to algae, microcrustaceans and brook sticklebacks (Eucalia inconstans). The 4 ponds will provide this experimental set-up:

Pond 1. Filtered pond water, clean sand bottom. No DDT added. Periphyton measured, using 104 sheets (10' x 3'), hung one foot below surface. Pond with microcrustaceans and sticklebacks.

Pond 2. Same as 1, but treated with 15 ppb DDT (para para).

Pond 3. Same as 2, but without sticklebacks.

Pond 4. Same as 2, but with Artemia, and without microcrustaceans.

Thirty days after DDT is added to 2, 3, and 4, fin-clipped sticklebacks to be introduced into 1, 2, and 4, and periphyton sheets will be placed in each pond. Experiments will run 30 days; samples will be frozen for later analysis of DDT. The experiment will provide three food chains for study of DDT transmission.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Michigan State Government

5.0576, LAKE MICHIGAN CHEMICAL CONTROL OF SEA LAMPREY

W.E. GAYLORD, U.S. Dept. of Interior, Biological Station, *Lundington, Michigan*

The Bureau of Commercial Fisheries, under the direction of the Great Lakes Fishery Commission, is using selective larvicides as an experimental method of control for sea lampreys in Lake Michigan. The study is designed to eliminate all generations present in the streams tributary to the lake by treatment of these streams with chemical, and to determine if such action will control effectively the parasitism on lake trout and other fish.

The control method requires a thorough knowledge of: the presence and distribution of ammocete populations in tributaries; physical characteristics and flow data of infected streams, accurate bioassays and chemical analyses of the water; precise metering of the chemicals; and posttreatment surveys to measure and analyze the effectiveness of individual treatments.

A total of 99 Lake Michigan streams contain sea lampreys. All streams were treated by July 1966. Treatments since then have been repeated at approximately 4-year intervals or at intervals determined from observations on the rate of reestablishment and growth of sea lampreys.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

5.0577, LAKE SUPERIOR CHEMICAL CONTROL OF SEA LAMPREY

R.A. BRAEM, U.S. Dept. of Interior, Biological Station, *Marquette, Michigan*

The Bureau of Commercial Fisheries, under the direction of the Great Lakes Fishery Commission, is using selective larvicides as an experimental method of control for sea lampreys in Lake Superior. The study is designed to eliminate all generations present in the streams tributary to the lake by treatment of these streams with chemical, and to determine if such action will control effectively the parasitism on lake trout and other fish.

The control method requires a thorough knowledge of: the presence and distribution of ammocete populations in tributaries; physical characteristics and flow data of infected streams; accurate bioassays and chemical analyses of the water; precise metering of the chemicals; and posttreatment surveys to measure and analyze the effectiveness of individual treatments.

There are 75 streams tributary to the U.S. shore of Lake Superior containing sea lampreys. The initial treatment of these streams was completed in 1961. The second application was finished in 1964. Since then treatments have been repeated at intervals determined from observations on the rate of reestablishment and growth of sea lamprey ammocetes.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

5.0578, LAKE HURON CHEMICAL CONTROL

B.R. SMITH, U.S. Dept. of Interior, Biological Station, *Marquette, Michigan*

The Bureau of Commercial Fisheries, under the direction of the Great Lakes Fishery Commission, is using selective larvicides as an experimental method of control for sea lampreys in Lake Huron. The study is designed to eliminate all generations present in the streams tributary to the lake by treatment of these streams with chemical, and to determine if such action will control effectively the parasitism on lake trout and other fish.

The control method requires a thorough knowledge of; the presence and distribution of ammocete populations in tributaries; physical characteristics and flow data of infected streams, accurate bioassays and chemical analyses of the water; precise metering of the chemicals; and posttreatment surveys to measure and analyze the effectiveness of individual treatment.

There are 48 tributaries along the U. S. shore of Lake Huron known to contain sea lampreys. Three of these were treated in 1962. Treatments in this area were resumed in 1966 and 18 streams were treated.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

5.0579, DEMONSTRATION AND EVALUATION OF POLYMERIC ADDITIVES IN THE TREATMENT OF STORM SEWER OVERFLOW

R.F. WUKASCH, Dow Chemical Company, *Midland, Michigan*

This project describes a two year study of the use of chemicals to control water pollution resulting from combined sewer overflows including the following areas of study.

1. Develop information pertaining to the Milk River Pumping Station, Crosse Pointe, Mich. and the corresponding Drainage Basin. 2. Flocculant studies will be carried out on both laboratory scale and full scale to demonstrate improvement in treatment efficiency with the use of polymeric flocculants. 3. Disinfection study. A demonstration will be made of the effectiveness of the disinfectants, with and without polymers. Work will be done on both a pilot plant and laboratory scale. 4. Model studies. A model will be made of the existing basin, and tested concurrently with the full scale basin to validate its use for model extrapolation. An optimized model will be conceived, built, and tested as a design for sedimentation incorporating chemical flocculation. 5. Conclusion. A concluding phase of the project will consist of economic analysis, restoration of the site to its original condition, and the preparation and distribution of the final report.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0580, BIOASSAY

J.H. HOWELL, U.S. Dept. of Interior, Hammond Bay Biolog. Sta. , *Millersburg, Michigan*

Research is directed toward the discovery of chemicals which, when a stream environment, will be selectively toxic to larval sea lamprey (Petromyzon marinus). The procedure consists of bioassaying a wide variety of organic compounds, representing most of the basic structural classes, under standard conditions against larval sea lamprey and rainbow trout (Salmo gairdnerii). The discovery of a chemical possessing the desired biological activity (toxicity and selectivity for larval lamprey) results in the testing of structurally related compounds. The relation between molecular structure and biological activity are studied and compounds custom synthesized to produce the best possible biological activity. Chemicals selected for field use are tested to determine what effect environmental factors such as water chemistry, temperature, turbidity and light have on their biological activity. Tests are run on promising compounds to determine their toxicity to a variety of game and nongame fish species as well as aquatic invertebrates. Methods are devised for preparing concentrated stock solutions of compounds being considered for field use. Analysis techniques, which are fast and accurate are developed. A chemical's potential as a sea lamprey control agent is evaluated under simulated stream conditions and in carefully controlled experimental stream treatments.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

5.0581, A COMBINED SEWERAGE COLLECTION AND TREATMENT FACILITY

H.E. MCENTEE, Mount Clemens Government, *Mount Clemens, Michigan*

The existence of combined sewers may be an asset instead of a liability. Recognizing that the separation of sewers may be an intolerable economic burden and may not accomplish the goal of alleviating pollution in outlet streams, it is proposed to collect all of the run-off from the projected area. While the rate of run-off is usually a problem, the total accumulation of rainfall during any storm is not usually immense. By minor storage in streets the total flow can be collected at the treatment site.

The treatment facility will be developed in a City Park concept with the treated collected combined sewage forming two lakelets which are expected to be used for boating, fishing, and providing an aesthetic setting for picnicking. The original collection reservoir (Lake A) will be hidden from public view. Water from Lake A can then be pumped at a slow rate (between storms) through a micro-strainer and chlorine contact chamber before discharge into Lake B and thence to Lake C.

Before discharge into the outlet River it will be additionally filtered for algae removal by means of microstrainers and sand filters. The lakes will be oxygenated as necessary by spray fountains and other aerators.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Mount Clemens City Government - Michigan

5.0582, PHOSPHATE REMOVAL BY BIOLOGICAL PROCESS

T.L. HENNESSEY, Trenton City Government, *Trenton, Michigan* 48183

The purpose of this project is to develop a modified form of the activated sludge processes in which soluable phosphates are removed by natural biological processes from waste water and contained in the sludge withdrawn from the treating units. Phosphates will be removed from the liquid discharged from sludge dewatering either chemically or physically. Pilot plant operation shall establish the design criteria for the new secondary plant to be put into operation by November 1, 1970.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Trenton City Government - Michigan

5.0583, NUTRIENT CONTROL PROJECT - DETROIT LAKES, MINNESOTA

W.C. LARSON, Detroit Lakes Engin. Dept. , *Detroit Lakes, Minnesota*

Disposal of nutrients from municipal, private, domestic, and agricultural wastes in the Detroit Lakes, Minnesota area poses a serious problem owing to the high groundwater table, very permeable gravel aquifer, and wide interception routes of groundwater underflow. Several lakes in the chain of lakes in this area are very important to the recreational needs of the community and valuable to the tourist industry, have experienced catastrophic aquatic weed and algal growths in recent years as a result of nutrient enrichment. These lakes are interconnected by the Pelican River or its tributaries and are situated down gradient (to the southwest of Detroit Lakes, Minnesota. Since sources of nutrients are widely scattered, it would not be economically feasible to intercept all waste outfalls with a central distribution system and provide subsequent treatment. It is proposed that nutrients in this sewage disposal system be intercepted or diminished in two different ways: 1) by dispersing the effluent from secondary treatment facilities on peat land and 2) by harvesting aquatic vegetation which contains nutrients. It is intended that by manipulation of natural environmental processes the rate of eutrophication will be arrested at minimal expense.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0584, CHRONIC EFFECTS OF HEAVY METALS ON FISH

R.W. ANDREW, U.S. Dept. of Interior, Natl. Water Quality Lab. , *Duluth, Minnesota*

The overall objective of this work is to develop analytical and toxicological techniques for relating the chronic effects of heavy metals and heavy metal wastes to observable short-term metabolic and physiological effects. The acute, subacute, and chronic effects of Cr, Cu, Cd, and Zn will be studied with Brook Trout, Yellow Perch, and for Bluegills as possible test species. Emphasis will be placed on the effects of the metals on the respiratory and reproductive systems, growth rates, and overall production efficiency of the fish. Tracer and radiotracer techniques will be used to determine modes of metabolism (intake/disposition/excretio) and physiological effects of one or more of the metals. Ultimately, attempts will be made to correlate the chronic physiological and toxiocological effects with measurable short-term (acute) effects.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0585, THE INVESTIGATION AND ANALYSIS OF BIOCHEMICAL PROCESSES OF AQUATIC ORGANISMS UNDER STRESS

G.M. CHRISTENSEN, U.S. Dept. of Interior, Natl. Water Quality Lab. , *Duluth, Minnesota*

The objective of this work is to carry out investigations on a molecular level on organisms, organs, tissues, cells and chemicals of aquatic life which have been exposed to toxicological or noxious situations and stress; to establish base-line data, or normal values, for specific biochemicals or biochemical systems in organisms and also, later, to establish parallel experimental values for those systems when under toxicological or noxious situations and stress. It is proposed that work be done to investigate and clarify the interreaction between stress source and stressed system, diagnosis and prognosis. It is proposed that research be carried out in order to determine whether it is possible to carry out a qualitative and quantitative analysis on specific biochemicals in an organism and deduce the general state of health or well-being of that organism or diagnose its ill health and have a basis for making a prognosis regarding its future state or health condition.

Initially, work is being carried out with the general 'fight-or-flight' (stress) hormones, adrenaline and noradrenaline. We are in the process of establishing normal values for these two biochemicals in fish, and plan then to determine non-normal values for the organism when under toxicological or other types of stress. Equipment which is particularly useful for this study includes a recording spectrophotometer, thin-layer and paper chromatographic apparatus, a recording spectrophotofluorometer and a sensitive infra-red spectrophotometer.

Other biochemicals that may be investigated in the future include, tentatively, blood glucose, serum non-protein nitrogen, certain inorganic salts, specific serum enzymes, plasma fatty acids and other specific hormones that are known to be involved in stress-type biological reactions.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0586, CULTURING, PROPAGATION AND CONDITION EVALUATION OF FISHES

D.A. HILDEN, U.S. Dept. of Interior, Natl. Water Quality Lab. , *Duluth, Minnesota*

Ten species of fish have been selected on the basis of economic importance and nationwide distribution, to be utilized in developing water quality criteria, for the protection of all forms of aquatic life. These fish species and the organisms in their respective food chains will be used to determine the effects of various types of water pollution on all forms of aquatic life. Acute, subacute, and chronic bioassay studies will be made.

This particular project will develop methods and techniques for culturing and natural spawning (propagation) of the selected wild fish species, in the laboratory environment. This must be done in order that chronic bioassay work can be carried out through at least one complete life cycle of the species.

Physiological parameters such as hematocrits, hemoglobins, total and fractional serum protein determinations, blood calcium to magnesium levels, blood phosphate levels, hormone levels, enzyme levels, as well as histological studies will be measured bimonthly to determine the physiological well being and condition of the species before they are used for bioassay work--and to develop 'laboratory' normal parameter means, to which, the same physiological parameters from fishes subjected to experimental treatments, can be compared.

The initial work will be with yellow perch, Perca flavescens, brook trout, Salvelinus fontinalis and lake herring, Coregonus artedi.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0587, RECOVERY OF INDICATOR BACTERIA ON SELECTIVE MEDIA DURING DECREASE OF VIABLE COUNTS

A.W. HOADLEY, U.S. Dept. of Interior, Natl. Water Quality Lab. , *Duluth, Minnesota*

There is some evidence that selective procedures for the enumeration of indicator bacteria underestimate actual viable populations as counts decrease during 'die-away', resulting in an apparent rate of 'die-off' which is greater than the actual rate. It is the objective of this project to determine whether commonly accepted procedures yield meaningful results when applied during the so-called 'die-away' of indicator bacteria. Answers obtained should aid in interpretation of field data, in the development of better procedures, and in answering the broader question of what factors cause decreases in viable bacteria in water.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0588, RELATION OF SWIMMING WATER QUALITY TO THE OCCURRENCE OF EAR INFECTIONS

A.W. HOADLEY, U.S. Dept. of Interior, Natl. Water Quality Lab. , *Duluth, Minnesota*

Several studies have indicated a need to devote attention to the relationship of bathing water quality to ear, nose, throat, and skin infections among swimmers. There exists some evidence that pathogenic bacteria playing an important role in outer ear infections occur in some surface swimming waters. It is the objective of this project to determine whether the strains of pathogenic bacteria isolated from surface bathing waters are, in fact, identical to those strains isolated from infected ears.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0589, EFFECTS OF D.O., TEMPERATURE AND POTENTIAL TOXICANTS UPON SELECTED MACROINVERTEBRATES (EMPHASIZING NON-ARTHROPODS)

M.J. IMLAY, U.S. Dept. of Interior, Natl. Water Quality Lab. , *Duluth, Minnesota*

Effects of dissolved oxygen, temperature and toxicants (such as CuSO4) on commercially valuable fresh-water clams and on fish food chain macroinvertebrates such as snails, leeches, scuds, insects, and flatworms will be studied.

Relation of cellular changes and daily activity patterns to toxicant or environmental stress and relation of mass filter-feeders (clams and sponges) to bacterial water quality will also be investigated.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0590, EFFECTS OF TEMPERATURE ON MATURATION, EMBRYONIC DEVELOPMENT AND CONDITION OF FRY IN YELLOW PERCH - LAKE HERRING, SMELT AND WALLEYE

B.R. JONES, U.S. Dept. of Interior, Natl. Water Quality Lab. , *Duluth, Minnesota*

The project is to determine levels of temperature needed for sustained production of freshwater fish through study of effects on reproduction. Criteria thus to be determined are to serve as a basis for water quality standards.

Fish will be exposed to several levels of temperature related to seasonal temperature variations. Effects of elevated temperatures on gonad development to be determined in part by histological technique, on embryonic developemnt and on condition of larvae will be measured in yellow perch. Effects of elevated temperatures on embryonic development and condition of larvae will be measured in lake herring, smelt and walleye.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0591, CULTURING AND PROPAGATION OF SELECTED INVERTEBRATES AND ASSOCIATED FOOD ORGANISMS

A.E. LEMKE, U.S. Dept. of Interior, Natl. Water Quality Lab. , *Duluth, Minnesota*

To maintain selected invertebrate forms from field collections at any specific stage without loss of strength of change from collected condition; and to continuously produce a crop of animals which are suitable for continuing the life cycle and/or to use in experiments for determining the water quality requirements for that species. A necessary adjunct will be the propagation of the desired food organism of the desired species.

Initial work will be concerned with culturing Hydropschye betteni and propagation of Gammarus faciatus, Daphnia magna, Cyclops sp., Bosmina sp. from the invertebrate group, and Rhizolclonium, Coccochlorus, and Synedra as plant representatives. Temperature, light, and flow will be controlled using continuous flow systems.

The initial phases of the work will be begun in fiscal 68 and finished in fiscal 69. Subsequently, work will be started with those organisms that can be reared to change their life cycle by manipulation of the listed factors.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0592, PHYSIOLOGIC AND METABOLIC RESPONSE AS INDICATORS OF STRESS

J.M. MCKIM, U.S. Dept. of Interior, Natl. Water Quality Lab. , *Duluth, Minnesota*

The objective of this research is to measure the subtle internal metabolic and physiologic responses of fish to environmental changes.

Initially this project will be involved with the effects of low dissolved oxygen levels on cardiac and respiratory functions in the yellow perch (Perca flavescens) and the brook trout (Salvelinus fontinalis). It has been shown by other investigators that these functions are altered considerably when an individual is subjected to low dissolved oxygen levels. These alterations in cardiac and respiratory function indicate a shift in metabolism due to hypoxic conditions. If the level of dissolved oxygen at which these changes occur is different for each species, then a method to aid in setting dissolved oxygen standards for fresh water fish might be initiated.

The fish will be held at a constant temperature in metabolism chambers through which flows water of varying oxygen concentrations.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0593, EFFECTS OF HIGH TEMPERATURE, LOW OXYGEN, AND PH EXTREMES ON THE SURVIVAL OF

AQUATIC INSECTS AND CRUSTACEA IMPORTANT AS TROUT FOOD

A.V. NEBEKER, U.S. Dept. of Interior, Natl. Water Quality Lab., *Duluth, Minnesota*

To establish dissolved oxygen, temperature, and pH requirements for various species of aquatic insects and crustacea which have been found to be important in the food chain of brook, rainbow, and lake trout. Two species of Lake Superior crustaceans, Mysis relicta and Ponteporeia affinis, and five species of aquatic insects, Acroneuria lycorias, Taeneopteryx maura, Brachycentrus americanus, Hydropsyche betteni, and Ephemerella subvaria, will be used as test organisms. The work will consist of determining the TLm(LD50) values for 96 hours and 30 days, and longer if possible, for high temperatures, low oxygen, and low and high pH.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0594, EUTROPHICATION - REMOVAL OF NUTRIENTS - SHAGAWA LAKE

L.P. SEYB, U.S. Dept. of Interior, Shagawa Lake Eutroph. Project, *Ely, Minnesota* 55731

The objective is to evaluate the removal of algal nutrients from municipal sewage in an advanced waste treatment pilot plant as a means to impede blue-green algal blooms. Nutrient removal will be accomplished by combinations of coagulation, filtration, ion exchange and carbon adsorption operations. Pilot plant effluent will be mixed with lake water in one 125,000 gallon pond immersed in the lake to determine the effect of nutrient removal on algal populations. A similar pond will receive trickling filter effluent mixed with lake water. A third pond will serve as a control. Similar tests will be made in 200 gallon and 5 liter containers to determine scale effect. Water quality of Shagawa Lake, its inflow, and outflow streams will be determined regularly to establish base-line information.

If nutrient removal by the pilot plant is effective, a full scale tertiary sewage treatment plant for the removal of algal nutrients from Ely's sewage will be considered as a demonstration. Because bottom sediment might be a reservoir for algal nutrients, studies to determine the effect of sediment on the quality of lake water will be undertaken when experimental work in the pond ceases because of weather conditions.

Ultimately, enough facts about algal and aquatic plant growths in Shawgawa Lake will be available to provide for a plan to reverse the lake from its eutrophic condition to one that is less or non-eutrophic.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0595, USE OF FUNGI IMPERFECTI IN WASTE CONTROL

B.D. CHURCH, North Star Res. & Dev. Inst., *Minneapolis, Minnesota*

The objective of this project is to select and develop rapidly growing fungi strains that will utilize dissolved and suspended organic matter in waste streams from the food processing industry to produce a mycelium readily removed from the streams by filtration and also to develop practical processes for the utilization of such fungi in selected waste streams from the food processing industry. Initial studies will be on waste streams from soybean and sweet corn processes.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Minneapolis City Government - Minnesota

5.0596, DEMONSTRATION OF THE CHANNEL AERATION PROCESS IN TREATMENT OF SEWAGE

H. BAUER, State Dept. of Health, *Minneapolis, Minnesota*

The purpose of the project is to demonstrate the efficiency of the channel aeration process of sewage treatment on the removal of plant nutrients such as phosphate and bound nitrogen, and the removal of Salmonella and enterovirus from the incoming sewage. The effect of the treated effluent on algae and other aquatic plant growth in the receiving lake will be studied.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Minnesota State Government

5.0597, MATHEMATICAL MODEL OF STORM AND SANITARY INTERCEPTOR SYSTEM

C.E. BOWERS, Univ. of Minnesota, School of Engineering, *Minneapolis, Minnesota* 55455

The objective of this study is the development of a mathematical model of the interceptor system of the Sanitary District, to assist in the operation of diversion structures in the trunk sewer system. The model will take precipitation data at 8 locations around the area as input and compute runoff in the trunk system, inflow to the interceptors and route the flow through the interceptors. It should provide the operation with information on peak flows and depths, to assist in operation of the diversion structures. The study started in the winter of 1967 and will take about one year to complete.

SUPPORTED BY Saint Paul City Government - Minnesota
Minneapolis City Government - Minnesota

5.0598, NITRIFICATION AND DENITRIFICATION OF WASTE WATER

W.K. JOHNSON, Univ. of Minnesota, School of Engineering, *Minneapolis, Minnesota* 55455

The objective of this project is to conduct samll-scale continuous flow pilot plant investigations to investigate nitrification in the activated sludge process and denitrification for the purpose of removing nitrogen from wastewaters. Several flow patterns will be investigated including a staged operation with nitrification and denitrification used alternately. A synthetic milk waste will be used as the raw waste feed to the pilot plants. No results of the investigations are available at this time. It is planned that larger scale demonstration plant tests using domestic sewage will also be conducted during the coming year.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0599, REMOVAL OF COLLOIDAL MATTER FROM WASTE WATER

W.J. MAIER, Univ. of Minnesota, School of Engineering, *Minneapolis, Minnesota* 55455

The broad objective of the proposed investigation is to define the mechanisms by which microorganisms contribute to the physical removal and metabolism of organic colloidal matter from dilute solutions. This information will be used to formulate theoretically based rate equations to describe the time-rate of removal of colloidal particles as a function of the physical-chemical properties of the particles and of the solution.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0600, A STUDY OF THE OPEN WATER DISTRIBUTION AND ABUNDANCE OF NET-PLANKTON AS AN INDEX OF EUTROPHICATION IN LAKE SUPERIOR

T.A. OLSON, Univ. of Minnesota, School of Public Health, *Minneapolis, Minnesota* 55455

This research is aimed at applying the Continuous Plankton Recorder Techniques of Hardy to non-oceanic situation, namely Lake Superior. Hardy recorders were designed for marine work and can be towed behind merchant vessels and other commercial craft proceeding at their normal cruising speeds. During these tows, a band of silk bolting cloth is automatically fed across a tunnel-opening to collect organisms from the water. Under highly efficient filtering conditions, three cubic meters or 3000 liters of water are strained over each ten-mile section of the course and organisms in the catch are deposited in a chronological order on the moving band. After exposure the band is covered by another layer of silk to hold the organisms in place and the two bands are then tightly rolled up in a small tank of formalin preservative. At the end of each 500-mile run the roll is removed from its chamber and shipped to the laboratory where a count is made of the organisms. The zooplankters (herbivores) which make up the second trophic level of the ecological pyramid can be accepted as a reflection of the primary production and therefore as an expression of the state of fertility or quality of the water being studied.

Because such large areas can be covered and each mile traversed can be associated with a definite point on the bolting cloth band one can detect variations which occur over the entire lake and can readily locate such areas of variance accurately on a geographical basis. The method is envisioned as a practical parameter of water quality which will be of distinct value in studies of any of the Great Lakes.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Minnesota

5.0601, BENTHONIC INVERTEBRATES AS AN INDEX OF WATER QUALITY

T.A. OLSON, Univ. of Minnesota, School of Public Health, *Minneapolis, Minnesota* 55455

The proposed water pollution study will be made on immature aquatic invertebrates. Primary efforts will continue to be concentrated on the oxygen requirements of each species during its aquatic life cycle. It is believed that through such a study a more exact evaluation can be established on the status of these invertebrates as indicators of water quality or as potential bioassay indicators. A subsequent cataloging of each species should be of value to agencies and persons concerned with water pollution.

Since environmental conditions can be more closely controlled in the laboratory, the work will be centered on this aspect. A limited number of field studies will be included. A flow-through respirometer in which the oxygen is measured by an electrochemical transducer and the conventional Manometric technique will be employed to measure oxygen consumption rates.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0602, RELATION OF PHOSPHORUS IN LAKE BOTTOM DEPOSITS AND POLLUTIONAL HISTORY OF MINNESOTA LAKES

J. SHAPIRO, Univ. of Minnesota, Graduate School, *Minneapolis, Minnesota* 55455

A study is to be made of the phosphorus content of sediment profiles from a wide variety of lakes in Minnesota. The shapes of these profiles will be interpreted in the light of other events as determined through micro-fossil analysis. This study coupled with direct studies of the availability to recycling of phosphorus from different depths in the cores will aid in determining the extent to which sedimentary phosphorus is of meaning to the productivity of lakes.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Minnesota

5.0603, INORGANIC-ORGANIC INTERACTIONS IN NATURAL WATERS

J. SHAPIRO, Univ. of Minnesota, Graduate School, *Minneapolis, Minnesota* 55455

To study the yellow colored organic substances in natural waters from the following aspects: 1. The relationships between the color and inorganic constituents of water. 2. The significance of the above to algae. 3. The physical state of the coloring matter. 4. The chemical nature of the coloring matter. 5. Geographical variations in the nature and properties of the coloring matter.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0604, THE ROLE OF MIXING IN MAINTAINING STRATIFIED FLOW

E. SILBERMAN, Univ. of Minnesota, School of Engineering, *Minneapolis, Minnesota* 55455

In controlling pollution of lakes, streams, and beaches, it is desirable to be able to predict the relative importance of stratification and mixing between an effluent and ambient water when there is a difference in density between the two. Density differences may arise, for example, when warm water is discharged into cooler water, when aerated sewage is discharged into normal river water, when fresh water wastes are discharged into salt water, and when sediment- laden water is discharged into clear water. Two somewhat different physical situations are involved; these are the outfall area where effluent and ambient fluid first meet and the area distant from the outfall where persistence of stratification requires study. A broad analytical and experimental study of the problems involved is proposed. The objectives are to improve the ability of the engineer to: (1) determine the degree of stratification that may be expected under given outfall conditions, (2) control stratification and mixing at an outfall, (3) determine the presistence of stratification at a distance from an outfall, (4) determine the effect of wind waves on stratification and mixing, and (5) make model studies of stratification and mixing problems.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0605, METHODOLOGY FOR INTEGRATING WATER QUALITY MANAGEMENT WITH THE MANAGEMENT OF THE TOTAL WATER RESOURCES IN MINNESOTA

C.P. STRAUB, Univ. of Minnesota, School of Public Health, *Minneapolis, Minnesota* 55455

This research is aimed at studying the water quality problems associated with the many existing and possible uses of the water resources of Minnesota and proposing methodology for integrating water quality management with the management of the other aspects of the resource. The investigations will include: collection of data on water quality for the total resource, both surface and groundwater, in Minnesota; and a study of these data: a) to determine water quality parameters to be incorporated in future programs of data collection and analysis and b) to propose methodology for integrating quality management with that of the total resource, bearing in mind likely uses of the resource.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Minnesota

5.0606, DEVELOPMENT OF A MATHEMATICAL MODEL TO PREDICT THE ROLE OF SURFACE RUNOFF AND GROUND WATER FLOW IN OVERFERTILIZATION OF SURFACE WATERS

C.P. STRAUB, Univ. of Minnesota, School of Public Health, *Minneapolis, Minnesota* 55455

Better control of agricultural and natural pollution is required to protect Minnesota intrastate and interstate surface waters. Since nutrient enrichment information is inadequate, studies are planned to develop a mathematical model to predict the role of surface runoff and groundwater flow in the overfertilization of surface waters. Following development of the model, which will include theoretical expressions required for a complete hydrologic budget and general expressions relating to nutrient balance, criteria will be developed for controlling sources contributing to the overfertilization or eutrophication of Minnesota waters. The research effort will identify the primary factors introducing nitrogen and phosphorous to the aquatic environment, will delineate areas where additional data are needed and will evaluate the resultant model under field conditions. The model will assist state and federal agencies in initiating surface water fertilization control programs.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Minnesota

5.0607, PRIMARY PRODUCTIVITY OF MINNESOTA LAKES

H.E. WRIGHT, Univ. of Minnesota, Graduate School, *Minneapolis, Minnesota* 55455

Primary productivity will be measured by the light-dark-bottle method in lakes across Minnesota, from the acid bog lakes on crystalline rocks in the coniferous forest of the northeast, to the alkaline or even saline lakes in calcareous glacial drift in the prairie of the southwest, in order to extend and refine the survey that was started on an earlier project. Besides the productivity and concurrent chemical measurements that will be made for vertical profiles in the lakes, plankton counts will be made of the same water samples to determine what organisms are responsible for the biochemical activity. Pigment and diatom analyses will be made for comparison with already available analyses of bottom sediments, and samples will be provided to other investigators for trace-element analyses to provide further information on plankton ecology and chemical hydrology. Primary productivity will also be measured concurrently at selected sites with the carbon-14 technique, to provide comparisons between the two methods under controlled conditions.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Minnesota

5.0608, AEROBIC BIOLOGICAL TREATMENT, SLUDGE DEWATERING AND DISPOSAL AND EFFLUENT REUSE FOR A SIDE LEATHER TANNERY

B. CHRISTENSEN, S.B. Foot Tanning Company, *Red Wing, Minnesota*

The four year project will provide a full scale demonstration and investigation of primary sedimentation, biological secondary treatment utilizing aerated lagoons, and primary and secondary sludge dewatering and disposal by means of pressure filtration and incineration. The system will treat the total waste flow of 2.1 MGD from the side leather tannery. In addition an evaluation will be conducted to determine the influence of final treatment plant effluent reuse on hide processing and quality of the finished product by reusing it in the 'limepaddle' and 'wash soak' tanning operations.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
S.B. Foot Tanning Company

5.0609, DISPATCHING SYSTEM FOR CONTROL OF COMBINED SEWER LOSSES

R.L. MICK, Minneapolis St. Paul San. Dist, *Saint Paul, Minnesota* 55106

The project involves installation of control gates at key points in a combined sewer system which will be controlled from a control location using real-time analysis of meteorlogical, hydrologic, and hydraulic data to optimize combined sewer system performance and minimize lesson of combined wastes to the receiving stream. An analysis will be made of the extent and effect of losses from the combined sewer system under present operation, and a comparison will be made to show the improvements resulting from the control system. Extensive analytical data will be obtained as well as extensive measurements of sewer system performance.

The annual level of expenditure will vary. The project is financed by a 50 per cent grant from the Federal Water Pollution Control Administration, with the remainder shared by the cities of Minneapolis and Saint Paul and the Sanitary District.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Saint Paul City Government - Minnesota
Minneapolis City Government - Minnesota

5.0610, EFFICIENCY AND ECONOMY OF POLYMERIC SEWAGE CLARIFICATION

K.D. LARSON, Saint Paul Sewage Disp. Comm. , *Saint Paul, Minnesota* 55075

The project objectives are to determine the increased purification attainable by treating industrial wastes (packing house), sanitary sewage, combined sanitary sewage and storm waters or combinations of such wastes with polyelectrolytes and floc 'weighting agents.' Design parameters for the degree of treatment to be expected will be established on the combined city sewage and industrial wastes, on the city wastes for both 'dry weather' and 'wet weather' flows, and on the industrial wastes separately. Physical and chemical characteristics of the sludge obtained as a result of this treatment procedure will be established.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
South St. Paul City Government -
Minnesota

5.0611, PEAT BOG WASTE STABILIZATION

A.M. DEYOANNES, State Dept. of Iron Rge. Res. , *Saint Paul, Minnesota* 55101

The purpose of the project is to explain the phenomenon whereby wood products waste water from an industrial plant in Floodwood, Minnesota, becomes biologically stabilized rapidly when in contact with peat native to the area. Tests will be made to see whether this phenomenon can be effected with other waste waters, including domestic sewage; and to find a way to accomplish this phenomenon with peat which can be transported to places where it does not exist naturally. Peat which has been partially dried and subsequently re-watered and re-- seeded with peat bacteria if necessary will also be studied.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Minnesota State Government

5.0612, STORAGE AND MOVEMENT OF WATER IN SOILS AS RELATED TO SPACIAL AND TIME CHANGES IN THE CLAY-QUARTZ MATRIX

G.R. BLAKE, Univ. of Minnesota, School of Agriculture, *Saint Paul, Minnesota*

Storage and movement of water in soils depends on the stability and puddlability of the soil matrix and also upon time changes in the matrix stability. Laboratory studies will be made of time dependent changes in matrix stability and of bond formation and bond strength between particles. Soils will be selected, collected and sieved. Artificial aggregates will be prepared and time-dependent changes in their wet strength will be measured by wet sieving and by modulus of rupture measurement. Effect of aging temperature and soil water content during aging will be measured. The matter of biological activity during aging will be investigated.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Minnesota

5.0613, FARM ANIMAL MANURE DISPOSAL LAGOONS

R.E. LARSON, Univ. of Minnesota, Agricultural Experiment Sta. , *Saint Paul, Minnesota*

Plan of Work: This project will be largely a 'field test' of data obtained from laboratory analysis and test. Lagoon design criteria will be developed from the laboratory data, from findings of other researchers and from observation of performance of operating lagoons and used to design prototype lagoons for the various kinds of manure. Performance of the prototypes will be observed and studied to evaluate the coliform bacteria reduction, rate of sludge accumulation, and other factors. As opportunities develop, design data for construction of prototype lagoons by the University of Maryland or by operating farmers in the vicinity will be furnished in exchange for opportunity to obtain performance data.

SUPPORTED BY U.S. Dept. of Agriculture

5.0614, EFFECT OF PAPER FIBER WASTES ON FISH EGGS AND JUVENILES

L.L. SMITH, Univ. of Minnesota, School of Agriculture, *Saint Paul, Minnesota*

Suspended wood fiber is to be tested for its effects on fish eggs, fry and fingerlings. Effects of wood fiber mats in Rainy River on fish and invertebrates will be tested. Decomposition products of wood fiber mats will be tested in laboratory. Effect of Sphaerotilus natans on fish eggs and fry is to be tested. Deleterious effects of low oxygen levels in connection with fiber decomposition products will be determined.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0615, INFLUENCE OF WATER POLLUTANTS AND WATER QUALITY ON EARLY LIFE HISTORY AND POPULATION DYNAMICS OF MINNESOTA FISHES

L.L. SMITH, Univ. of Minnesota, Agricultural Experiment Sta. , *Saint Paul, Minnesota*

The objective of this study is to determine the influence on fish production of various water pollutants of industrial and domestic origin; specifically, what such materials as H2S, detergents, paper mill wastes and similar materials have on growth rate, fecundity, and survival of fish. Fish food organisms are also included in investigations.

Field observations in polluted areas are made to determine limits of major parameters such as temperature, 02, pollutant levels and fish survival. Laboratory bioassays, long-term tests at sublethal levels of various materials, and fecundity tests will be made in the laboratory under controlled conditions to separate out effects of various factors and to define subtle long-term effects of pollutants that will influence level of annual harvestable crop of fish.

SUPPORTED BY Minnesota State Government

5.0616, IRON ORE FLOTATION

N.B. MELCHER, U.S. Dept. of Interior, Twin Cities Met. Res. Ctr. , *Saint Paul - Twin City Airport, Minnesota* 55111

Conduct bench scale and pilot plant research on fine grained nonmagnetic taconite, both independently and in cooperation with major iron mining companies, to devise and advance applicable flotation technology. Investigations will be conducted to determine the role of frothers and certain select dispersants in introducing certain undesirable side-effects on flotation, to achieve further efficiency in the selective flocculation-desliming steps, and to improve grinding practice so as to minimize steel consumption.

Research will be continued to construct a basis for process control based on measurements of unadsorbed calcium ion and starch in flotation pulps undergoing anionic flotation of silica.

Additional effort will be directed to studies on: (1) Flotation systems employing cationic collectors. (2) Filtration of finely ground concentrate with the objective of increasing capacity and lowering moisture content of filter cake, and (3) Clarification of slime overflows to enable water reuse and to prevent stream pollution, preferably while maintaining solution alkalinity.

SUPPORTED BY U.S. Dept. of Interior - Bureau of Mines

5.0617, DETERMINING CHANGES IN PHYTOPLANKTON POPULATIONS IN CLOUDS OF FLUORESCENT DYE MOVING IN THE MISSISSIPPI RIVER

C.D. MCNABB, Saint Marys College, Graduate School, *Winona, Minnesota* 55987

The degree of integrity maintained by clouds of fluorescent dye as they move through the 14 mile stretch of the Mississippi River pool 06 near Winona, Minnesota will be studied using continuous discharge and point discharge of Rhodamine B that will be detected downsteam on surveyed transects with a boat mounted, continuous flow Turner Model 11 flurometer. Time-in-travel and dispersal patterns between consecutive transects will be studied in different seasons. Plankton will be sampled within clouds of dye as they move between transects so that quantitative changes in the population of the diatom Stephanodiscus hantzschii caused by such things as immigration and emigration from the flow of the main channel might be determined. This work will be centered at the Hydrogioloby Station of St. Mary's College located at Homer, Minnesota.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Saint Marys College

5.0618, MAYFLY DISTRIBUTION AS A WATER QUALITY INDEX

C.R. FREMLING, Winona State College, Graduate School, *Winona, Minnesota* 55987

Hordes of mayflies rise from the Mississippi River every summer and create nuisance problems for river residents and river traffic. The relative abundance of the various species in a given area, however, is probably a reliable indicator of general water quality in that area.

Adult mayflies will be collected systematically along the Upper Mississippi River. An efficient, reliable, large-scale collection system was initiated in 1957 and it has been in continuous operation since that date. Past and future collections will be analyzed to determine (1) geographical distribution of the various species, (2) times of adult emergence, (3) areas of scarcity and abundance, (4) population trends, and other basic biological data. Most important, this analysis will determine the present state of the river as habitat for pollution-sensitive organisms. These data will provide a basis for comparison, should the quality of the aquatic habitat change in the future.

I have developed methods for rearing large numbers of burrowing mayflies in the laboratory. Laboratory populations will be maintained to determine the effects of limiting factors such as concentrations of dissolved substances, food supply, temperature, intraspecific strife and interspecific competition. The degree to which burrowing mayflies contribute to total turbidity will be determined. Laboratory populations will also be studied to learn more concerning the environmental factors which coordinate mass rhythmic emergences of mayflies.

Laboratory experiments in conjunction with field investigations will enable me to evaluate the importance of the various roles played by mayflies in the aquatic ecosystem. This evaluation becomes increasingly important as river cities contemplate mayfly control programs.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0619, A STUDY OF COLIFORM BACTERIA AND ESCHERICHIA COLI ON POLLUTED AND UNPOLLUTED OYSTER BOTTOMS OF MISSISSIPPI

G. GUNTER, State Marine Conserv. Comm. , *Biloxi, Mississippi*

Objectives: 1) To establish a regular sampling program on transects across Mississippi Sound and extending from fresh water to the Gulf of Mexico and on selected polluted and unpolluted oyster reefs. 2) To perfect technique for collecting comparable samples. 3) To complete bacterial analyses of collected samples. 4) To compare the bacterial flora from polluted and unpolluted areas of Mississippi Sound and adjacent waters, especially as it relates to sewage polluted oyster beds.

Procedures: 1) Field - (a) Surface, mid-water and bottom samples will be collected at established stations where there is sufficient depth of water. Additional samples will be collected as necessary. (b) Techniques to insure the collection of samples under sterile conditions will be established. (c) Temperature and salinity will be determined at all stations. (d) Collected samples will be refrigerated and returned to the laboratory for analysis. 2) Laboratory - (a) The Most Probable Number of coliform organisms and of Escherichia coli of presumptive human fecal origin will be determined by competent bacteriologists. (b) Additional studies will be carried out where feasible.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.
Mississippi State Government

5.0620, NUTRIENT ASSIMILATION RATES - FIELD STUDIES

W. ABBOTT, Gulf Coast Research Laboratory, *Ocean Springs, Mississippi*

A series of estuarine ponds have been formed by capturing a bayou channel between levees. The ponds are utilized for factorial experimentation on effects of various nutrients in multiple dose combinations.

Phosphorus studies have shown that the ultimate fate of an added tracer spike is conditioned by the recent fertilization history of the pond. Ability of the whole pond ecosystem to function as a sort of 'phosphorus buffer' is indicated by the results.

Repetition of phosphorus studies and studies on the nitrogen cycle are planned for the near future.

5. WATER QUALITY MANAGEMENT AND PROTECTION

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0621, STUDIES ON INORGANIC NUTRIENT ASSIMILATION RATES IN ESTUARINE PONDS

W. ABBOTT, Gulf Coast Research Laboratory, *Ocean Springs, Mississippi*

The captioned research grant has provided funds for construction of 18 estuarine ponds. These ponds are being utilized for field scale testing of hypotheses developed during a series of microcosm studies (Abbott, J. Water Poll. Control Fed., 38:258-270 (1966); 39: 113-122 (1967).

Studies are oriented toward evaluation of phosphorus and nitrogen turnover rates, kinetics of uptake of these elements, and validity of their roles as limiting nutrients in hyperfertilized estuarine situations.

SUPPORTED BY Rockefeller Foundation

5.0622, DEVELOPMENT OF STRUCTURAL MEASURES FOR SEDIMENT CONTROL AND FOR STREAM CHANNEL STABILIZATION IN THE SOUTHERN BRANCH

D.A. PARSONS, U.S. Dept. of Agriculture, *Oxford, Mississippi*

Object: To develop criteria for water training, grade control, and sediment deposition and/or removal structures to protect bed and banks and to maintain water conveyance capacity of natural and constructed channels of agricultural watersheds.

Plan of Work: Field locations are selected where stabilization measures are already in place and where these measures are to be installed. In the existing stabilized areas data are collected and compiled to establish reasons for success or failure. Where such measures are to be installed, data are acquired on the channel hydraulic conditions and geometry, and effectiveness periodically checked. Information is obtained on boundary velocity and shear stress reductions with various spacings, angles, densities, and alignments of the protective measures. Other measures are placed to withstand direct forces of flowing water.

SUPPORTED BY U.S. Dept. of Agriculture

5.0623, THE DECOMPOSITION OF PETROLEUM PRODUCTS IN OUR NATURAL WATERS

L.R. BROWN, Mississippi St. University, Graduate School, *State College, Mississippi* 39762

The anaerobic decomposition of crude and refined petroleum products in marine, brackish, and/or aquatic environments may be highly detrimental to the biological life of the area. Such occurrences can arise from the treatment of soil 'slicks' with precipitants or the discharge of hydrocarbons adsorbed onto particulate matter.

The specific aims of the present proposal are (1) to investigate the anaerobic decomposition of crude and refined petroleum products in terms of hydrocarbon removal and the production of water-soluble organic materials, (2) to generate sufficient data to be able to project what changes can be expected in a given water depending upon the volume of product being decomposed, (3) to determine if the process can be expedited by the addition of some essential nutrients such as phosphate and nitrate, and (4) to determine whether the addition of other compounds to neutralize the products resulting from the anerobic decomposition of hydrocarbons might be of value.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Mississippi State University

5.0624, PESTICIDE RESISTANT FISH IN NATURAL ECOSYSTEMS

D.E. FERGUSON, Mississippi St. University, Graduate School, *State College, Mississippi* 39762

The applicant and his students first reported pesticide resistance in natural populations of fish in 1963. Since that time, our studies have concerned the extent and nature of resistance in vertebrates, and little effort has been directed to an assessment of the significance and potential of resistance to natural ecosystems. Recent findings indicate that the ecological impact of resistant populations of fish may be so great and macabre as to stagger the imagination. For example, large numbers of highly resistant mosquitofish are able to survive as 10-day exposure to 2000 ppb endrin. If a medium-sized predaceous fish eats just one of these survivors, death ensues in about 6 hours. We suspect that the same would be true of an egret, snake, turtle or any other predator. What about man?

In a paper now in press, we show that a single resistant fish exposed to 1000 ppb endrin will release sufficient toxicant into 10 liters of tapwater to kill 5 susceptible fish in 38.5 hours.

How much pesticide are resistant fish able to tolerate? How much do they actually contain in heavily contaminated areas? What predators eat them? What is the consequence? Are humans eating them? These are some questions we hope to answer, and it is a matter of urgency that they be answered quickly! Our objectives are to attempt to assess the actual and potential significance of the presence of resistant fishes in natural ecosystems.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0625, WATER TEMPERATURE EFFECTS ON BED FORMS

J.J. FRANCO, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The purpose of the investigation is to determine the effects of changes in water temperatures on sediment transport, streambed forms, and bed roughness of various types of bed materials found in natural rivers and materials used in movable-bed models. Tests will be conducted with fine, medium, and coarse sand and crushed coal at different water temperatures, ranging from a winter minimum of 40 degrees F to a summer maximum of 80 degrees F and three rates of introduction of bed material for each temperature. Each test will be run to the point of stability where input and extrusion of sand are equal. The overall program can be divided into testing of fine sand, testing of crushed coasl, testing of medium sand, and testing of coarse sand.

SUPPORTED BY U.S. Dept. of Defense - Army

5.0626, NEUTRALIZATION OF ACID STRIP-MINE LAKES

J.R. WHITLEY, State Div. of Fisheries, *Columbia, Missouri*

Objectives: To determine the feasibility of converting acid strip-mine lakes to fish producing lakes by rapid neutralization with calcium hydroxide.

Procedures: A small acid lake will be treated with sufficient calcium hydroxide to raise the pH to 7.5. Agricultural ground limestone will be applied to the acid-producing portion of the watershed to neutralize additional sulphuric acid as it forms.0 Monthly measurements will be made of pH, acidity, alkalinity, specific conductance and turbidity. The lake will be stocked with fish immediately after neutralization.

The cost of treatment will be calculated to determine if this would be a practical method of raising the pH of acid strip-mine lakes to a level which will sustain a normal fish population.

Justification: The water in many coal strip pit lakes is too acid to support a normal aquatic fauna. Significant amounts of sulphuric acid may be formed when sulphur-bearing material on the bottom of the new strip pits is oxidized during the early stages of filling with water. The amount of acid formed during this early stage is often sufficient to acidify the entire body of water. Once the coal vein and associated sulfur containing formations are covered with water, much smaller amounts of acid are formed. If the spoil banks and other parts of the watershed do not contain acid-forming materials, the lake may be neutralized by calcium carbonate leached from the watershed. The time required for neutralization by this process varies greatly, depending on the initial amounts of acid formed and on the composition of the spoil banks. Several years often are required before a strip-mine lake is capable of supporting a significant amount of aquatic life.

Neutralization of moderately acid strip-mine lakes with calcium hydroxide should permit early use of these pits for fish production. Spreading agricultural lime over localized acid-producing areas in the spoil should assist in maintaining the lakes in an alkaline condition.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Missouri State Government

5.0627, BIOCHEMISTRY OF FISH SEMEN

D.D. CRUEA, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

The objective of the study is to evaluate the biochemistry of fish semen to detect effects of pesticides.

A biochemical screening of seminal plasma, sperm cells, and the tails of the sperm from cutthroat trout and other fishes will be performed to establish biochemical criteria useful as indices of fertilizing capacity. The study will cover presence of free amino acids, various cations, glycolyzable substrates, adenylic acids, and nucleic acids. Semen from fish exposed to endrin will be compared with that from untreated fish.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0628, COMPARATIVE UPTAKE OF 10 CHLORINATED HYDROCARBON PESTICIDES BY FISH

R.D. EARNEST, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

The purpose of this work is to compare uptake of 10 chlorinated hydrocarbon pesticides of fish. Fish are held in like concentrations of each pesticide and sampled as scheduled. Samples are measured for pesticide residue at Columbia.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0629, SERUM ANALYSIS OF CUTTHROAT TROUT EXPOSED CHRONICALLY TO METHOXYCHLOR PESTICIDE EFFECTS ON FISH ENDOCRINE FUNCTIONS

F.B. GRANT, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

The serum of cutthroat trout will be studied during extended bath and feed treatments carried out at Jackson, Wyoming. The parameters to be measured are: Na, K, Ca, Mg, Cl, HCO3 (equilibrated with 5% CO2), NPN, urea, uric acid, creatinine, creatine, amino acids, cholesterol, total protein, and osmolality.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0630, THE CONSTITUENTS AND PHYSICO-CHEMICAL PROPERTIES OF SERUM FROM GOLD-FISH EXPOSED CHRONICALLY TO MALATHION AND ENDRIN

F.B. GRANT, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

The serum of goldfish receiving different treatments with malathion or endrin will be studied in detail. These insecticides will be administered over a broad concentration range in their food over a period of several months. The fish will be held in flowing water (18 plus or minus 2 degree C) and fed daily on a balanced diet at the rate of 3% of the body weight per week in dry weight of food. The serum parameters to be estimated are Na, K, Ca, Mg, Cl, HCO3, PO4, NPN, urea, uric acid, creatinine, creatine, amino acids, glucose, cholesterol, phospholipids, total proteins, lipoprotein, glycoprotein, esterases, LDH isozymes, catechol amines, adrenocorticoids, sex steroids, pH, and osmolality.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0631, THYROID FUNCTION OF GOLDFISH AND RAINBOW TROUT EXPOSED CHRONICALLY TO MALATHION AND ENDRIN - PESTICIDE EFFECTS ON FISH ENDOCRINE FUNCTIONS

F.B. GRANT, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

Thyroid activity will be studied in goldfish and rainbow trout receiving chronic exposures to malathion and endrin. Thyroid activity will be assessed by radioiodine uptake, radiothyroxine production (butanol extractable iodine), and mean thyroid cell heights. Serum iodine (I127) will be determined for collateral information on iodine metabolism. Hypophysectomized and intact fish receiving exogenous thyrotropin will be studied similarly to detect a possible mode of action of the pesticide.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0632, BLOOD OXYGEN AND CO2 CARRYING CAPACITY OF 4 FISH EXPOSED TO MALATHION AND ENDRIN - PESTICIDE EFFECTS ON FISH ENDOCRINE FUNCTIONS

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The influence of selected carbamates, organophosphates, and chlorinated hydrocarbon pesticides on the in vitro oxygen and carbon dioxide loading capacity of erythrocytes will be studied. Pilot studies will be carried out using carbaryl, malathion, and endrin on erythrocyte suspensions from carp, tilapia and rainbow trout. The conditions for optimal incubation will be determined for each species prior to treatment with these toxicants.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0633, EFFECTS OF MALATHION ON THE SEXUAL DEVELOPMENT OF MALE RAINBOW TROUT - PESTICIDE EFFECTS ON FISH ENDOCRINE FUNCTIONS

F.B. GRANT, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

Hypophysectomized trout will be allowed to regress completely and then will be treated with gonadotropin to stimulate gonad development. The fish will be exposed to different levels of malathion during the gonadotropin treatment. The rate and extent of development will be studied. Observations on thyroid activity and serum composition will be made.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0634, EFFECTS OF ENDRIN & MALATHION ON GONADAL HYDRATION RESPONSE OF MALE GOLDFISH & RAINBOW TROUT. PESTICIDE EFFECTS ON FISH ENDOCRINE FUNCTION

F.B. GRANT, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

Prespawning, goldfish, and rainbow trout will be exposed to various levels of malathion and endrin prior to inducing the seminal thinning response in intact animals. The hydration response will be elicited by exogenouus gonadotropin. The effects of these pesticides on this 24-hour hydration response will be studied.

The physico-chemical properties of the sperm cell carrier and urine will be studied.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0635, LITERATURE SEARCH FOR POSSIBLE PESTICIDE DETOXIFYING AGENTS - CHEMICAL AND PHYSICAL STUDIES ON REDUCTION OF PESTICIDE HAZARDS

R.J. HESSELBERG, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

A literature search will be made in an effort to determine the known detoxifying agents which show some promise in reducing toxicity. At the same time, a search will be made for possible methods of screening chemicals for their detoxifying effect.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0636, SCREENING FOR PESTICIDE DETOXIFICATION AGENTS - CHEMICAL AND PHYSICAL STUDIES ON REDUCTION OF PESTICIDE HAZARDS

R.J. HESSELBERG, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

Chemicals will be screened for possible detoxifying agents for DDT and aldrin/dieldrin. Laboratory chemical tests would be run on GLC and by bioassay methods. Chemicals which show promise will be further tested in some type of an expanded program.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0637, COMPARISON OF METHODS USED TO MEASURE ESTERASE ACTIVITY. INTERACTIONS BETWEEN PESTICIDE ON FISH ENZYME SYSTEMS

J.W. HOGAN, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

This work unit will attempt to correlate results of esterase activity measurements obtained by two colorimetric methods and by a manometric method. Brain tissue from three species of fish, cutthroat trout (Salmo clarki Richardson), bluegill sunfish (Lepomis macrochirus Rafinesque), and channel catfish (Ictalurus punctatus Walbaum) will be analyzed for acetylcholinesterase levels. The entire brain will be removed from the fish, homogenized in deionized water, divided into aliquots, and diluted with the appropriate buffer. At least triplicate samples of each homogenate will be analyzed by all methods. Also, effects of storage by freezing will be studied. In vitro inhibition will be determined. Samples of homogenate will be incubated with various anticholinesterase agents and the resultant decrease in acetylcholinesterase activity will be measured. Brains removed from fish which have been exposed to various anticholinesterase agents will be analyzed to correlate in vivo inhibition. All results will be analyzed statistically to determine if there are any significant differences.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0638, SEASONAL CHANGES IN ESTERASE ACTIVITY IN FISH AND INVERTEBRATES. INTERACTIONS BETWEEN PESTICIDES ON FISH ENZYME SYSTEMS

J.W. HOGAN, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

Samples of adult bluegill and at least one species of aquatic invertebrate will be collected at monthly intervals and assayed for acetylcholinesterase activity. The initial study will continue for at least one year. If statistically significant changes in esterase activity are found to be correlated with sampling date the study will be extended for a second year and may be expanded to include additional species.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0639, SCREENING AQUATIC INVERTEBRATES TO DETECT AN ORGANISM SUITABLE FOR USE IN A MONITORING PROGRAM

J.W. HOGAN, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

Various aquatic invertebrates will be screened in an attempt to find one or more organisms which can be used to monitor for the presence of anticholinesterase agents. Ideally, such an organism should exhibit a reaction to levels of anticholinesterase agents which are not toxic to fish. Should such an organism be found, it could then be used to detect the presence of anticholinesterase agents beofre they can reach levels which are harmful to other members of the aquatic ecosystem. Initially, various invertebrates will be selected on the basis of availability and sensitivity to various anticholinesterase agents as indicated by bioassay test results. Dependent upon initial results, the enzyme system will be characterized in regard to optimum substrate, optimum substrate levels, both in vitro and in vivo reaction to various anticholinesterase agents, sex, date of sampling, etc. After a number of organisms have been screened, one or two of the more promising will be selected for use in an actual monitoring program in the field.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0640, CHARACTERIZATION AND COMPARISON OF ESTERASE(S) PRESENT IN THE HEADS OF THE IMMATURE FORM OF TWO SPECIES OF DAMSELFY

J.W. HOGAN, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

To characterize and compare the esterases(s) present in the heads of the immature form of two species of damselfly (Ishnura verticalis Say and Lestes congener Hagen). Initial experiments will be designed to determine a practical homogenization technique which will produce an active enzyme preparation. Enzyme characterization will proceed immediately after the optimal enzyme preparative technique is determined. The manometric assay procedure will be used. Characterization will include establishment of assay conditions such as optimum substrate and optimum substrate concentration. In addition, the effects of various selective inhibitors will be studied. In vitro inhibition of cholinesterase will be determined by incubating enzyme preparations with various concentrations of anticholinesterase agents.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0641, ROLE OF ENTERIC MICROORGANISMS IN DETOXIFICATION - INTERACTION BETWEEN MICROORGANISMS AND PESTICIDES

B.T. JOHNSON, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

The purpose of this study is to investigate the role of enteric microorganisms endogenous to fresh-water fish in detoxification of insecticides.

Members of the microflora will be isolated in pure culture, identified, grown in enriched media and inoculated with various pesticides. Data will be gathered to ascertain the role these organisms play in the biodegradation and abolition of insecticide in fish.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0642, INFLUENCE OF PROTOZOAN ACTIVITY ON HALOGENATED HYDROCARBON RESIDUES - INTERACTION BETWEEN MICROORGANISMS AND PESTICIDES

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Axenic cultures of a broad spectrum of free living fresh-water protozoans will be studied in vitro with selected insecticides.

The parameters of this investigation will be as follows: 1. Effects on protozoan population of the insecticide. 2. Ability of the organism to utilize the pesticide as a sole carbon source. 3. Role of protozoans in degradation of halogenated hydrocarbon pesticides. 4. Study possible use of protozoans as bio-indicators of low concentrations of pesticides.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0643, EFFECTS OF PESTICIDES ON PROTEIN, CARBOHYDRATE, AND NUCLEIC ACID METABOLISM. INTERACTION BETWEEN MICROORGANISMS AND PESTICIDES

B.T. JOHNSON, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

Preliminary investigations will be initiated utilizing a selected group of yeast, bacteria and protozoa to ascertain the influence pesticides play in basic respiration and synthesis. Fundamental work will involve development of suitable radio-respirometry and disc electrophoresis technique.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0644, BIOTRANSFORMATION OF ALDRIN AND DIELDRIN BY BACTERIA - INTERACTION BETWEEN MICROORGANISMS AND PESTICIDES

B.T. JOHNSON, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

Pure culture of bacterial species commonly inhabiting soil, water and fresh-water fish will be investigated to determine the role they perform in the metabolism of aldrin and dieldrin. Variables of pH, temperature, oxygen tension, etc., will be investigated. Analysis and identification of metabolites will be done utilizing gas chromatography, infrared spectroscopy, and C-14 tracers.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0645, BIOTRANSFORMATION OF HEPTACHLOR BY BACTERIA - INTERACTION BETWEEN MICROORGANISMS AND PESTICIDES
B.T. JOHNSON, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

Pure cultures of bacterial species commonly inhabiting soil, water and fresh-water fish will be investigated to determine the role they perform in the metabolism of heptachlor. Variables of pH, temperature, oxygen-tension, etc., will be investigated. Analysis and identification of metabolites will be done utilizing gas chromatography and infrared spectroscopy.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0646, CHRONIC EFFECTS OF MALATHION ON BLUEGILLS
H. KENNEDY, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

The purpose of the work is to measure chronic effects from the exposure of bluegills and channel catfish to malathion at Columbia, Missouri. The fish are exposed to single and multiple sets of treatments in ponds, at three concentrations. Samples are withdrawn at intervals, and fish are examined for histopathology, cholinesterase inhibition, and blood chemistry, and the populations monitored for growth, mortality, presence of disease, reproduction characteristics, and quality of offspring. Comparisons among lots are made to assess effects of malathion.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0647, CHRONIC EFFECTS OF METHOXYCHLOR ON BLUEGILLS AT COLUMBIA, MISSOURI
H. KENNEDY, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

The objective of the work is to measure chronic effects resulting from the exposure of bluegills to methoxychlor in ponds at Columbia, Missouri. The fish are exposed to various levels of methoxychlor in 1/10-acre earthen ponds, and samples of fish are collected at intervals for residue analysis, histopathological studies, growth measurements, and measurements on reproduction and quality and quantity of offspring. Comparisons among groups of fish are made on these factors. Residues of methoxychlor are made in pond waters, bottom sediments, and aquatic vegetation for information on rate of breakdown of the insecticide and on the quantity and quality of the breakdown products.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0648, CHRONIC EFFECTS OF METYHL PARATHION AND ENDRIN ON CHANNEL CATFISH AND GOLDFISH IN PONDS. PESTICIDE-INDUCED CHANGES IN POND ECOLOGY
H.D. KENNEDY, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

Objective: To assess the chronic effects of a multiple exposure contact treatment, utilizing methyl parathion and endrin (introduced alone and in combination), on two species of warm-water fish in 12 one-quarter acre and eight one-tenth acre ponds.

Nine one-quarter acre ponds will receive two treatments (May 20 and August 19) of the combined pesticides in three replicates of three concentrations. High treatment - methyl parathion 200 ppb, and endrin .04 ppb. Medium treatment - methyl parathion 40 ppb, and endrin .008 ppb. Low treatment - methyl parathion 20 ppb, and endrin .004 ppb. Three additional ponds will serve as controls. The one-tenth acre ponds will also receive two treatments (June 6 and September 5). Two ponds will be treated with methyl parathion at a concentration of 200 ppb, two with endrin at .07 ppb., and two will receive the combination treatment of the same levels as those of the medium treatment of the one-quarter acre ponds. Two additional ponds will serve as controls.

Samples of fish will be taken at 1, 3, 7, 14, 28, 56, and 84 days after each treatment for chemical residue analysis, stomach samples, and for histopathological examination. Measurement of fish growth, survival, and reproduction will be made. Blood samples will be taken for hematocrit and grams percent protein levels. Effects of these pesticides on other components of the pond ecosystem; aquatic invertebrates, plankton, vegetation, mud and water for residue analysis, and water quality will also be measured.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0649, ACUTE TOXICITY OF PESTICIDES TO FRESHWATER FISH AND OTHER VERTEBRATES
K.J. MACEK, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

The objective of this work is to determine whether the uptake and activity (consequently the toxicity) of various insecticides differs among eggs, fry, various sizes of immature fish, and various sizes of mature fish. Representatives of the salmonids, centrarchids, and other families will be studied. The work will involve exposing the various life stages to the insecticides and determining relative toxicity indices.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0650, EFFECTS OF CHRONIC EXPOSURE TO METHOXYCHLOR ON THE GROWTH AND REPRODUCTION OF GUPPIES - CHRONIC TOXICITY OF PESTICIDES TO FISH
K.J. MACEK, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

Mature guppies will be exposed to methoxychlor in either bath or feed for at least 112 days. The effects of methoxychlor on growth, brood frequency, brood size, viability of offspring, and sensitivity of offspring to methoxychlor, will be determined. Aquaria will be set up with 40 females and 20 males initially. Samples will be removed periodically for residue analyses and histological examination.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0651, ACUTE TOXICITY OF PESTICIDES TO FRESHWATER FISH AND OTHER VERTEBRATES
K.J. MACEK, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

A stamina tunnel will be installed, techniques for its use will be developed, and studies to determine the best methods for utilizing this facility in evaluating the effects of pesticides on fish will be completed.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0652, ACUTE TOXICITY OF PESTICIDES TO FRESHWATER FISH AND OTHER VERTEBRATES
K.J. MACEK, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

The objective of the work is to determine relative acute toxicity indices of a variety of pesticides, and combinations of pesticides, tested against several species of fish, under both static and continuous flow conditions of exposure. The work will involve determining TL 50 values for various periods of exposure under standard conditions of temperature and water quality.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0653, RELATIVE SUSCEPTIBILITIES OF FISH FAMILIES TO INSECTICIDES - ACUTE TOXICITY OF PESTICIDES TO FRESHWATER FISH AND OTHER VERTEBRATES
K.J. MACEK, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

The objective of the work is to establish a hierarchy, in terms of relative susceptibility to insecticides, for the families Salmonidae, Centrarchidae, Cyprinidae, Ictaluridae, and Percidae. Standard bioassay methods, under both static and continuous flow conditions, will be used to determine 24- and 96-hour TL50 values as indices of the susceptibility of the various taxonomic groups to representative organochlorine, organophosphate, and carbamate insecticides.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0654, EFFECTS OF CHRONIC EXPOSURE TO SUBLETHAL LEVELS OF INSECTICIDES ON REPRODUCTION IN BROOK TROUT. CHRONIC TOXICITY OF PESTICIDES TO FISH

K.J. MACEK, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

The objectives of the work are to determine the nature and extent of the effects of chronic exposure of brook trout to sublethal levels of an organochlorine, an organophosphate, and a carbamate insecticide on gametogenesis, potency of the gametes, viability of the offspring, and susceptibility of early developmental stages to exposure to the same or other insecticides. Brook trout will be exposed to insecticides for 9-12 months prior to spawning. During the last three months samples of the gonads will be prepared for histological examination of the gametogenic processes. The volume, viability, and potency of the gametes will be determined. Developing offspring will be exposed to the insecticides at various developmental stages, and for varying periods of time, and mortality will be measured.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0655, INVESTIGATION OF STRESS-INDUCED MOBILIZATION OF INSECTICIDE RESIDUES - CHRONIC TOXICITY OF PESTICIDES TO FISH

K.J. MACEK, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

The objectives of the work are to determine if mobilization of insecticide residues, similar to that reported for higher vertebrates, does occur in fish during periods of stress, what the effects of such mobilization are, and what organs are involved in producing such effects. The work will involve feeding DDT and dieldrin to fingerling chinook salmon for approximately 200 days. After the exposure period, the fish will be subjected to several combinations of degrees of starvation and temperature fluctuations. Residue concentrations will be measured in whole fish and various organs and tissues to determine amounts accumulated and metabolized during exposure, as well as the activity of such residues during stress.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0656, THE INFLUENCES OF ENVIRONMENTAL CONDITIONS ON THE TOXICITY OF PESTICIDES

K.J. MACEK, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

The objective of the work is to investigate the effects of variations in bioassay conditions on the toxicity of pesticides to fish. Controlled variation of temperature, water quality, mass-volume relationships, and other factors will provide information concerning the influence of such factors on fish-pesticide relationships.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0657, INTERACTION OF ENDRIN AND PROLACTING-INDUCED FAT SYNTHESIS IN THE PLAINS KILLIFISH - PESTICIDE EFFECTS ON FISH ENDOCRINE FUNCTIONS

P. MEHRLE, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

Purified mammalion preparations of prolactin have been shown to stimulate the synthesis of total body fat in various species of vertebrates, including the golden top-minnow, if injected near the midlight interval of the diurnal cycle, and cause loss of total fat if injected shortly after the beginning of the light interval. This hypothesis will be tested first on another species of fish and, if proven true, the observations will be extended toward elucidating specific body lipids that may show preferential increases over others, whether selective lipid synthesis will be altered by the presence of endrin, and whether certain lipid increases will affect endrin stores in the body.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0658, MINERAL IMBALANCE IN BLUEGILLS EXPOSED TO MALATHION PESTICIDE-INDUCED MINERAL IMBALANCE IN FISH

E.T. OBORN, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

For acute concentrations of malathion - Sexed bluegills would be exposed to acute or near acute concentrations of malathion in either/or both bath water or from capsule ingestion. Sample harvest would follow 24 hours later.

For chronic concentrations of malathion - Sexed bluegills would be exposed to chronic concentrations of malathion for 30 days in either bath water and/or in the feed. Sample harvest would follow the 30-day exposure.

After both acute and chronic exposures to malathion, brain and blood would be incubated and measured for acetylcholine hydrolysis. Additional procedures followed and methods used would be in accordance with standard colorimetric analysis. Blood smears would be taken and blood coagulation time and hematocrit percent would be measured. After dissecting and proper processing, the tissues would be examined for iron, manganese, copper, zinc, phosphorus, calcium, and magnesium content.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0659, 2,4-D UPTAKE AND METABOLISM - METABOLISM OF PESTICIDES IN FISH

C.A. RODGERS, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

Rainbow trout, channel catfish, and goldfish will be exposed to 0.1 and 1.0 ppm of 2,4-D butoxyethanolester under laboratory conditions. Carbon 14 labeled 2,4-D will be used as a tracer to determine the areas of storage of the herbicide. Two to four gram fish will be used for the test program and the following organs will be analyzed for 2,4-D: head, liver, kidney, and muscle. Blood will also be analyzed. In addition to individual parts, an autoradiograph of the whole body will be made.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0660, DDT AND DIELDRIN METABOLISM AND STORAGE BY CHINOOK SALMON UNDER LABORATORY CONDITIONS

C.A. RODGERS, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

This work will be a preliminary investigation involving DDT and dieldrin. Various organs and tissues of the fish will be analyzed for storage, buildup, and metabolism of the pesticides. This study will involve only the following organs: brain, heart, liver, kidney, blood, storage fat, lateral line muscle, body muscle, gill, stomach and hind gut. This study may indicate if it will be meaningful to select only a few primary target organs or tissues for future work with chlorinated hydrocarbons.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0661, LITERATURE SURVEY OF PESTICIDE METABOLISM IN FISH - METABOLISM OF PESTICIDES IN FISH

C.A. RODGERS, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

Survey all available material relating to pesticide metabolism in fish. With his survey as a guideline, a better test program can be initiated and carried out with a limited repetition of reliable work.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0662, ACUTE TOXICITY OF PESTICIDES TO FRESH-WATER INVERTEBRATES

H. SANDERS, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

The objective of the work is to obtain preliminary acute toxicity measurements for several pesticides and several species of aquatic invertebrates at Columbia, Missouri, during Fiscal Year 1969. Invertebrates and pesticides are tested in static bioassay systems in the laboratory. The work will involve determinations of LC50 values at 24, 48, and 96 hours under static conditions involving control of animal age, water temperatures, and water chemistry.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0663, INFLUENCE OF SALINITY AND TEMPERATURE ON TOXICITY OF SOME PESTICIDES TO BRINE SHRIMP

H. SANDERS, U.S. Dept. of Interior, Fish Pesticide Res. Lab., *Columbia, Missouri* 65201

The objective of the work is to obtain preliminary acute toxicity measurements for several pesticides to brine shrimp, Artemia. Temperature and salinites will then be varied to measure effects. Preliminary bioassays will be conducted at 70 degrees F. The work will involve determination of LC50 values at 24, 48, and 96 hours under conditions involving control of water temperatures and water salinity.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0664, MEASUREMENT OF THE EFFECTS OF PESTICIDES ON INVERTEBRATE RESPIRATION - ACUTE TOXICITY OF PESTICIDES TO FRESHWATER INVERTEBRATES

H. SANDERS, U.S. Dept. of Interior, Fish Pesticide Res. Lab., *Columbia, Missouri* 65201

Invertebrates will be exposed to varying concentrations of a number of pesticides for limited time periods. Effects on respiration will be measured by using the manometric technique. Oxygen uptake and/or carbon dioxide liberation will be determined with Warburg apparatus and macro-vessels. If respiration is affected the rate and magnitude of any effects will be measured. Pesticides will be selected from all groups, i.e., chlorinated hydrocarbons, organophosphates, carbamates, etc.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0665, CONTINUOUS-FLOW INVERTEBRATE BIOASSAYS AND PESTICIDES AT COLUMBIA, MO. - ACUTE TOXICITY OF PESTICIDES TO FRESHWATER INVERTEBRATES

H. SANDERS, U.S. Dept. of Interior, Fish Pesticide Res. Lab., *Columbia, Missouri* 65201

The objective of the work is to obtain acute toxicity information on aquatic invertebrates with insecticides, herbicides, and other pesticides at Columbia, Missouri. Invertebrates and toxicants will be tested in continuous-flow systems in the laboratory according to a standard test method, and the data will be treated by probit analysis to obtain LC50 values under various time schedules.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0666, METHOXYCHLOR-CAUSED EFFECTS ON CUTTHROAT TROUT PHYSIOLOGY CHRONIC TOXICITY OF INSECTICIDES TO COLD-WATER FISH

D. SWEDBERG, U.S. Dept. of Interior, Fish Pesticide Res. Lab., *Columbia, Missouri* 65201

The purpose of the work is to measure chronic effects from the exposure of cutthroat trout to methoxychlor at Jackson, Wyoming. Fish will be divided into lots and sub-lots and held in pens in hatchery raceways. Some groups will be given no methoxychlor, some given methoxychlor in feed at two levels, and some given methoxychlor baths at two levels. Samples will be taken according to a pre-arranged schedule, and fish will be examined and measured for growth, pathology, incidence of disease, blood chemistry, insecticide residues, mortality, reproduction, and quality of offspring. Comparisons among lots will be made to assess effects of methoxychlor.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0667, EFFECTS OF MALATHION ON LEARNING AND RETENTION IN THE GOLDFISH

D.F. WOODWARD, U.S. Dept. of Interior, Fish Pesticide Res. Lab., *Columbia, Missouri* 65201

The present study will be conducted in order to evaluate the effects of sub-lethal levels of malathion on learning and retention in the common goldfish. By using alternate light and shock, the fish will be trained to avoid light by moving over a barrier into the darkened end of the test chamber. Control and malathion treated fish will be evaluated by their ability to learn the avoidance response and their ability to retain the avoidance response on reconditioning after exposure to malathion.

Since organic phosphorus insecticides exert their action by acetylcholinesterase inhibition, one would expect an exposure to malathion to have a destructive effect on the nervous system. If this is the case, there may be a modification in the ability of a fish to learn or retain a certain response pattern.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0668, EFFECTS OF HEATED WATER, ACID MINE DRAINAGE & ALKALINE ASH DRAINAGE ON WATER QUALITY & RESERVOIR COMMUNITY METABOLISM (ABBREV)

R.S. CAMPBELL, Univ. of Missouri, Water Resources Research Ctr., *Columbia, Missouri* 65202

A 1500 acre reservoir, constructed to provide cooling water for steam generation of electricity, receives a constant inflow of heated water. Acid drainage from strip mines, and from bottom ash piles containing sulfides, and alkaline drainage from fly ash (CaO) also enter the lake. Alkaline inflow has caused occasional fish kills. The purpose of this investigation is to evaluate the influence of these effluents on the water quality and on the autotrophic aspects of community metabolism.

Water quality evaluation will be based on routine monthly measurements of dissolved substances and on detailed seasonal determinations by the University Spectrographic Laboratory. Special attention will be given to the influence of heated water on dissolved gases and on the pattern of stratification.

The study will stress qualitative and quantitative measurement of net plankton and of bottom fauna and their relation to pollution. Measurements of primary production will be by carbon-14 fixation. We expect to establish through measurement of this fundamental process, whether community processes are significantly altered by acid, alkali and heat input.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Missouri
Missouri State Government

5.0669, RECOVERY FROM ACID POLLUTION IN FOUR STRIP-MINE LAKES

R.S. CAMPBELL, Univ. of Missouri, Graduate School, *Columbia, Missouri* 65202

The purpose of this research is to determine the successional changes in strip-mine lakes during recovery from acid pollution. This series of lakes created by strip-mining in 1919-21 show widely divergent biological and chemical characteristics which are related to differences in acidity ranging from pH 3.0 to pH 8.6. Total acidity ranges from 5090 to 98 mg/liter CaCO3.

These lakes were first investigated in 1940-41 and again in 1949- 50. The present study dates from 1960. Successional changes are therefore documented within individual lakes and inferred from lake to lake as the acid climate is slowly altered.

In addition to seasonal physical, chemical and biological investigations, special effort is directed toward: (1) Evaluation of chemical stratification, and of the iron (Fe II - Fe III) complex; and (2) Measurement of water quality, of comparative primary and secondary production, of community metabolism and of energy flow.

5. WATER QUALITY MANAGEMENT AND PROTECTION

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0670, ISOTOPES IN THE BIOSPHERE

E.R. GRAHAM, Univ. of Missouri, Agricultural Experiment Sta., *Columbia, Missouri* 65202

To study the movement of rain-out Sr90 from surface soil to impounded water systems.

DESCRIPTION OF WORK: Runoff and erosion experiments of plots contaminated with fission product radioactive nuclides will be continued. It is planned to use I131 and Ce144 in addition to Sr85 on the plots next year. The plots under study will be continuous bluegrass, corn stover, and wheat stubble. The collected runoff water and soil removed by erosion will be assayed as previously. Some preliminary studies on the effect of nitrogen fertilizers on growth rate of forages and the accompanying effect on the uptake of fission product ratio-nuclides will be undertaken. These will be greenhouse experiments with small grains and legumes.

SUPPORTED BY U.S. Dept. of Agriculture
Missouri State Government

5.0671, SPECTROPHOTOMETRIC AND FLUOROMETRIC DETERMINATION OF SELECTED ANION WATER CONTAMINANTS

J.C. GUYON, Univ. of Missouri, Water Resources Research Ctr., *Columbia, Missouri* 65202

A study is proposed to develop sensitive and selective spectro- photometric and fluorometric methods for the determination of selected anions. The systems to be studied initially are: a) development of spectrophotometric methods for the nitrate ion and b) development of fluorometric methods for the fluoride ion.

The research will center upon the development of simple, practical, and useful analytical methods that may be directly applied to aqueous systems.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Missouri

5.0672, SPECTROPHOTOMETRIC AND FLUOROMETRIC DETERMINATION OF SELECTED ANION WATER CONTAMINANTS

J.C. GUYON, Univ. of Missouri, Graduate School, *Columbia, Missouri* 65202

Analysis for specific anion contaminants in aqueous system is one of the most difficult analytical problems in present-day water resources determination and control. Their Research purpose to develop selective and sensitive methods for the determination of selected anion. The methods would be directly applicable to all aqueous systems, and especially for the determination of amounts and types of anion contaminants as they exist in naturally occurring water samples.

Spectrophotometric Investigations: a) Develop methods for traces of Carbonate ion b) Time permitting, develop methods for thiocyanate ion and cyanide ion

Fluorometric Investigations: a) Develop method for traces of iodide ion b) Develop method for traces of phosphate ion

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Missouri

5.0673, EFFECTS OF AUDIO VIBRATIONS ON AERATED BIOLOGICAL SYSTEMS

L. HEMPHILL, Univ. of Missouri, School of Engineering, *Columbia, Missouri* 65202

The objective of this study is to ascertain effects of acoustical vibrations on individual components of an aerated biologically active system such as might be found in an activated sludge plant. This work, performed on a laboratory scale, will determine effects of audio vibrations (a) on oxygen transfer rates from air bubbles in aqueous solution, (b) on individual bacterial cells suspended in aqueous solutions, and (c) on activity and strength of activated sludge floc particles.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Missouri

5.0674, DYNAMIC SEPARATION OF SUSPENDED SOLIDS

A.T. HJELMFELT, Univ. of Missouri, School of Engineering, *Columbia, Missouri* 65202

The separation gained by flowing a sediment bearing fluid through a nozzle is being evaluated to determine the utility of the system for separation of suspended solids.

An experimental study of the concentration distribution in the throat of the nozzle are used to determine the power required to achieve various levels of separation.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Missouri

5.0675, THE ECOLOGY OF STREAM BIOTA IN WASTE ASSIMILATION

D.L. KING, Univ. of Missouri, Water Resources Research Ctr., *Columbia, Missouri* 65202

This study represents an attempt to evaluate a technique which can be used to determine the biodegradability of complex organic wastes and to ascertain the role of each portion of a simple three compartment aquatic community in stream self-purification. This community consists of reducers, represented by bacteria and protozoa; producers, represented by periphytic algae; and grazers, represented by snails. Alterations in the organic wastes and consequent increases in biomass will be measured as changes in caloric energy, chemical oxygen demand, and total and organic carbon.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Missouri

5.0676, AUTOMATED POTENTIOMETRIC TECHNIQUES FOR THE ON-SITE MONITORING OF ANION CONCENTRATIONS IN WATER

S.E. MANAHAN, Univ. of Missouri, Graduate School, *Columbia, Missouri* 65202

The overall objective of the proposed research is the development of new and improved techniques applicable to the automated monitoring of low concentrations of anions in water. Methods are to be developed which are simple, fast, reliable, sensitive and low in cost per sample. The analysis techniques will require a minimum of operator time.

Water resources management requires a knowledge of the nature and concentrations of solutes dissolved in water. It is desirable that such information be obtainable on a day-to-day basis and on site. The proposed research should help meet this demand for anions of interest in water quality control.

Methods to be explored for meeting the objectives of the proposed research include (1) a multi-sensor technique and (2) a standard addition technique, both utilizing anion-selective electrodes for anion sensors. These techniques are to be applied specifically to the determination of nitrate ion in the presence of interfering ions and, ultimately, to the determination of other anions such as cyanide, phosphate, sulfate, sulfite, fluoride, chloride, bromide and iodide.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Missouri

5.0677, TRACE AMOUNT SUBSTANCES IN ENVIRONMENTAL HEALTH

C.J. MARIENFELD, Univ. of Missouri, School of Medicine, *Columbia, Missouri* 65202

Completion of second year of 3 year program project directed toward: the identification and characterization of trace substances in our environment; the biological interactions of such substances; and the epidemiology of the long term health effects of such trace substances. The epidemiologic methodology on a statewide basis has been developed and tested. Effects upon the embryo have been selected as the first health effect being measured using both rates per live births and coordinate mapping of occurrences of such effects to determine possible clustering.

Trace analysis techniques have been developed for water, food and air. Progress being made in increasing capacity for multiple sample analysis.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0678, RELATION OF SOIL FERTILITY TO THE EXCHANGE COMPLEX

C.E. MARSHALL, Univ. of Missouri, Agricultural Experiment Sta., *Columbia, Missouri* 65202

The general purpose is the understanding of the relationships between the proportions of cations on the exchange complex, their absolute and relative activities and the mineral nutrition of plants. This is to be a field study, to take up certain aspects of a previous greenhouse study. (Research Bulletin 285 - 'The Exchangeable Bases of Two Missouri Soils in Relation to Composition of Four Pasture Species.')

DESCRIPTION OF WORK - Field plots, consisting of 7 treatments and 14 lysimeters, will be installed. The surface 12 inches of soil will be removed with a crawler tractor and scraper. Chemical treatments will be thoroughly mixed with the soil and the mixture replaced. In addition to the untreated soil and a basal treatment of NH4Cl,(NH4)2SO4 and (NH4)2HPO4,NaHCO3, KHCO3, MgCO3 and CaCO3 will be added in sufficient quantities to give a pH of 7 to individual plots. An additional treatment will consist of addition of CaCO3 at four times the amount to provide a pH of 7.

Lysimeters will be of two depths for each plot, 12 and 24 inches. Equipment will be installed for collecting and sampling of drainage waters. Analyses will be made of drainage water, herbage and soil to determine nutrient movement and losses.

SUPPORTED BY U.S. Dept. of Agriculture
Missouri State Government

5.0679, NITRATES IN WATER SUPPLIES

G.E. SMITH, Univ. of Missouri, School of Agriculture, *Columbia, Missouri* 65202

Soils in feed lots of different ages and in various geologic areas are being sampled to depths of 15-25 feet to determine the penetration of nitrate. Included in the sampling are abandoned feeding areas where no livestock have been present for some years. Samples are also collected on transects at different distances from the area of contamination (both feed lots and sewage disposal systems) to determine lateral movement. Movement is being correlated with soil physical properties.

Detailed soil samples are being collected and topographic maps are being prepared of areas where new feed lots are being built. This information will serve as a basis for measuring changes that occur in the surrounding soil areas in the future.

Accumulation of residual nitrate from chemical fertilizers is being measured at locations where detailed soil fertility studies are being conducted with varying rates of nitrogen fertilization. Samples of soil, to depths of 10-20 feet, are also being made on individual farms where accurate records of heavy fertilization with nitrogen are available for 10 to 15 years. These results are compared with adjacent areas that have no nitrogen.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0680, NITRATES IN PLANTS

G.E. SMITH, Univ. of Missouri, Agricultural Experiment Sta., *Columbia, Missouri* 65202

A. To study the effect of N, P, K and trace element fertilization on the accumulation of nitrates in forages and vegetables. B. To investigate the effect of species and plant age on nitrate reduction in plants and the accumulation of other nitrogen fractions. C. To survey the nitrate content of domestic and livestock water supplies in the state and determine the influence of watershed fertilization on nitrate content of runoff.

Forages and vegetables will be grown in the greenhouse under different nitrogen fertilizer treatments and samples collected at different stages of growth for analysis. These samples will be used to determine the different nitrogen fractions and the reductive activities of different species.

Surveys will be made of surface water supplies and shallow wells in the different areas of the state where high nitrates have been found. Effort will be made to find the source of contamination. Runoff water from erosion plots receiving different levels of nitrogen fertilizers will be sampled to determine the amount of nitrogen lost.

SUPPORTED BY U.S. Dept. of Agriculture
Missouri State Government

5.0681, THE EVALUATION OF ENVIRONMENTAL ALTERATION BY THERMAL LOADING AND ACID POLLUTION IN THE COOLING RESERVOIR OF A STEAM-ELECTRIC STATION

A. WITT, Univ. of Missouri, Graduate School, *Columbia, Missouri* 65202

Thomas Hill Reservoir is subject to thermal loading in one of two of its lower arms, and in the upper end it receives a constant inflow of acid mine drainage into one of two similar arms. This provides two control arms and two experimental arms in which environmental alterations, due to thermal loading and acid water inflow, can be studied.

Field investigations will determine the effects of thermal loading on: 1. Growth of young-of-the-year and yearling fishes. 2. Survival of fishes in an altered thermal regime. 3. Movement and harvest of fishes. 4. Primary production.

Field studies will also determine the effects of acid inflow on: 1. Water quality 2. Ability of reservoir-water to ameliorate the impact of acid water. 3. Chemical stratification. 4. Benthos composition and distribution.

The results of this study will lead to a better understanding of an environment altered by heat and acid inflow, and how it may be managed for the benefit of man.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Missouri

5.0682, CONTROL OF UNDESIRABLE AQUATIC VEGETATION IN LAKE TANEYCOMO, MISSOURI

J.R. WHITLEY, State Div. of Fisheries, *Jefferson City, Missouri* 65101

The objective of this project is to evaluate chemical methods for control of nuisance aquatic weeds.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Missouri State Government

5.0683, ORGANICS CAUSING TASTE OR ODOR IN THE MISSOURI RIVER

J.R. POPOLISKY, Kansas City Water Department, *Kansas City, Missouri*

The objective of the project is to build a library of Infrared and Gas Chromotographic spectra and ultimately, demonstrate the feasibility of running routine analysis with a Gas Chromotograph and Infrared Spectograph for identification of impending taste and odor problems.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Kansas City Government - Missouri

5.0684, RESEARCH AND FIELD ENGINEERING STUDIES FOR OPTIMIZING LIPID BIOSTABILIZATION PROCESSES

W. GARNER, Midwest Research Institute, *Kansas City, Missouri* (14-12-198)

To improve the biostabilization of lipids which normally accumulate in the top layers of anaerobic digesters. This would be accomplished by using high-shear homogenization to create a large interfacial area between aqueous and lipid phases.

The study program is proposed in two parts. Part 1 is a laboratory bench scale model utilizing four-liter anaerobic reactors to investigate th effect of homogenization. Part 1 would be summarized and completed with a process evaluation as a prelude to a field study. Part 2 is a field study applying the findings of Part 1 to a full scale treatment plant.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0685, OXYGENATION OF AQUEOUS BODIES USING LIQUID OXYGEN

W. GARNER, Midwest Research Institute, *Kansas City, Missouri* (14-12-168)

This is a proposed study of the parameters controlling the transfer of liquid oxygen (i.e., LOX) to dilute aqueous solutions. The study would include measurements of the oxygen transfer coefficient, design of suitable oxygenation equipment, development of application techniques, and process-cost calculations; this last item would, in turn, permit accurate comparisons of the costs of accomplishing various levels of oxygen enrichment with LOX vs. mechanical aeration or compressed gaseous oxygen.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0686, AN INVESTIGATION OF LIGHT-CATALYZED CHLORINE FOR TREATMENT OF WASTE WATER

A.F. MEINERS, Midwest Research Institute, *Kansas City, Missouri* (14-12-72)

The purpose of the study is to investigate the effect of light on rate and extent of chlorine oxidation of a variety of organic materials typical of those found in waste water and representative samples of effluent from biological treatment plants; to determine the capabilities of light-catalyzed chlorine oxidation and to make an economic analysis of the feasibility of such treatment.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0687, SEPARATION OF MAGNESIUM FROM CALCIUM IN THEIR SALINE SOLUTIONS

K.L. CHENG, Univ. of Missouri, Graduate School, *Kansas City, Missouri*

The purposes of this project are: (1) to find a simpler and cleaner separation of magnesium from calcium, (2) to study the theoretical basis for this separation, (3) to test the feasibility of this separation with a combination of a chelating agent and an ion exchange resin and (4) to study the separation as affected by salts and other factors.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

5.0688, A QUANTITATIVE STUDY OF TRACE ELEMENTS ON ABIOTIC AND BIOTIC AGGREGATES IN THE MISSOURI RIVER

P.F. LOTT, Univ. of Missouri, Graduate School, *Kansas City, Missouri*

The purpose of the research is to ascertain if bacteria present, through pollution, in the Missouri River are capable of concentrating certain selected trace elements, and thereby serve as the first step in the ecological chain which leads to high concentrations of these elements in higher forms of life. Analytical methods will be developed and applied to quantitatively analyze for the concentrations of the trace elements in the natural water, the silt aggregates, and micro- organisms to determine which predominant river organisms can concentrate the trace elements, and to determine the effect and interaction of silt on this process.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Missouri

5.0689, THE IMPACT OF LEAD-ZINC MINING ON THE QUALITY AND ECOLOGY OF SURFACE WATERS IN SOUTHEAST MISSOURI

E.A. BOLTER, Univ. of Missouri, Water Resources Research Ctr. , *Rolla, Missouri* 65401

A study is proposed to investigate the impact of Lead-Zinc mining activity on the quality and ecology of surface waters in the 'New Lead Belt' of SE Missouri. The study area now has little population and industry, but intensive mining activity will develop during the next few years.

During the investigation, the background values for lead, zinc, copper, iron, silver and cadmium in unpolluted surface waters, sediments and aquatic life samples will be determined. After pollution has started, the self-cleaning capacity of the streams by precipitation or adsorption of the metals and the uptake of the metals by aquatic life will be determined. The analyses will be done with an atomic absorption spectrophotometer.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Missouri

5.0690, SORPTION AND DESORPTION OF CHLORINATED HYDROCARBON PESTICIDES IN AQUATIC SEDIMENT MINERALS

J. HUANG, Univ. of Missouri, School of Engineering, *Rolla, Missouri* 65401

The proposed research project involves laboratory investigations of the sorption and desorption behavior of chlorinated hydrocarbon pesticides in aquatic sediment minerals. Emphasis is directed toward the evaluation of the effects on the sorption and desorption processes of several environmental factors, including pH, temperature, salt concentration, grain size of the sediment, and concentration of the pesticide.

Pesticides selected for this study would include DDT, dieldrin and heptachlor. Sediment minerals employed would be calcite, quartz, dolomite and three clays, kaolinite, illite and montmorillonite.

Laboratory investigations would include the following studies: 1. Preliminary equilibrium studies in order to evaluate the adsorption isotherms of pesticides with each sediment mineral. 2. Sorption and desorption studies in laboratory-controlled model aquatic systems in order to evaluate the effects on the sorption and desorption processes of several environmental factors.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Missouri

5.0691, EFFECT OF SURFACTANT MICELLES ON METAL ION REMOVAL BY FLOTATION FROM METALLURGICAL WASTEWATER

R.L. VENABLE, Univ. of Missouri, Water Resources Research Ctr. , *Rolla, Missouri* 65401

Pollution of our water resources is now recognized as a pressing national problem. Among the serious contaminants are heavy metal ions such as copper, nickel, zinc, and lead. The proposed work will be a fundamental study of a possible way of removing such metal ions from dilute aqueous solutions by flotation with surfactants. The behavior of heavy metal ions in the presence of surfactants is complex and little work has been done to elucidate this complex behavior.

It is proposed to determine the state of solution of metal ions at various surfactant concentrations by a combination of turbidity and surface tension measurements. This is necessary to an understanding of the flotation process because the flotation characteristics of free heavy metal-surfactant molecules would be expected to be different from that of such molecules when they are incorporated into the interior of aggregates of surfactant molecules called micelles, which would be still different from the flotation characteristics of precipitated heavy metal-surfactant particles.

As a further aid to understanding the flotation process, efforts will be made to disintegrate surfactant micelles to fragments with bursts of ultrasonic energy and observe the effects of this disintegration on the efficiency of flotation.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Missouri

5.0692, REMOVAL OF METAL IONS BY FLOTATION WITH SURFACTANTS

R.L. VENABLE, Univ. of Missouri, Graduate School, *Rolla, Missouri* 65401

The nation's water resources are rapidly becoming seriously polluted and some of the very toxic contaminants are metal ions. If a way of removing these metal ions from solution could be developed which is more economical than present treatment methods, the technique would have potential as a means of reducing this pollution. The proposed study would be a fundamental investigation of the method called ion flotation which utilizes solutions of surface active agents or surfactants and which has potential as an economical treatment procedure.

The objectives of the proposed work are to make ion flotation studies on ions not previously investigated. The studies will attempt to determine what type of surfactant is most effective and what conditions of pH, surfactant concentration, and temperature are necessary for the method to be effective. An additional objective will be to study the effects of addition of surfactant on the state of solution and availability for flotation of the metal ions. These studies are to be correlated with the flotation studies as an aid to understanding the results obtained there.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0693, STREAM POLLUTION IN THE NEW LEAD BELT OF SOUTHEAST MISSOURI

B.G. WIXSON, Univ. of Missouri, Environmental Health Res Ctr, *Rolla, Missouri* 65401

The proposed research plan involves field and laboratory investigations to determine the initial and cumulative effects of lead- zinc mining wastes on the water quality and aquatic biota of the presently unpolluted streams in the 'New Lead Belt' of S. E. Missouri. The unpolluted water quality and natural ecological background data have already been established since mining activity is scheduled to start in the immediate future. The unique study area makes possible a before, during, and after pollution investigation. Specific objectives are: 1. To study and evaluate the initial shock of mining pollution on the water quality and aquatic biota of affected streams. 2. To study and evaluate the cumulative effects of increasing amounts of mining pollution upon water quality and ecological systems. 3. To determine water quality and aquatic biota in control unpolluted streams in the area which will not be affected by increased population of new industry. 4. To evaluate and correlate all the investigative data and relate the findings to the unpolluted control streams and initial background survey of the streams in the study area.

Pollution effects on water quality would be evaluated by changes in pH, dissolved oxygen, turbidity, color, alkalinity and water hardness. Pollution effects on the biota would be evaluated by the response or changes in bacteria, algae, snails, crayfish, and fish.

The evaluation of all investigative data would provide information which will help conserve and protect healthy streams and biotic communities from futrue lead-zinc mining pollution.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Missouri

5.0694, MICROBIOLOGY OF SLUDGE - DNA ANALYSES AND N2 REMOVAL

R.L. IRGENS, Southwest Missouri State Coll. , Undergraduate School, *Springfield, Missouri* 65802

We are in the process of developing a method whereby DNA may be extracted from activated sludge floc. Having perfected this method, the possibility of using DNA concentration as an estimate of the viable bacterial population of activated sludge floc will be determined. The relationship between the quantity of DNA, the oxygen uptake and the concentration of volatile solids will be investigated.

We are presently comparing denitrification by activated sludge floc at two temperatures, 23 degrees C and 45 degrees C.

Future projects involve the investigation of nitrogen removal in waste treatment at near zero temperatures and the relationship between oxygen tension and denitrification at these temperatures.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0695, WATER RESOURCES IN SOURDOUGH AND MIDDLE CREEK WATERSHEDS - A COMPARATIVE STUDY OF QUALITY AND HYDROLOGY

R.L. SANKS, Montana State University, School of Engineering, *Bozeman, Montana* 59715

Bozeman Creek (or Sourdough) and Middle Creek watersheds are two adjacent drainages of 30.8 and 48.2 square miles respectively, located about 10 miles south of Bozeman, Montana. The two watersheds are rather similar in size, elevation, and topography; but entirely different as to land use. Since 1917 Bozeman Creek watershed has been closed to public use, since it is one of the sources of water for the city of Bozeman. Hyalite (or Middle Creek) has always been open and has been widely used for grazing and recreation. There has been some logging on each watershed. There is currently much pressure to have Bozeman Creek watershed opened to the public. A target date of August 1968 has been set for opening but may not be met. Water samples which have been collected from selected points on both watersheds since 1964 have shown that Bozeman Creek consistently has higher counts of microorganisms than does Hyalite Creek.

The present study has been inaugurated to provide answers to the question of whether Bozeman Creek and similar watersheds which are used for municipal water supply should remain closed to human use; to pinpoint areas of potential erosion and sedimentation problems and to evaluate the severity of erosion and sedimentation on the watersheds; and to determine some knowledge of the basic hydrology of the watersheds, which will aid in planning studies on these, and on similar watersheds throughout the Pacific-Northwestern United States.

Hydrologic data to be collected includes information from a series of raingages, weather stations and streamflow recorders on each watershed. Water quality data to be collected includes pH, suspended and dissolved solids, and concentrations of various ions from selected sampling stations on both watersheds.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Montana State University

5.0696, MICROBIOLOGICAL STUDIES IN AN OPEN AND A CLOSED WATERSHED

W.G. WALTER, Montana State University, Graduate School, *Bozeman, Montana* 59715

Preliminary microbiological and chemical studies have been made during recent summers on waters serving Bozeman. One of the watersheds has been closed to the public for about 47 years except for limited logging; the other has been open for extensive logging and recreation. Quantitative and qualitative bacteriological tests have often resulted in higher 'total' enterococcic and coliform counts in the closed area possibly because of closer proximity to streams of animals present.

Studies will be directed to identifying microbes in deer, elk, moose etc. droppings and to determine the presence of these bacteria in the waters at different locations, particularly in the closed watershed which may be opened soon for public use.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Montana State University

5.0697, HYDROBIOLOGY OF THE MADISON RIVER AND ITS HEADWATERS

J.C. WRIGHT, Montana State University, Graduate School, *Bozeman, Montana* 59715

A qualitative and quantitative analysis of the soluble organic substances that are released during periods of rapid photosynthesis by aquatic plants in the Madison River will be undertaken. These substances are apparently readily metabolized heterotrophically since their concentrations rapidly decrease when respiration exceeds photosynthesis.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0698, HYDROGEOCHEMICAL INVESTIGATION OF SELECTED WATERSHEDS IN SOUTHWESTERN MONTANA

M.R. MILLER, Montana Coll. of Min. Science, Graduate School, *Butte, Montana* 59701

Chemical characteristics of natural water are mainly controlled by the media through which the fluid passes; however, detailed rock- aggregate-water relationships are still relatively unknown. The primary goal of the proposed research is to establish quantitative and qualitative relationships between the natural geologic environment and the water chemistry.

Several small watersheds will be selected where the bedrock is known and the structure and stratigraphy are not complex. A large number of water, soil, and rock samples will be collected and analyzed for approximately 30 different parameters using atomic absorption, colorimetric, and titration techniques. Laboratory and field data will be transferred onto computer punch cards for rapid statistical evaluation

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Montana College of Mineral Science & Tech.

5.0699, WATER QUALITY REQUIREMENTS FOR AQUATIC INSECTS

A.R. GAUFIN, Univ. of Montana, Graduate School, *Missoula, Montana* 59801

The objectives of the work are to determine the dissolved oxygen, temperature and pH requirements of the 14 species of aquatic insects. These 14 species are distributed among five different families: 1) Ephemeroptera, 2) Plecoptera, 3) Odonata, 4) Trichoptera, and 5) Diptera. It is proposed that at the completion of this research, accurate estimations of the effects to be ascertained for each of the three factors over a range of concentrations, from lethal to that of no adverse effect, will be accomplished. Interpretable measures of effect shall be used rather than any change that is observed. Although growth and reproduction are the most sensitive and significant parameters of effect, conditions will not allow their use, however, special effort shall be made to study egg production and survival whenever possible.

Lethal ranges for a short exposure shall be established for temperature and oxygen simultaneously during the initial months of the project. 30 to 90-day exposures during growth, molting, and food consumption shall be measured. Temperature is important, as pre emergence is a hazard resulting from thermal discharges and warming of natural waters during the winter months.

Optimum growth rates will be established because the insects are fish food. Further temperature/oxygen relationships are to be evaluated because minimum acceptable oxygen concentrations will increase as temperature rises. The pH tolerances and optimal ranges shall be determined in separate tests. Particular emphasis shall be placed on emergence since previous work shows that good growths of fish occurs at pH values at which spawning will not occur. This work will be accomplished at the University of Montana Biological Station which is not located on the main campus at Missoula.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0700, DETECTION AND SIGNIFICANCE OF ENZOOTIC WATER POLLUTION

M. NAKAMURA, Univ. of Montana, Graduate School, *Missoula, Montana* 59801

1. A survey of protozoa and bacteria (fecal streptococci) present in game animal feces, including deer, elk, moose, buffalo, etc. 2. A study of the survival rate of microorganisms in the laboratory under varying conditions of temperature, pH and aeration. 3. A study of the existence of fecal streptococci in vegetation to learn if fecal streptococci originates from the feed and pasture. 4. A study of the comparative biochemical and physiological properties of fecal streptococci (including the enterococci and the viridans group).

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0701, COPPER TOXICITY ON ALGAE OF THE BIG BLACKFOOT RIVER

R.P. SHERIDAN, Univ. of Montana, Graduate School, *Missoula, Montana* 59801

This proposal describes a water quality study of the Big Blackfoot River, and is designed to provide information concerning the effect of copper salts on the indigenous algal flora. The experimental approach will be physiological and the experiments designed to provide data in advance of potential pollution in the form of copper salts. These data must be collected prior to the construction of the proposed Anaconda mill to add substance to arguments for the installation of control devices before pollutants are released into this river rather than after the major part of the flora has been destroyed.

Type Species Collection - Samples will be collected seasonally from the Big Blackfoot River at the headwaters near Lincoln, Montana and from several downstream stations. Clone cultures will be established from these samples, and maintained as a type collection and serve the following purposes: a.) Source of material for the proposed copper toxicity study. b.) As prepollution types which may be unavailable for study after pollutants have been added to the River.

Proposed Experiments - 1. Recording the relative abundance of each species in the seasonal collections. 2. Studies designed to provide quantitative data concerning the effect of copper salts on the growth, respiration and photosynthesis of each major species.

These data will be used to construct a pollution standard for copper. In addition to establishing the maximum copper content tolerated by the indigenous algal flora, projections can be made concerning the effect of copper at concentrations above those specified by the maximum pollution standard.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Montana

5.0702, INVESTIGATIONS OF THE RELATION BETWEEN THE USE OF CHLORINATED HYDROCARBONS AND THEIR RESIDUES IN CHANNEL CATFISH

L.A. WITT, State Game & Parks Commission, *Lincoln, Nebraska* 68509

The purpose of this job is to determine the relationship between the pattern of usages of chlorinated hydrocarbons and their residual concentrations in channel catfish tissue. Factors already being considered in this relationship are land use, land capability, rainfall, and pesticides used. The analysis of previously collected channel catfish blood and fat samples will be completed by use of a gas chromatograph equipped with electron capture detectors. A secondary objective is to gain information which may be useful in determining to what degree Nebraska contributes to the pollution of the Missouri River with chlorinated hydrocarbons.

A publishable report of this work will be completed during this segment and will be furnished in lieu of a completion report.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Nebraska State Government

5.0703, EFFECT OF POLLUTION ON THE QUALITY OF SURFACE AND GROUND WATER RESOURCES

D.M. EDWARDS, Univ. of Nebraska, Agricultural Experiment Sta., *Lincoln, Nebraska* 68508

To quantitatively and qualitatively study, in the laboratory and in the field, different components of potential contamination to water and the effect of these constituents on changing soil and water characteristics. Specific objectives are: 1. To evaluate the effects different agricultural chemicals and wastes may have upon surface and subsurface waters, 2. to determine what effect contaminated water supplies have upon the characteristics of the soil, 3. to devise improved and/or new methods of water pollution prevention and control, 4. to train graduate and undergraduate students for research in the area of water pollution, supply, treatment, and quality as related to agricultural production and rural and urban water supplies and sanitation.

Procedure: Laboratory and field studies will be conducted to determine the level and type of natural and artificial water contamination, objective 1. This information will be compiled and evaluated to allow building of simulated laboratory models. The models will be used for qualitative studies of the basic parameters of these waters and their effect upon soil conditions, as well as upon surface and subsurface water pollution, objectives 2 and 3. Finally, the information gathered from the laboratory studies will be used initially in the laboratory, and, if promising there, in the field for improved and/or new methods of water reuse and pollution prevention and/or control, objective 4. Radiological and electrokinetic techniques of electrophoresis, streaming potential, and electroosmosis will be extensively used for the study.

SUPPORTED BY U.S. Dept. of Agriculture
Nebraska State Government

5.0704, BRACKISH WATER PURIFICATION BY BIOLOGICAL FUEL CELL POWERED ELECTRODIALYSIS

W.A. SCHELLER, Univ. of Nebraska, School of Engineering, *Lincoln, Nebraska* 68508

Purification of brackish water containing 1000-5000 ppm of salts by electrodialysis appears to be more economical than any of the present day distillation techniques, but it is still expensive. A reduction in the water costs might be realized if a useful byproduct were produced in the water purification process.

The primary objective of the proposed research is to investigate the possibility of using an electrodialysis cell for brackish water purification in conjunction with a biological fuel cell powered by microorganisms capable of living in the brine effluent from the electrodialysis unit, feeding on cellulose containing materials such as hay, corn stalks, etc. and suitable for processing into cattle feed or feed supplement. Furthermore it is planned to investigate the effect of operating variables on the performance of the electrodialysis unit within the range of voltage-current-power capabilities of a battery of biological fuel cells. Finally, using the experimental results as a basis, economic evaluations will be made in order to determine the economic optimum arrangement of electrodialysis units and biological fuel cells. This is a five year program from fiscal 1966 through fiscal 1970.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Nebraska

5.0705, DEVELOP AND DEMONSTRATE A METHOD FOR ASSESSING THE EXTENT OF POLLUTION FROM STORM WATER RUNOFF IN AN URBAN AREA

R.A. ROHLING, Henningson Durham & Richardson, *Omaha, Nebraska* 68131

The Contractor will conduct a detailed engineering investigation of applicable solutions, evaluation of benefits and the economics of alternate methods for the control of pollution from combined sewer overflow from the Des Moines, Iowa urban area.

A river sampling program will be conducted to establish the basic stream quality and an investigation of the effect of the nutrients pollutional load on the Red Rock Reservoir downstream of Des Moines will be made.

The total quantity of pollutants contributed from the study area will be determined from a combined sewer overflow and storm water runoff monitoring program. A rain-gage network will be established to provide basic information to establish rainfall-runoff relationships and the effects of rainfall on combined sewer overflows. Corrective measures will be investigated, on a watershed basis, to determine the feasibility of storm sewer separation and/or temporary impoundment with controlled reslease with or without subsequent treatment. A detailed combined sewer separation study will be made on a combined system typical of the types of development encountered in the study area and cost data will be expanded to other areas as applicable. Evaluation of the existing water pollution control facilities will determine the capabilities for treating combined sewer overflows from storage, and recommend improvements and operation procedures as applicable to combined sewage treatment.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0706, WATER-QUALITY REGIMEN OF TAHOE-TRUCKEE SYSTEM

J.V. SHARP, Univ. of Nevada, Water Resources Research Ctr. , *Reno, Nevada* 89507

The first objective is an improved understanding of the source, movement, and fate of water-quality parameters in the Tahoe-Truckee system, Nevada-California. This system is faced with accelerated degradation from disposal of Lake Tahoe basin sewage and by intensification of land and water use in the middle and lower reaches. Specific objectives are: 1) documentation of existing time and spatial variation of water quality, 2) determination of environmental (geologic, hydrologic, climatologic) and human-associated factors which control quality of water, 3) development of a quantitative model which describes the existing water-quality regimen and which will be useful in predicting future patterns of water quality, and 4) adaptation of the model to simulation by digital computers.

The simulation technique will permit testing of the model and will provide a basis for prediction of the effects of: 1) man's actions which promote or restrain the introduction of contaminants and pollutants and 2) scheduling of water releases from sources of varying quality.

The second objective is evalution of the applicability and usefulness of the above approach for description and prediction of water quality in large and complex natural hydrologic systems in general, using the Tahoe-Truckee system as an illustrative case.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0707, PESTICIDAL RESIDUES OF AGRICULTURAL CHEMICALS

L.L. STITT, Univ. of Nevada, Agricultural Experiment Sta. , *Reno, Nevada* 89507

1. To determine inherent modulcations on 'scans' of agricultural products, soil and water resources before contamination by the pesticides. 2. To develop improved methods for analysis, identification of pesticides, and their metabolites or degradation products. 3. To determine pesticide residues and their degradation products from investigations in research and demonstration evaluations in various areas of Nevada.

Description of Work - Long range investigations will be intiated to determine build up of residues from pesticide treatments on previously untreated soils. Modified analytical methods for Nevada conditions. Determinations of residues and their metabolites will be used to set time limits for farmer use and limitations as to types of use.

SUPPORTED BY U.S. Dept. of Agriculture
Nevada State Government

5.0708, PHYSICAL AND CHEMICAL CHANGES OF RECIRCULATED HATCHERY WATER SUPPLIES

D.A. NORMANDEAU, State Fish & Game Department, *Concord, New Hampshire*

Unlike other phases of this project, this particular work plan and job will change somewhat from those of the previous two segments. This change is prompted by the lack of adequate facilities, personnel, the excessive cost of pursuing this program, and the inherent difficulties which would make this kind of operation impractical for New Hampshire hatcheries at this time. A substantial portion of this Work Plan should be considered as an area for a major study. By all indications, it is now apparent that this work plan is sufficiently broad as to justify the establishment of a separate project. Therefore, the goals of this work plan and job are somewhat reduced and include only one phase of recirculation.

The objective of Work Plan III, Job 1, is to evaluate and describe the physical and chemical changes which occur in waters that are recirculated and in which trout eggs and sac fry are being incubated.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
New Hampshire State Government

5.0709, RESIDENT POPULATION DETERMINATION

P.H. WIGHTMAN, State Fish & Game Department, *Concord, New Hampshire*

Objectives: Determination of the effects heated effluents will have on the existing fishery in the Hooksett-Amoskeag Impoundments as well as the tributaries.

Procedures: The effects of the increased thermal effluents on the existing fishery composition will be obtained by the use of fyke nets, pound nets, gill nets and electro-shocking equipment. Tributaries which flow into the river will be electro-shocked to determine changes in existing fish populations. Such work will be done during the summer of 1968. All fish caught in the nets will be differentiated by species; these, in turn, will be weighed, measured and counted. Fin-clipping will be necessary to mark individuals which may be caught more than once and to determine movement.

Summarization of the collected data will be accomplished during the winter months and written in report form. All findings may, in turn, be utilized in planning for anadromous fish restoration.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
New Hampshire State Government

5.0710, STORM WATER DEMONSTRATION PROJECT - CITY OF SOMERSWORTH, NEW HAMPSHIRE

P. GUERTIN, State Water Sup. & Pol. Contr. , *Concord, New Hampshire* 03301

The investigations to be conducted as part of this project evaluation will include: 1. A complete evaluation of the effect of chlorinating and withholding combined sewerage with subsequent discharge to the receiving stream. Chlorine dosage and contact time will be varied to determine optimum dosage and contact time. 2. The effect of chlorinated combined sewerage on a treatment facility will be completely evaluated using varying degree of mixing with un-chlorinated sewerage. 3. An exact determination of the value of injecting 'Polymers' into the sewerage to increase the flow capacity (decrease the roughness coefficient) of the pipe line. Also, a complete determination of the value of 'polymers' to obtain increased efficiency of treatment from a treatment facility.

The data collection will take place in Somersworth, N. H. The assimilation, correlation, and reporting location has not as yet been determined.

This project was initiated in December 1967. It is anticipated that the project shall be completed in Mid 1972.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
New Hampshire State Government

5.0711, THE ANALYSIS OF AROMATIC CONSTITUENTS IN WATER USING FLUORESCENCE AND PHOSPHORESCENCE

D.W. ELLIS, Univ. of New Hampshire, Graduate School, *Durham, New Hampshire* 03824

The proposed research plan is designed to develop new methods for the analysis of aromatic compounds in fresh water utilizing techniques which will permit trace analysis.

Fractional crystallization or extraction will be employed to isolate the aromatic species from the water and to concentrate them. Chromatographic procedures, thin-layer or paper, will be used to separate specific aromatic compounds. Finally, fluorescence and/or phosphorescence, in conjunction with infrared and ultraviol-visible absorption where obtainable, will be used to identify and analyze these compounds.

Procedures and optimum conditions will be worked out initially using synthetic mixtures. Fresh water samples, from a wide variety of sources and environments, will then be analyzed in order to test the methods which have been developed.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of New Hampshire

5.0712, A STUDY OF ALGAL POPULATIONS ASSOCIATED WITH DIFFERENT LEVELS OF WATER QUALITY IN NEW HAMPSHIRE

A.C. MATHIESON, Univ. of New Hampshire, Graduate School, *Durham, New Hampshire* 03824

In the present investigation the species composition, periodicity and abundance of algal populations from three areas (Newfound Lake, Winnisquam Lake and New Hampton Stabilization Pond), differing with respect to water quality, will be compared in order to assist in the prediction, prevention, and control of algal blooms in New Hampshire water supplies. These three areas show a marked difference with respect to pollution, i.e., Newfound Lake has no pollution, Winnisquam Lake is moderately polluted and New Hampton Stabilization Pond is an oxidation pond, or sewage lagoon, which is extremely polluted. A comparative study of this nature will assist in the maintenance of a high quality water supply.

Weekly samples will be taken at New Hampton Stabilization Pond, while collections will be made on alternate weeks at Winnisquam and Newfound Lakes. Samples from New Hampton Stabilization Pond will be primarily restricted to phytoplankton and floating mats of algae, while those from Newfound and Winnisquam lakes will include the attached bottom forms and the epiphytic types as well. The types, abundance, and occurrence of algae at all three areas will be enumerated throughout the year. Various techniques will be employed - Sedgwick-Rafter slide technique as outlined by Palmer (1959), a modification of the Hess Method for floating vegetation, collection of host plants and epiphytes, bottom sampling by SCUBA diving and dredging. Statistical differences will be determined between the various populations and areas studied. Routine culturing of several of the algae will be an integral part of this study - for identification of species and determination of nutrient requirements.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of New Hampshire

5.0713, DETECTION AND ENUMERATION OF VIRUS IN NATURAL WATERS

T.G. METCALF, Univ. of New Hampshire, Graduate School, *Durham, New Hampshire* 03824

It is proposed to introduce equipment and methods which will make it possible to determine the presence of virus populations in surface waters on a quantitative basis. The proposed study is directed towards development of the capability for routine quantitative monitoring of the microbiological quality of surface water. The proposal recognizes the great need for addition of a quantitative capability to existing qualitative methods for detecting the presence of viral macromolecules in water. The proposed study anticipates the forging of a powerful technical tool which can be directed toward the solution of a variety of existing problems of both fundamental and applied nature involving the virus macromolecule in water.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of New Hampshire

5.0714, ULTRAVIOLET ABSORPTION AND ITS POSSIBLE RELATION TO EUTROPHICATION IN LARGE NEW HAMPSHIRE LAKES

D.A. NORMANDEAU, Univ. of New Hampshire, Water Resources Research Ctr. , *Durham, New Hampshire* 03824

The proposed investigation is designed to determine the feasibility of using ultraviolet absorption in lake water as an index to the degree of eutrophication of large New Hampshire Lakes.

A correlation is known to exist between eutrophication and the quantity of dissolved organic matter. Since most dissolved organic matter is known to absorb strongly in the U.V., it is believed that a correlation exists between U.V. absorption and eutrophication.

Procedures to be used in determining ultraviolet absorption will take into account interference factors. Suspended and colloidal matter will be removed by filtration. Interfering inorganic ions will be removed by ion exchange. Procedures will also be developed for rapid field determination of U.V. absorption.

Other factors to be studied will include variations in U.V. absorption as a result of: (l. seasonal changes, (2. stratification, (3. increased or decreased biological activity (e.g. phytoplankton blooms).

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of New Hampshire

5.0715, BEHAVIOR OF NITROGEN IN THE SOIL

N.K. PETERSON, Univ. of New Hampshire, Agricultural Experiment Sta. , *Durham, New Hampshire* 03824

Description of work: Nitrogen levels in undecomposed litter and soils in the vicinity of alder will be compared to that from the vicinity of white pine. The nitrogen content of drainage water from alder & white pine growing on the same soils will also be determined. In order to study nitrogen balance, the amounts of water leaching through a given amount of soil in a given time will be determined.

Samples of water, litter, and soil will be taken during the period April through October under alder and adjacent white pine or poorly drained sandy soils near small streams. Bulk density samples will be taken at each site. Ground water and stream samples will be collected for analysis for nitrogen content. The amounts of nitrogen in the drainage water coming from each site investigated will be measured in order that comparisons may be made between sites. Soil and water temperatures will be recorded at the time of sampling as will the maximum and minimum air temperatures between sampling periods.

SUPPORTED BY U.S. Dept. of Agriculture
New Hampshire State Government

5.0716, COMPARATIVE STUDIES OF DINOFLAGELLATE TOXINS

J.J. SASNER, Univ. of New Hampshire, Graduate School, *Durham, New Hampshire* 03824

The proposed research program will attempt to elucidate the physiological and pharmacological effects of several naturally occuring marine dinoflagellate biotoxins. Primary objectives are; 1) to culture several toxin producing dinoflagellate species in the laboratory; 2) to concentrate these cells, extract and accumulate the harmful materials; and 3) to test, in a comparative manner, their effects on living systems, particularly nervous and muscle tissues. The primary goal is to study the deleterious effects of these microorganism products on the electrogenic properties of excitable systems; including resting and action potential in nerve and muscle and parameters of contraction and tension development in muscle. Both vertebrate and invertebrate nerve-muscle systems will be tested. Similar experiments, comparing neurogenic and myogenic cardiac systems, are planned. In general, comparative studies will include the testing of toxins on invertebrate organisms, particularly Molluscs and Crustaceans which, in nature, are subject to the effects of dinoflagellate 'blooms'.

The association of paralytic shellfish poisoning and ciguatera- like poisoning with substances produced by marine dinoflagellates has closely linked commercial fisheries research with that of public health Relatively recent chemical and biological findings concerning this association will now permit studies of the comparative effects of these naturally occuring biotoxins, as well as their specific site(s) and mode(s) of action. It is toward this understanding that this research proposal is intended.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0717, AN INVESTIGATION OF APHANIZOMENON FLOS-AQUAE, A TOXIC BY-PRODUCT OF EUTROPHICATION

P.J. SAWYER, Univ. of New Hampshire, Graduate School, *Durham, New Hampshire* 03824

An investigation of the toxicity of Aphanizomenon flos-aquae, is proposed. The project is divided into three parts. Part I, to be executed by Prof. Ikawa, will be an attempt to isolate and identify chemically the endotoxin found in the algae. Part II, under Dr. Sasner's direction, will be a study of the physiological effects of the toxin at the cellular level particularly among the excitable tissues. Part III, to be accomplished by Dr. Sawyer, will be a study of the effects of the toxin on members of the aquatic communities associated with eutrophic lakes.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of New Hampshire

5.0718, ENTERIC BACTERIA AND VIRUSES IN SEWAGE, WATER, AND SHELLFISH

L.W. SLANETZ, Univ. of New Hampshire, Graduate School, *Durham, New Hampshire* 03824

Studies will be continued on the correlation of numbers of coliforms, fecal coliforms, and fecal streptococci with the presence of salmonellae and enteroviruses in seawater and oyster samples collected from stations in our bay and estuarine areas. Particular attention will be given to the detection of salmonellae and viruses in oysters harvested from shellfish growing waters considered to be of approved sanitary quality based on recommended coliform standards. Hydrographic conditions in the study areas will be determined to establish the possible impact of such conditions on the microbiological data obtained. Studies will also be continued to assess the efficiency of newly installed sewage treatment plants in eliminating enteric bacteria and enteroviruses in seawater and shellfish at sampling stations in several estuarine and bay areas. The effectiveness of depuration procedures for providing shellfish of acceptable microbiological quality will be determined using shellfish harboring indicator bacteria, salmonellae, and enteroviruses.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0719, MICROBIOLOGY OF ESTUARINE AND SHELLFISH POLLUTION

L.W. SLANETZ, Univ. of New Hampshire, Graduate School, *Durham, New Hampshire* 03824

The research objectives of this project are designed to (1) determine the reliability of current bacteriological criteria or standards for monitoring the sanitary quality of shellfish and shellfish growing waters, (2) determine whether fecal streptococci should replace coliforms as indicators of fecal contamination of estuarine water and shellfish, (3) determine whether bacteriophages will be useful indicators of enteric virus contamination of estuarine water and shellfish, (4) evaluate depuration procedures and factors which affect the decontamination of oysters and clams under laboratory and field conditions, (5) determine the efficiency of newly installed sewage treatment plants in reducing or eliminating contamination of estuarine waters with enteric bacteria and viruses.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0720, THERMAL PREFERENCES OF MARINE FISHES AND INVERTEBRATES

D.W. BRIDGES, U.S. Dept. of Interior, Sandy Hook Marine Lab. , *Highlands, New Jersey*

Introduce marine fishes and invertebrates into experimental aquaria or tanks having temperatures similar to the natural environment of the organisms. By altering substrates, lighting, etc., attempt to determine normal patterns of behavior and response in a particular temperature regime; compare the activity in experimental aquaria with that observed in the field. Then manipulate temperature so that vertical and horizontal gradients or thermal regimes are established; observe behavior which occurs concomitant with alteration of established temperature in order to determine if thermal preferences or optimal temperatures exist.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0721, EFFECTS OF HOT WATER MASSES ON MARINE FISHES

D.W. BRIDGES, U.S. Dept. of Interior, Sandy Hook Marine Lab. , *Highlands, New Jersey*

After conditioning a group of fish to approach a feeding station on cue, introduce different hot water strata between the fish and the food source to determine the effect of water temperature on modifying their behavioral responses.

We will measure the rate of fish passage through heated water to determine at what level temperature may act as a barrier. Experimental animals will include forms commonly found in the Cape Cod area. Techniques will be developed which can be adapted to similar studies for evaluating effects of thermal effluents anticipated in other coastal areas.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

5.0722, TREATMENT RECOVERY, AND REUSE OF COPPER WIRE MILL PICKLING WASTES

L.E. LANCY, Volco Brass & Copper Company, *Kenilworth, New Jersey* 07033

Volco Brass and Copper Company produces 75 TPD of copper and copper alloy wire. Wastes from the pickling, bright dipping, and drawing operations consist of spent treating solution dumps, dragout, and rinse waters containing acids; alkalies; and hexavalent chromium, copper, fluoride, and copper complexing ammonium ions. Lancy Laboratories has designed a process and waste treatment system which will recover the copper electrolytically, will regenerate the treating solution, and will permit reuse of 95 % of the waste water as process water. The process is free of any significant sludge disposal problem. The project is to be completed in one year.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Volco Brass and Copper Company

5.0723, EXPERIMENTS TO DETERMINE THE EFFECTIVENESS OF PHOSPHATE REMOVAL BY MEANS OF THE MOVING BED FILTER

G.R. BELL, Johns Manville Corporation, *Manville, New Jersey* (14-12-154)

The effectiveness of the Moving Bed Filter will be determined for the removal of suspended solids and phosphate removal as compared to conventional methods. The Moving Bed Filter (15,000 gpd) will be installed at a typical waste treatment plant to optimize the flocculation and filtration and filtration procedures for phosphate and solids removal. Design and engineering data will be developed for a fullscale installation. Estimates of the capital and operating costs for various sizes of plants also will be made.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0724, EXPERIMENTAL CLOSED WATER SYSTEM TO ELIMINATE WASTE WATER DISCHARGE FROM JOHNS MANVILLE PLANT 03, DEFIANCE, OHIO

W.E. CRAMPTON, Johns Manville Corporation, *Manville, New Jersey*

The objective of the project is to completely eliminate the discharge of waste water from a fiber glass insulation plant. The caustic cleaning solution presently used to clean chain conveyor belts will be replaced by a system utilizing water sprays from power driven rotating descaling nozzles. The residual particles of glass fiber and phenolic binder will be removed by fine screening followed by a diatomite filter. Dissolved phenolic binder in the water will be reused.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Johns Manville Products Corporation

5.0725, AN INVESTIGATION OF TECHNIQUES FOR THE REMOVAL OF CHROMIUM AND CYANIDES FROM ELECTROPLATING WASTES

W.V. TURNER, Metal Finishers Foundation, *Montclair - Upper Montclair, New Jersey*

The Metal Finishers' Foundation will conduct a two-phase research and demonstration project on methods for economically treating cyanide and chromium wastes from small plating shops. Phase I will include (a) a 'State of the Art' review of recovery techniques, (b) accumulation of data on waste stream compositions, (c) selection of techniques for bench scale study and selection of extractants and complexing agents, (d) bench scale experimental investigation of selected techniques and (e) evaluation of the test results and preparation of recommendations. This phase will require one year.

Phase II will consist of (a) the design of the process and the processing equipment, (b) acquisition and installation of the equipment in an electroplating plant, (c) operation of the demonstration plant to accumulate data, and (d) the evaluation of the data and preparation of reports.

The work will be performed by subcontract to the Battelle Memorial Institute at Columbus, Ohio. Various treatment methods, including liquid-liquid extraction, ion flotation, and precipitate flotation, will be investigated and compared.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Metal Finishers Foundation

5.0726, ANALYSIS OF THERMAL POLLUTION DISPERSION

R.C. AHLERT, Rutgers The State University, School of Engineering, *New Brunswick, New Jersey* 08903

The purpose of this research is to describe the dispersion of thermal effluents. Molecular and turbulent diffusional coefficients will be used to generate temperature gradients in both longitudinal and normal directions. Models which characterize these temperature gradients in terms of outfall temperature, relative effluent flow rate, and outfall location will be developed. Because of the contributions of natural convection in some outfall configurations, laboratory experiments will be used to clarify the contribution of stratification or natural convective effects in the development of cross-sectional profiles.

Reaeration processes including pollution demands, interfacial transport and photosynthesis are nonlinear in temperature. Therefore, the model of stream behavior that assumes the stream to be a continuous reactor with both longitudinal and normal temperature gradients will be more precise than earlier models involving cross-sectional uniformity. Once appropriate temperature profiles have been developed for typical thermal effluent situations, these relations will be coupled with mass and energy balances. The ultimate result will be a clearer picture of the effect of thermal pollution on total stream properties.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Rutgers The State University

5.0727, PROCESS CONTROL MODEL FOR OXYGEN REGENERATION OF POLLUTED RIVERS

B. DAVIDSON, Rutgers The State University, School of Engineering, *New Brunswick, New Jersey* 08903

A distributed parameter model of the transient behavior of dissolved oxygen in a polluted river is developed for the case where artificial, in-stream aeration is employed. The model is designed for automatic process control theory application with appropriate load and control variables defined for the particular case studied. Signal flow diagrams for the complete process control of an aeration station specifying transfer functions for the mixing cell model, measurement device for dissolved oxygen and chemical oxygen demand, error detecting devices, controller action, and final control value for the aerators will be developed.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Rutgers The State University

5.0728, THE ENGINEERING APPLICATIONS OF DISTRIBUTED AND MULTIVARIABLE SYSTEM THEORY TO THE DYNAMICS OF WATER POLLUTION CONTROL

B. DAVIDSON, Rutgers The State University, School of Engineering, *New Brunswick, New Jersey* 08903

In line with the long range objectives of water resource research at Rutgers the Control Theory Group of the Department of Electrical Engineering is proposing a system engineering apraoch to the control of water pollution. The proposed program would be part of an over-all interdisciplinary effort. That is, all activities would be closely coordinated with the research in the Chemical and Civil Engineering Departments. Dynamic control techniques of optimization will be developed for a class of multivariable distributed systems. Specifically, this work would be applied to the problems of artificial in-stream aeration. Various critical parameters, such as dissolved oxygen and biological oxygen demand, will be utilized together with engineering and economic constraints in the formulation of appropriate penalty functionals. Digital system simulations will be performed for various configurations. These will employ the results of cell model simulations and available field data.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Rutgers The State University

5.0729, PURIFICATION OF HARD CLAMS FROM POLLUTED WATERS

H.H. HASKIN, Rutgers The State University, Graduate School, *New Brunswick, New Jersey* 08903

This project is designed to define optimal conditions for maximum hard clam activity. The activities of greatest interest are those which purify (depurate) the clams of bacterial and viral contaminants. Since purification experiments are lengthy and involved, other indicators of clam activity will be used in a study of such environmental parameters as temperature, salinity, turbidity, food levels, light, oxygen levels, etc. Uptake and disposal of bacterial and bacteriophage contaminants will be further studied in the laboratory and the results of these studies will be related to bacterial and, hopefully, enteric viral levels in the Raritan Bay estuary and its clam populations.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0730, WATER POLLUTION

H. HEUKELEKIAN, Rutgers The State University, Agricultural Experiment Sta. , *New Brunswick, New Jersey* 08903

Objectives are (1) development of analytical methods for detecting pesticides, herbicides and phenols in water, (2) determine the presence and morphological, cultural, phhsiological and chemical characteristics of populations of bacteria in well waters, (3) environmental factors affecting bacterial pollution of well waters and stream self purification; and (4) factors affecting efficiency of septic tank operations.

Current analytical methods will be modified, tested and used in the analyses of representative samples of potable waters. Model systems will be developed for laboratory studies of bacteria appearing in polluted water. The effectiveness of various diatomaceous materials for removing bacteria from polluted waters will be evaluated in relation to flow. The relative rates of oxidation of organic particles of varying sizes will be determined. Septic tank efficiency work will relate affluent characteristics to soil characteristics.

SUPPORTED BY U.S. Dept. of Agriculture
New Jersey State Government

5.0731, WASTE TREATMENT

H. HEUKELEKIAN, Rutgers The State University, Agricultural Experiment Sta. , *New Brunswick, New Jersey* 08903

Objectives are to (1) determine the chemical composition of the substrate in the bulking of activated sludge, (2) the biodegradability of commercial and experimental detergents and effects of same on the operation and efficiency of the sewage treatment process and plant, and (3) to evaluate the principles of simultaneous enzymic adaptation and inducation and repression of enzymes in mixed bacterial populations involved in the waste treatment process.

This work will be performed in model systems in the laboratory and in nearby municipal waste treatment plants.

SUPPORTED BY U.S. Dept. of Agriculture
New Jersey State Government

5.0732, REMOVAL OF PHOSPHATE FROM WATER BY ALUMINUM AND IRON

P.H. HSU, Rutgers The State University, School of Agriculture, *New Brunswick, New Jersey* 08903

The proposed research involves the investigation of the reaction mechanism between phosphate and aluminum (or iron) with its ultimate objective projected toward defining the optimum conditions for the removal of phosphate from water. The main approach in the investigation is to prepare aluminum or iron phosphates under various conditions and to characterize the products in detail.

The factors to be considered for the preparation will be the nature of phosphate removing cations M (aluminum or iron), the concentration of M , the concentration of phosphate, the M/P ratio, the NaOH/M ratio, the source of M (for example, AlCl3 or amorphous aluminum hydroxides), the presence of other components, and possibly other factors which may develop during the progress of investigation. Precipitates will be analyzed for their chemical composition, solubility, crystallinity, and homogeneity. The solution phase will be analyzed for the nature of aluminum (or iron) phosphate ionic complexes.

Emphasis in the initial study will be on the reaction products at equilibrium state, followed by a study of the reaction kinetics.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Rutgers The State University

5.0733, PHOTOSYNTHETIC REAERATION IN THE UPPER PASSAIC RIVER

J.V. HUNTER, Rutgers The State University, School of Agriculture, *New Brunswick, New Jersey* 08903

The purpose of this research is to determine the contribution of photosynthesis to the reaction of the upper Passaic River, and to determine the effect of this photosynthesis on the dissolved oxygen level - specifically, the diurnal fluctuations, in both a natural state and under conditions of artificial aeration.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Rutgers The State University

5.0734, THE ORGANIC CONCENTRATION GRADIENT IN AN AERATION COLUMN

B.T. KOWN, Rutgers The State University, School of Engineering, *New Brunswick, New Jersey* 08903

The proposed research is to investigate those chemical and physical factors, in addition to operational variables and equipment geometrics, which influence the organic concentration gradient in the bulk solution of an air bubble column containing waste water. The objectives of the proposed research are to determine the factors influencing the gradient and to evaluate its possible application to the removal of the pollutants from waste water.

The initial phase of the proposed study will be concerned with the determination of the relationship between the nature of foams generated by rising air bubbles in a bubble column and the nature of the pollutants in the waste. The studies are to be made by batch equilibrium-type experiments.

The second phase of the study will involve laboratory studies of the organic concentration gradient which resulted from stripping action of the rising air bubbles and deposit of concerntrated pollutants at the liquid level by ruptured air bubbles. Equipment geometrics and operational variables which influence the equilibrium concentration gradient will be investigated.

The final phase of the study will be devoted to the evaluation of the possible application of the concentration gradient in the separation of organic pollutants from waste water. The application will be considered in two areas; one in which the pollutants are directly separated by removing the organic-rich-surface liquid, and the other in which the gradient is applied to improve the foam fractionation process.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Rutgers The State University

5.0735, AQUATIC WEEDS

D.N. RIEMER, Rutgers The State University, Agricultural Experiment Sta. , *New Brunswick, New Jersey* 08903

Objectives: 1. To determine the incidence and geographic and seasonal distribution of the various important aquatic weeds in relation to varying ecological conditions, natural and imposed. 2. To determine the physiological and biochemical characteristics of the above species in relation to their susceptibility to chemical control and to other manipulative practices. 3. To determine the behavior of herbicides in an aquatic environment. 4. To develop safe and economic control measures.

Description of Work Proposed: A distribution survey will be accompanied by determination of variation in substance, rate of flow and chemical composition of water. Nutrition with relevence to peculiarities of metabolism under low oxygen tension and reproduction under varying environmental stresses will be studied in the laboratory and field. Activity, retention and degradation of chemicals in plants, water, substrate and associated flora and fauna will be investigated.

SUPPORTED BY U.S. Dept. of Agriculture
New Jersey State Government

5.0736, FARM ANIMAL WASTE DISPOSAL

J.E. STECKEL, Rutgers The State University, Agricultural Experiment Sta., *New Brunswick, New Jersey* 08903

Objective: Improvement of management systems with regard to handling, treatment, and disposition of the wastes. Description of work proposed: 1. Application phase: refinement of equipment and techniques for disposal of poultry manure by Plow-Furrow-Cover and sub-sod injection; 2. Field experiment phase; study of application rates, frequency, and length of time that poultry manure may be disposed of in soil; 3. Field experiment analytical and laboratory phases; measurement of the chemical, physical, and biological changes occurring in the soil and the pollutional effects on ground and surface water; 4. Statistical phase: evaluation of the performance of soils as disposal media with loading regime and soil characteristics.

SUPPORTED BY U.S. Dept. of Agriculture
New Jersey State Government

5.0737, REMOVAL OF BOD AND NUTRIENTS BY BIOLOGICAL SLIMES

W.N. TORPEY, Rutgers The State University, Graduate School, *New Brunswick, New Jersey* 08903

The objective of this proposal is to exploit the activities of attached biological growths on closely spaced rotating disks alternately submerged in sewage and exposed to air for high degree removal of organic matter, nitrogen and phosphorus. It is proposed to utilize a series of such units for sequential specialized populations. It is expected that neither artificial aeration nor secondary sedimentation will be necessary by virtue of the fact that the biological growths will not be allowed to accumulate to great thickness and will, therefore, not slough off but instead they will be removed at will after they have reached the logarithmic stage of growth.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0738, REMOVAL OF PHOSPHATE FROM WATER BY ALUMINUM AND IRON

UNKNOWN, Rutgers The State University, Agricultural Experiment Sta., *New Brunswick, New Jersey* 08903

(1) To study the reaction mechanisms between phosphate and aluminum or iron, and (2) to define the optimum conditions for removal of phosphate from water.

Using wet chemical and diffraction techniques, studies will be made of the nature of the phosphate-removing cations (Al or Fe), their concentration, the concentration of phosphate, ratios among these, various sources of cations, the presence of other components, and additional factors.

SUPPORTED BY New Jersey State Government

5.0739, EFFECTS OF THERMAL AND OTHER FORMS OF POLLUTION ON SOME ANADROMOUS FISHES

J.R. WESTMAN, Rutgers The State University, School of Agriculture, *New Brunswick, New Jersey* 08903

This research is divided into two parts: (1) the temperature tolerance and preference ranges of juveniles of four species of anadromous fishes will be determined. The species are: the striped bass, Roccus saxatilus, the American shad, Alosa sapidissima, the blueback herring, Alosa aestivalis, and the alewife, Alosa pseudoharengus (2) The dissolved oxygen requirements of the four species will also be measured at three water temperatures, and at two salinities in addition to 'fresh' water. Oxygen requirements will also be measured in the presence of various concentrations of petroleum products, of ammonia, and in the presence of both.

A temperature preference tank will be employed for determining preference ranges; and oxygen reduction will be obtained by the use of nigrogen, and by helium for comparative purposes.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Rutgers The State University

5.0740, OXYGEN REGENERATION OF POLLUTED RIVERS

W. WHIPPLE, Rutgers The State University, Water Resources Research Inst., *New Brunswick, New Jersey* 08903

The purpose of this project is to demonstrate the effectiveness and economy of commercially available equipment in restoring to satisfactory dissolved oxygen levels the polluted waters of one small river, the Upper Passaic, and one large navigable river, the Delaware. After detailed analysis and preparation, aeration units of several types, of a size sufficient to materially change the oxygen level, will be installed on the Passaic River. Utilizing information gained from this portion of the study, aeration equipment will be installed on the banks of the Delaware. By field tests and dispersion analyses, the optimum configuration and type of stations, adapted to affect entire cross sections without interfering with the navigation, will be obtained.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Rutgers The State University

5.0741, FATE OF PESTICIDES

B.R. WILSON, Rutgers The State University, School of Agriculture, *New Brunswick, New Jersey* 08903

The herbicide 3,4-dichloropropionanilide, or propanil is transformed in soil by microorganisms and in pure cultures of fungi isolated from soil, to 3,4-dichloroaniline which condenses to form 3,3',4,4' tetrachlorobenzene. Results from adsorption experiments utilizing DDT, linuron, malathion, and diphenamid in clay, soil, and humic acid systems indicate that these chemical compounds are strongly adsorbed by both clay and humic acid systems and released to the soil solution at an extremely slow rate. Analytical methods have been developed for organophosphate insecticides in water. Kinetic studies of chemical oxidation of organic pesticides is continuing. Thus far, 2,4-D is the only herbicide which appears to be biodegradable.

In cabbage and crabgrass increasing amounts of the herbicide diphenamid are absorbed as a function of time which results in reduced uptake of magnesium, calcium, potassium and phosphorus.

Propanil is enzymatically degraded in rice to 3,4-dichloroaniline and other products. The enzyme responsible is contained in subcellular particles similar to the lysosomes of animal cells.

Photoaldrin, the photoconversion product of aldrin, is 7x as toxic as aldrin to mosquito larvae. Repeated sublethal exposures of mosquito larvae to ethanol or ethanol-DDT generally becomes lethal due to ethanol accumulation. Reaction of large mouth bass to parathion is being determined.

Photochemical transformations of aldrin, patoran, linuron, diphenamid, and propanil have been completed. A procedure has been devised for the determination of diphenamid in plants.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0742, PURIFICATION OF LOW QUALITY WATERS BY FOAM SEPARATION

T.E. WILSON, Rutgers The State University, School of Engineering, *New Brunswick, New Jersey* 08903

The proposed research will involve laboratory scale experiments of both the batch and continuous type. Removal of turbidity, color and bacteria will be studied using both natural and lab-prepared water. Kinetic data from the batch studies will be used to develop a suitable continuous flow system. The constituents of the raw water will be varied and their effect, as well as the effect of air bubble size will be studied.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Rutgers The State University

5.0743, THE PREDICTION AND OPTIMIZATION OF STREAM RESPONSES TO POLLUTANT WASTES

R. DRESNECK, Found. For Adv. of Grad. Study, *Newark, New Jersey* 07103

The ability of the mathematical models presently used to predict the effects of pollutant loads upon the resultant stream biochemical oxygen demand (BOD) and dissolved oxygen (DO) profiles is questionable. The problem is complicated by the fact that some of the stream parameters are difficult to measure and that the mathematical models used do not, in many instances, adequately describe the physical conditions they model.

In this research, a previously developed model is presented which makes use of measured BOD and DO stream values for particular loading conditions to evaluate those stream parameters which cannot be easily measured, and then uses them, in turn, to predict the effects of future loading situations. By testing selected streams, the effectiveness of the proposed mathematical model will be evaluated.

SUPPORTED BY U.S. National Science Foundation

5.0744, A CONCEPTUAL STUDY OF THE DISTRICT OF COLUMBIA BIOLOGICAL TREATMENT PILOT PLANT

J. ROSE, Burns & Roe Incorporated, *Oradell, New Jersey* 07649 (14-12-151)

To perform a study to develop the concept of the District of Columbia Biological Treatment Pilot Plant in accordance with the requirements set forth herein: I. Study Criteria A. Evaluate the process layout and hydraulic requirements of the two train (100,000 gpd per train) biological treatment pilot plant as described in the attached specification for installation at the District of Columbia Water Pollution Control Plant. B. Develop a sludge disposal system for the above pilot plant which includes: 1. Sludge dewatering systems a. vacuum filtration b. centrifugation c. experimental dewatering 2. Sludge incineration C. Prepare functional process layout for two larger pilot plants based on the design criteria and flexibility in above D. C. pilot plant and including disposal facilities for plant sized with: 1. Two nominal 250,000 gal per day treatment trains 2. Two nominal 500,000 gal per day treatment trains D. Furnish a cost estimate for the (100,000 gpd/train) pilot plant in A above.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0745, APPLICABILITY OF ARDOX CATALYSTS TO THE OXIDATION OF MUNICIPAL SEWAGE EFFLUENTS AND OF WASTES PRODUCED DURING MANNED SPACE FLIGHT

B. INTORRE, Arde Incorporated, *Paramus, New Jersey* (14-12-141)

To perform a study to determine the applicability of ARDOX Catalysts to the oxidation of municipal sewage effluents and of wastes produced during manned space flights.

Using the appropriate Ardox catalyst and continuous operation of the reactor system, experimental runs shall be carried out to determine the effect of operating variables upon the extent of oxidation and to select optimum values of the variables for carrying out further work with municipal secondary effluent.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0746, A COST-EFFECTIVENESS STUDY OF PRETREATMENT METHODS SUITABLE FOR INTEGRATION TO MEMBRANE DESALTING PLANTS

J.S. KNEALE, Ritter Pfaudler Corporation, *Paramus, New Jersey* 07652

The objective of this study is to evaluate the need for an economics of pretreatment for high solids waters to protect the membranes used in desalination plants. The waters under consideration are brackish waters, acid mine waters and irrigation return flow waters. The flows under consideration are 0.25, 1.0, 5.0, 10.0 and 50.0 million gallons per day net output.

To accomplish this objective we will do the following: 1. Establish the contaminants that foul or poison the membranes. 2. Establish the tolerable limits of the contaminants. 3. Develop the economic treatment system to meet the established requirements. 4. Evaluate the savings or other benefits that result from the pretreatment. 5. For those systems that prove feasible, prepare a manual or catalog of commercial available equipment, cost of installed plant and cost of operation.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

5.0747, COALESCING MARINE OIL-WATER SEPARATOR

J.H. SEELINGER, Ritter Pfaudler Corporation, *Paramus, New Jersey* 07652

Land based test and evaluation of a marine residual fuel oil coalescing separator was completed and presented in a final design report entitled: 'Research and Development for a Shipboard Oil and Water Separation System' dated December 1966.

This unit is applicable to high gravity oils and functions without additives or air floatation.

The final report is available to the public through the Clearinghouse for Scientific and Technical Information

This project was initiated in FY 62 and was terminated in FY 67.

SUPPORTED BY U.S. Dept. of Commerce - Maritime
Admin.

5.0748, INTERSTATE REGIONAL PLANNING FOR WATER SUPPLY AND WASTE DISPOSAL

J.F. WRIGHT, Delaware River Basin Comm. , *Trenton, New Jersey*

The project objectives are: to develop needed information and plans for water-supply and waste-disposal facilities for an interstate region; to demonstrate regional interagency planning for prevention of water shortages, pollution, and other environmental health problems in rapidly developing areas; to test the concept of legally protecting the regional plan by making it a part of the 'Comprehensive Plan' as provided by the Delaware River Basin Compact. Task groups, composed of Federal, State and local representatives of resource and pollution control agencies, will collect and analyze data, prepare plans, select optimum alternatives, and prepare reports. Areas of study for the impact region include water supply, liquid-waste disposal and solid- waste disposal.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Delaware River Basin Commission

5.0749, DELAWARE ESTUARY AND BAY WATER QUALITY SAMPLING AND MATHEMATICAL MODELING PROJECT

J.F. WRIGHT, Delaware River Basin Comm. , *Trenton, New Jersey*

The purpose of this project is to evaluate the accuracy and reliability of the research data, and information made available for use in a mathematical model of the Delaware Estuary by conducting a series of sampling runs in the estuary over a period of years. These samples will be analyzed and compared with mathematical model projections in an effort to validate the mathematical concept for use in an estuary pollution abatement program.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Delaware River Basin Commission

5.0750, MODEL STUDY TO PREDICT SALT DISTRIBUTION AND CONCENTRATION OF WATER IN SOIL PROFILES

J.F. ALFARO, New Mexico State University, Water Resources Research Inst., *Las Cruces - University Park, New Mexico* 88001

In irrigated lands, salts are accumulated within the root zone as a result of irrigation and subsequent removal of water by the processes of evaporation and transpiration. In arid regions, such as the State of New Mexico, the salinization problems become more accentuated because there is less rainfall available to leach and transport the salts, and because of further salt concentration in soils and surface waters due to the high evaporation rates characteristic of these zones.

This study will work toward developing a method to predict salt concentrations in stratified soil, uniform and non-uniform soils, and to determine the effect of initial salt concentrations, soil moisture and salt concentrations of irrigation water on the accuracy of prediction, and to investigate the soil responses to the application of irrigation water of various qualities.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
New Mexico State University

5.0751, WATER REQUIREMENTS FOR SALINITY CONTROL IN UNSATURATED SOILS

H.E. DREGNE, New Mexico State University, School of Agriculture, *Las Cruces - University Park, New Mexico* 88001

This project is directed toward one of the most important problems facing irrigated agriculture in the Western States and in all irrigated areas in the world. The need for applying limited amounts of water to the soil is illustrated by the following points.

1. Two of the irrigated areas in New Mexico, the Pecos and Gila River basins, are limited in annual water application to three acre-feet per acre, or less, by recent court decisions. This eliminates the free use of water for leaching salts from the soil. 2. With limited water application, salt build-up becomes a major problem in the management of the land and the water. 3. The water pollution control regulations presently being put into operation will demand that salts added to the water supply by irrigation be held to a minimum. This would apply both to areas with full water supplies as well as those with limited water supplies.

The results could have application to New Mexico, the Southwest, and other areas of the United States and to the world wherever irrigation is practiced. Irrigation must become a more nearly exact science, and it is to develop one phase of that science that this project is proposed.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

5.0752, SOILS, PESTICIDES, AND THE QUALITY OF WATER

H.E. DREGNE, New Mexico State University, Agricultural Experiment Sta., *Las Cruces - University Park, New Mexico* 88001

Objectives: 1. To establish whether movement through the soil constitutes a significant source of the pesticides found in surface and ground water. 2. To identify the properties of pesticides and of soils that control the extent of movement of pesticides in and through soils. 3. (New Mexico will not contribute to this phase of the work.) 4. To ascertain the effects of management of pesticides and land on the transport, by all means, of pesticides to water supplies.

Description of work proposed: Leaching columns of varying lengths will be used to follow adsorption, release and movement of herbicides, including betasan and derivatives of 2,4 dichlorophenoxy-acetic acid applied to various soils. These soils will be characterized mineralogically, physically, chemically and biologically by standard methods. Soils having different textures will be selected for study, and organic matter content, time content, and exchangeable cation status will be varied. Herbicide movement will be followed under conditions of continuous leaching and alternate wetting variables and to the chemical properties of the herbicides. Field studies will be sued to determine the extent to which herbicides applied to the soil move through and over the soil in the presence of close-growing and row crops under a variety of soil and water management conditions.

SUPPORTED BY U.S. Dept. of Agriculture
New Mexico State Government

5.0753, FEASIBILITY OF TREATING AND RECYCLING USED FISH HATCHERY WATER

R.E. SPEECE, New Mexico State University, Water Resources Research Inst., *Las Cruces - University Park, New Mexico* 88001

The most common problem in fish hatchery operation is a limited water supply, particularly during drought periods. Some hatcheries are also hampered by year-round water shortages. Appropriate treatment of the used water to restore the necessary quality characteristics for subsequent recycling offers the most promising solution to this problem. It would also permit construction of new fish hatchery facilities at sites with limited water supplies.

A treatment system, capable of removing ammonia, carbon dioxide, organic metabolites, disease producing organisms, and providing for restoration of the dissolved oxygen will be developed. A cost analysis of the treatment and recycle system will be made for several typical installations. A corresponding benefit analysis, based on increased fish production, will also be determined for the same installations. This will enable a benefit-cost ratio to be determined. Thus, conditions where treatment of used fish hatchery water for recycling would be economically feasible can be determined.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
New Mexico State University

5.0754, CONTROLLING FACTORS IN METHANE FERMENTATION

R.E. SPEECE, New Mexico State University, School of Engineering, *Las Cruces - University Park, New Mexico* 88001

The specific aim of this proposed work is to determine the fundamental factors which control: (1) the rate of methane fermentation under anaerobic conditions; (2) the initiation of methane fermentation of organic compounds under anaerobic conditions; and (3) the reinstating of active methane fermentation in an anaerobic digester which has ceased methane production due to adverse conditons.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0755, DEVELOPMENT OF A FROTH PROCESS FOR THE TREATMENT OF SOUR WATER

D.B. WILSON, New Mexico State University, Water Resources Research Inst., *Las Cruces - University Park, New Mexico* 88001

It is proposed to investigate the treatment of sour water by a chemical process in which the appropriate chemical scavengers for the sulfide ion will be surface active. The process will utilize a froth for contacting the sour water. Further, to improve the economics of the process, it is planned to utilize process chemicals which result in the production of elemental sulfur. Subsequent separation will permit recycle of the chemical scavenger and recovery of the sulfur.

Coincidental to the development of the above process will be research in areas of the kinetics of reactions involving non-rigid interfaces, surface diffusion, and the kinetics of precipitation in interfacial regions. The extent of the work done in these areas will be limited; however, a complete understanding of the proposed process will require further research into the above subjects.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
New Mexico State University

5.0756, CYTOTAXONOMY AND RELATED STUDIES OF HOLARCTIC MIDGES

J.E. SUBLETTE, Eastern New Mexico University, Graduate School, *Portales, New Mexico* 88130

Eighty-two species of midges (Chironomidae:Diptera) have been reported as having a holarctic distribution. The identify of many of these in North America is questionable. To elucidate the identities, conventional taxonomic studies of adults, both field collected series and museum types and named specimens, will be undertaken. To corroborate these results cytotaxonomic and biochemical studies will be made on appropriate larval populations.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0757, MORPHOLOGY AND STABILITY OF STREAM CHANNELS IN SOUTHWESTERN SEMIARID RANGELAND WATERSHEDS

R.B. HICKOK, U.S. Dept. of Agriculture, *Santa Rosa, New Mexico* 88435

Objective: Methods for predicting and control of gulley and stream channel erosion, and sediment deposition damage.

Plan of Work: Evaluate processes of channel aggradation, degradation, horizontal realignment, and changes in cross-sectional shape and net sediment yield in relation to types of bed and bank materials, upstream sediment sources, streamflow regimes and control measures.

SUPPORTED BY U.S. Dept. of Agriculture

5.0758, TREATMENT NEEDED BY SEWAGE BEFORE INJECTION - WELL RECHARGE

L.J. HETLING, State Dept. of Health, *Albany, New York*

Sewage effluent from a secondary (bio-filtration) plant will be given tertiary treatment including, but not limited to, rapid sand or diatomaceous earth or carbon column filtration. The effluent will then be recharged by injection well; at the same time, a portion of the effluent will be injected into a ground simulator. Both the ground simulator and the injection well will be loaded to failure to determine the factors that cause failure of the system. The treatment requirements for sewage reclamation for well recharging will be demonstrated.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
New York State Government

5.0759, SPRING CREEK AUXILIARY WATER POLLUTION CONTROL PROJECT

M. LANG, State Dept. of Pub. Works, *Albany, New York*

Phase I: To characterize and evaluate the combined sewer overflows into Jamaica Bay and relate their significance to sewage plant effluents, storm runoff, landfill leachants, dredging and tidal interchange. To determine the physical, chemical, bacteriological and biological characteristics of Jamaica Bay as effecting its recreational values. Develop mathematical models for dissolved oxygen and coliform in Jamaica Bay.

Phase II: Study in greater detail the conditions in the waters most affected by the discharges from the Spring Creek combined sewer overflow.

Phase III: The Spring Creek Auxiliary Pollution Control Plant must be completed before Phase III can be started. The objective of this Phase is to survey the areas of Jamaica Bay studied during Phase II, and the effluent from the Spring Creek Plant, and make a quantitative evaluation of the treatment processes and the results achieved.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
New York City Government - New York

5.0760, COMPOSITION OF RESIDUES FROM PULP BLEACHING TREATMENTS

C.W. DENCE, State University of New York, Graduate School, *Albany, New York* 12203

The spent liquors from kraft chlorination and alkali extraction pulp bleaching sequences are to be examined by various chemical and physical means to determine the structure and composition of the modified liqnin residues contained therein. Special emphasis will be placed on establishing the presence or absence of o-quinone intermediates in the chlorinated pulps and in the chlorination spent liquors. This phase of study will be prefaced by a detailed study of the reactions lignin- like (model) compounds with chlorine in which attempts will be made to isolate and characterized the anticipated o-quinone intermediates. Attempts also will be made to characterize the products arising from reactions of the (proposed) o-quinone intermediates and other substances likely to be present in the bleaching system. Finally the reactivity of chlorolignin toward alkali will be examined to gain an insight into the structure of the resulting residues particularly insofar as the location of the chlorine substituents on the chlorolignin molecule is concerned.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0761, RENOVATION OF A DYSTROPHIC LAKE INTO A EUTROPHIC LAKE

K.E. DAMANN, State University of New York, Graduate School, *Brockport, New York* 14420

A regular weekly collection program was initiated at McCargo Lake on the Fancher Campus of State University of New YOrk, College at Brockport, early in March, 1967. Preliminary investigations involved exploring the entire area of the lake with the hope of establishing a limited number of stations that might be considered typical for study of the chemical and physical factors related to biological activity.

Chemical analysis were performed weekly at the Fancher Campus laboratory on water collected at three levels (surface, 10', bottom) for the following parameters: Dissolved Oxygen, Carbon Dioxide, Calcium, Magnesium, Silicates, Phosphates, Nitrates, Hydrogen Sulfide, Alkalinity, pH.

Duplicate samples collected from three levels were analyzed each week in the laboratories on the Brockport Campus using more precise wet chemical methods for the following: Inorganic Nitrogen, Organic Nitrogen, Nitrates, Chlorides, Orthophosphate, Poly-phosphate, Sulfates, Sulfites.

The Perken Elmer, Model 303, Atomic Absorption Analyzer has been placed in operation and will be used for routine analyses during the remainder of the project.

Macro-bottom fauna, aerobic and anaerobic bacterial plate counts, direct microscopic bacterial counts from submerged slides, and a census of the fish population were the areas of biological investigation carried on during 1967-68.

Total plankton counts were made weekly at the same three levels used for the chemical analyses. In addition, a preliminary periphyton study was done by submerging glass slides at three levels. This work will be carried on in much more detail during 1968-69.

Two fiber glass cylinders (20' x 6') have been permanently located in the experimental lake. Aerating filters are installed and will be operated on an experimental basis during a portion of 1968. After determining the effect of aeration on chemical, physical and biological activity during a complete cycle, a decision will be made on whether or not to aerate the entire lake.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
State University of New York

5.0762, THE BIOCHEMISTRY OF ANAEROBIC DIGESTION

J.S. JERIS, Manhattan College, School of Engineering, *Bronx, New York* 10471

Investigations in anaerobic digestion have shown that the process has great potential for treatment of concentrated complex wastes. Yet, the process is not being used to its maximum potential because of a lack of fundamental knowledge of its microbiology and biochemistry.

The general objective of this proposal is to explore further the basic biochemistry in order to determine the general pathways involved in the anaerobic microbiological breakdown of various pure organic compounds which are constituents of complex wastes. Some of the compounds under study include propionic acid, lactic acid, succinic acid, glutamic acid, glycine, and oleic acid.

The role of intermediate compounds such as acetic, propionic and butyric acids is under study as they appear to be very important metabolic products.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0763, NEW SELECTIVE MEMBRANES

J. STEIGMAN, Polytechnic Inst of Brooklyn, Graduate School, *Brooklyn, New York* 11201

This research will consist of theoretical and experimental studies of the transport of ions through chemically modified extruded cellulose membranes. Previous work has shown that the small number of carboxylic acid groups in a cellulose membrane adsorb polyvalent ions like calcium, that amidification of the groups virtually eliminates the adsorption, and that the transport of calcium in amidified membranes is slower than that of sodium in quite dilute solutions. Work will be done on further chemical alteration of membranes and on the transport of various univalent and polyvalent cations (and on the effects of various anions) as well as on the transport of water itself in commercial cellulose and in chemically modified cellulose membranes.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

5.0764, DEPOSITION OF FINE SEDIMENTS IN TURBULENT FLOWS

***E. PARTHENIADES*, State University of New York, School of Engineering, *Buffalo, New York* 14214**

The proposed project concerns the hydrodynamic behavior of fine cohesive sediments in turbulent flow fields such as those created by open channel flows. The primary general goal is the discovery of the flow parameters, which control the initiation, the degree and the rates of deposition of that sediment and the derivation of analytical relationships between these variables for only one type of sediment. Recent investigations by the writer and others revealed some important relationships between certain flow parameters such as average boundary shear and secondary flow, and some depositional characteristics, such as the percent of fine load deposited under given flow conditions. The specific objectives of the proposed study are: (a) Effect of secondary currents on deposition and in boundary shear stress distribution together with an attempt to express them in terms of readily determinable flow parameters. (b) Effect of boundary roughness on depositions. Some pilot studies of the effect of sediment properties and water quality on deposition are anticipated.

The information sought is needed for rational control of shoaling, prediction of deposition sites of solid waste disposed in the form of fine sediment and selection of disposal sites to avoid pollution of specific zones.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0765, PRECISION ANALYSIS WITH ION-SELECTIVE ELECTRODES

***G.A. RECHNITZ*, State University of New York, Graduate School, *Buffalo, New York* 14214**

It is proposed to develop techniques and procedures for the precise analysis of ions in aqueous media using novel ion-selective membrane electrodes. Special emphasis will be given to the utilization of solid -state and liquid-liquid membrane electrodes. It is expected that superior methods can be devised for the rapid and continuous determination of Ca , Cu , Zn , SO4--, PO4---, Cl-, Br-, I-, F-, S--, NO3- over a wide concentration range.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

5.0766, DYNAMIC MODEL STUDY OF LAKE ERIE

***R.R. RUMER*, State University of New York, School of Engineering, *Buffalo, New York* 14214**

A rotating laboratory (11' x 18') is being used for a hydraulic model study of Lake Erie. The principal objective of this study is to determine the degree of usefulness of a rotating vertically distorted Froude model in the prediction of the response of Lake Erie to various physical inputs such as inflows, wind stress, etc. Analytical studies of others as well as of the investigators will be used in attempts to predict the dynamic behavior of the model lake. Field data taken during the GLIRB study and reports of other field studies will be used in the model verification process.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0767, NEUTRON ACTIVATION ANALYSIS OF IMPURITIES IN RAIN AND SNOW

***I.G. HAN*, State University of New York, Graduate School, *Fredonia, New York* 14063**

The goal of this project is to determine the average concentration of Ca and S in samples of precipitation collected in the vicinity of Fredonia which is located at the leeshore of Lake Erie. The lake effect storms characteristic of this region make it possible to study the meteorological functions affected by the large polluted lake.

Samples of rain and snow water will be activated in a reactor and will be analyzed to determine the average concentrations of Ca,K,and S of lake effect storm precipitation and non-lake effect storm precipitation separately.

The results will be correlated with meteorological variables in an attempt to pursue understanding of the role of these elements over the large polluted lake as materials for condensation nuclei, of the efficiency of precipitation for removing these elements from the air, of the probable origins, and of the characteristics of the lake effect storm.

According to the work done by Junge and others on the chemical concentration of rain water over the United States, precipitation samples of lake effect storms collected at the leeshore of a large lake will show chemical concentration ratios close of those of lake water if the lake is large enough. The assumption is supported by the Cl/Na ratio of the rain and snow water from lake effect storms and non-lake effect storms which was collected in the vicinity of Fredonia and analyzed by the applicant of this proposal in the summer of 1966.

The project is the continuation and expansion of the work on Cl and Na. The concentrations of Ca,K, and S are very high in the Lake Erie water. Preliminary samples with the activation method.

SUPPORTED BY State University of New York

5.0768, DISCHARGE OF INDUSTRIAL WASTES TO MUNICIPAL SEWER SYSTEMS

V.C. BEHN*, Cornell University, School of Engineering, *Ithaca, New York

The ultimate objective of this work is to prepare, for selected water using industries in New York State, results which should be of direct value to any industry contemplating the discharge of wastes into a municipal sewer system.

The study will concentrate on four different groups of plants, all of which are well represented within New York State. These four are pulp and paper mills, organic chemical plants, canned fruits and vegetables , and blast furnaces and steel mills . Two sites will be selected for study from each group of plants to represent small and large industries.

Feasibility studies will be run involving the following factors: equalization, neutralization, nutrient requirements, and sludge flow and handling characteristics. These will then be combined with a survey of sewer ordinances and rate structures now being applied within New York State.

The results should aid any industry now faced with a decision on whether or not to treat wastes separately or discharge the wastes into a municipal sewer system.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Cornell University

5.0769, DESIGN OF WASTEWATER TREATMENT SYSTEMS TO SATISFY EFFLUENT QUALITY REQUIREMENTS BASED ON INTENDED USE

A.W. LAWRENCE*, Cornell University, School of Engineering, *Ithaca, New York

It is the objective of this study to have a 'fresh' look at wastewater treatment processes and systems in light of the growing interest in the reclamation of wastewaters as a 'new' source of water. This fresh look or reevaluation of wastewater treatment technology will be directed towards:

1) a review of the intended uses for reclaimed waste waters and determination of the quality requirements associated with each use.

2) a reevaluation of existing wastewater treatment processes and systems in the context of expected future performance criteria, i.e., effluent quality requirements.

3) examination of new processes or new combinations of existing processes in an effort to develop treatment methodology capable of satisfying effluent quality requirements which are not presently attainable.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Cornell University

5.0770, ADAPTATION BY MICROBIAL POPULATIONS

N.C. DONDERO, State University of New York, School of Agriculture, *Ithaca, New York* 14850

Selected experiments on enzyme adaptation and repression have been made with pure cultures and mixed populations of microorganisms derived from activated sludge for the purpose of determining the physiological and nutritional homogeneity or heterogeneity of the populations transforming aromatic materials and other carbonaceous substrates.

The analysis of the populations have been made previously by enumeration and replica-plating on a series of substrates planned to show the capabilities of the population to utilize the substrates present and to reveal shifts in the microbial population when they occur.

Similar analyses will be made of the microbial populations in the processes of sewage treatment and a potable water impoundment.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0771, EFFECTS OF DISSOLVED OXYGEN CONCENTRATION ON SURVIVAL OF LARGEMOUTH BASS EMBRYOS

A.W. EIPPER, State University of New York, School of Agriculture, *Ithaca, New York* 14850

Objectives of this project are 1) To determine the effect of various oxygen concentrations on the survival of largemouth bass embryos until hatching, 2) To determine effects of interactions of temperature and oxygen on the survival of largemouth bass embryos until hatching, and 3) To determine effects of interactions of water movement and oxygen on survival of embryos until hatching. Construction of a 'degasser' to control dissolved oxygen concentrations in aquaria was completed early in 1968, and literature work on the effects of oxygen survival of fish embryos was begun. During the 1968 bass spawning season, lots of 50 bass embryos of known age were subjected to different oxygen concentrations at each of three different temperatures. The azide modification of the Winkler method was used to monitor O_2 levels, and dead embryos were removed each day. Preliminary analysis indicates that survival of embryos to normal larvae at oxygen levels above 2.1, 3.0 and 3.4 mg/liter at 15, 20 and 25 C, respectively, is similar to survival at 90% oxygen saturation for each temperature. At lower oxygen levels, survival decreases sharply. Approximations of LD50 levels would be 1.8, 2.3, and 3.1 mg/l for 15, 20 and 25 C, respectively. For the same temperatures, oxygen levels of approximately 1, 1.5, and 2.1 mg/l caused complete mortality. Further analysis of data is in progress and will continue through the coming academic year.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
New York State Government
Cornell University

5.0772, EFFECT OF WATER QUALITY ON FIRST-YEAR MORTALITY OF LARGEMOUTH BASS

A.W. EIPPER, State University of New York, New York Coop. Fishery Unit, *Ithaca, New York* 14850

The objective of the proposed project is to contribute to establishment of water quality standards by determining the effects of temperature, oxygen concentration and other aspects of water quality on mortality of largemouth bass during the egg and larval stages. Information on factors affecting first-year mortality of game fish species is also essential for management of populations necessary to increase the capacity of water resources to produce food and recreation. Investigations of causes of first-year mortality conducted by the New York Cooperative Fishery Unit will be continued and expanded. Additional equipment for temperature and oxygen control and monitoring will be employed to study survival of eggs and fry at various levels of temperature and dissolved oxygen. The relationships of turbidity, pH, and alkalinity to mortality will also be evaluated. Studies of the effects of water quality on predators, kinds and quantity of food available to fry, and other ecological phenomena are also planned. After preliminary observations and monitoring in nature, mortality factors will be evaluated under controlled laboratory conditions, and attempts will then be made to determine if relationships observed in the laboratory apply in earthen ponds and natural waters.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Cornell University

5.0773, LIMNOLOGICAL INVESTIGATION OF ONEIDA LAKE

D.J. HALL, State University of New York, Agricultural Experiment Sta., *Ithaca, New York* 14850

Objectives: 1. Investigate current nutrient conditions in Oneida Lake in light of possible nutrient enrichment. 2. Examine relationship between continuous nutrient recycling and plankton production. 3. Determine the fate of the zooplankton in Oneida Lake.

A two-year study is proposed in which extensive year-round water analyses, quantitative plankton and fish collections will be made in order to ascertain fundamental relationships in the food chain dynamics of Oneida Lake. Analyses of phosphorus, nitrogen and other selected nutrients will be routinely carried out. The rate of nutrient regeneration will be examined in relation to the unusual summer circulation (mixing) pattern in the Lake. The primary production of phytoplankton using the C14 technique and zooplankton population turnover rates will be estimated from appropriate field experiments and analyses. Extensive examination of fish stomachs collected by the Cornell Department of Conservation will yield information about the possible fate of zooplankton in this system.

SUPPORTED BY U.S. Dept. of Agriculture
New York State Government

5.0774, EQUIPMENT TO AGITATE POND SOILS FOR RELEASE OF NUTRIENTS

E.S. SHEPARDSON, State University of New York, Agricultural Experiment Sta., *Ithaca, New York* 14850

To develop principles and techniques for: (1) aggressively disturbing pond bottom sediments, (2) effectively produce a suspension of same and (3) the introduction of powdered limestone simultaneously into the disturbed suspension of bottom sediments. Develop the equipment and techniques to sufficient efficiency, portability and use with small boats to dispense large quantities of limestone in waters of moderate size (up to 50 acres).

Various ideas will be investigated to determine the best way(s) for plowing, harrowing, jetting or otherwise disturbing pond bottom sediments sufficiently with surface controlled equipment. Simultaneously, a means for suspending this material, temporarily, will be investigated. At the moment, air injection appears to be one possible technique. Mechanical beaters may be another approach. Following the development of the principle of satisfactorily rooting up and suspending the bottom sediment, a means of effectively introducing ground limestone into the disturbed mass will be sought. The exact course of investigation will depend on the above developments.

Appropriate pond soil and water tests will be made in the field test of the device to determine the immediate and seasonal effects of the treatment.

SUPPORTED BY U.S. Dept. of Agriculture
New York State Government

5.0775, POULTRY MANURE PROPERTIES, HANDLING AND DISPOSAL

A.T. SOBEL, State University of New York, Agricultural Experiment Sta., *Ithaca, New York* 14850

1. To determine the chemical, physical and rheological properties of poultry manure related to handling, disposal, and/or utilization. 2. To investigate basically several methods of disposal and utilization.

The properties related to handling, disposal or utilization of manure will be determined. Samples will be gathered from various sources to obtain a broad range of breed, management, and other factors which will influence the composition and quantity of manure produced. Such conditions will be recorded so that ranges can be established for the various properties, as the extremes of these ranges are important in handling the manure. The manure will be investigated as a solid waste and as a suspension in water. This information will then be used in trial methods in the laboratory (or in the field if indicated) and the results extended to consider what would be involved in handling larger quantities of manure.

SUPPORTED BY U.S. Dept. of Agriculture
New York State Government

5.0776, THE LOSS OF ORGANIC AND INORGANIC MATERIALS FROM ABOVE-GROUND PLANT PARTS, WITH REFERENCE TO DECONTAMINATION OF PARTS UTILIZED FOR FOOD

H.B. TURKEY, State University of New York, School of Agriculture, *Ithaca, New York* 14850 (AT(30-1))

Appreciable quantities of inorganic and organic metabolites are leached from above-ground plant parts by rain and mist. Mineral nutrients, amino acids, organic acids, and carbohydrates are leached from a wide range of plant species. Young plants, including food plants, are grown in radioactive nutrient solutions and are leached with a water mist. The leachates are collected on resins and losses by leaching are determined quantitatively by radioactive analysis and qualitatively by chromatographic means.

Important areas of investigation are: 1. Leaching of fallout products from food plants in relation to absorption and distribution of the fallout within the plant, 2. Influence of specific chemicals on leaching, such as surfactants, 3. Leaching of organic metabolites, 4. Leaching of growth regulating substances.

Leaching is influenced by species, metabolites being leached, leaf morphology and age, nutrition, environmental factors, injury, and duration and intensity of rain. Inorganic an organic metabolites leached from one plant are root-absorbed and utilized by other species. Leaching of calcium and other cations involves exchange reaction both within the plant and on the leaf surface. Leaching is an important ecological factor in plant development and association. It plays a role in the distribution of fallout products and the natural decontamination of plants.

SUPPORTED BY U.S. Atomic Energy Commission

5.0777, IMPROVEMENT OF TREATMENT OF FOOD INDUSTRY WASTE

S. TUWINER, R A I Research Corporation, *Long Island City, New York* 11101

To investigate on a laboratory scale electrochemical oxidation of milk whey as a method of waste treatment.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Rai Research Corporation

5.0778, ADVANCED WASTE TREATMENT FOR WATER RECLAMATION AND REUSE BY INJECTION

H.J. SIMINS, Nassau Co. Dept. of Pub. Works, *Mineola, New York* 11501

Nassau County is committed to a long-range program to demonstrate the feasibility of using water reclaimed from sewage-plant effluent to increase the available ground-water resources.

The objective of the project is to conduct studies of advanced waste treatment processes and to demonstrate that the reclaimed secondary effluent is suitable for reuse and injection into underground aquifers. The project will provide operating data on advanced waste- treatment processes and allow optimizing the economics of the process. It will also demonstrate the effectiveness and reliability of advanced waste treatment as a method of providing water for reuse from secondary treatment plant effluent.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Nassau County Government - New York

5.0779, WATER CONSERVATION BY WASTE WATER RECLAMATION AND INJECTION OR RECHARGE

H.J. SIMMS, Nassau Co. Dept. of Pub. Works, *Mineola, New York* 11501

The purpose of this project is to conduct pilot studies on activated sludge sewage effluent to improve its quality to conform with required drinking water standards and inject or recharge it into sub-surface water bearing strata for re-use after removal of suspended solids. Using all information available in this field and also data obtained from bench scale and pilot plant units, a tertiary treatment plant will be designed and constructed. In addition an injection well and a network of observation wells will be dry and operated on a three- four year program.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Nassau County Government - New York

5.0780, IMPROVED CAPABILITIES OF BIOLOGICAL SYSTEMS TO ASSIMILATE OIL

R.N. SIMONSEN, Amer. Petroleum Institute, *New York, New York* 10020

The project will consist of a study of laboratory scale activated sludge waste treatment systems which will be operated to determine their tolerance to various types and amounts of hydrocarbons, the nature of the interference of the hydrocarbons, the fate of the hydrocarbons in the system, and to study methods for improving pretreatment of the influent and of improving the operation of the system.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Amer. Petroleum Institute

5.0781, SEPARATION OF SANITARY SEWAGE FROM COMBINED SYSTEMS OF SEWERAGE

M.B. MCPHERSON, Amer. Soc. of Civil Engrs. , *New York, New York* (14-12-29)

The general concept on which the project is based involves discharging comminuted or ground sewage from individual buildings and/or building complexes through relatively small pressure tubing laid in existing building connections, and thence into new pressure conduits suspended in existing street sewers. The new separate sanitary sewage pressure conduits would then discharge into existing interceptors that would convey the sanitary sewage to treatment works. Storm water alone would be carried in what were formerly combined sewers. The most comparable alternative to meet the same objective is traditional, complete separation by means of new sanitary sewers and attendant separate sanitary and drainage building connections. The project scheme was conceived by Dr. Gordon H. Fair of Harvard University.

The basic objectives of the project are to determine the physical feasibility and limitations of the project scheme or modifications thereto, and to arrive at measures of cost for comparison with the traditional method of separation for evaluation of investment feasibility.

Headquarters for the project are provided by Harvard University at 40 Oxford Street, Cambridge, Mass. 02138.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Amer. Society of Civil Engineers

5.0782, HYDROLYSIS OF SLUDGE USING LOW PRESSURE STEAM WITH SO2 AS A HYDROLYTIC ADJUNCT AND TO STUDY THE UTILIZATION OF THE RESULTING HYDROLYSATE

B.C. REIDY, Foster D. Snell Incorporated, *New York, New York* 10011 (14-12-188)

To conduct a feasibility study to determine the effectiveness of a chemical process utilizing dilute sulfurous acid to digest and hydrolyze sludges of various types produced in waste disposal processes.

An evaluation of the economic aspects of the process will be made once the best reaction conditions are determined. This evaluation will include factors affecting the desirability of incorporating this process as an alternate disposal system. These include: (1) Chemical composition of digested products and the solid residue. (2) Process and equipment costs which are a function of temperature, pressure, and chemical composition. (3) Raw materials costs, such as SO2. (4) A study of methods of ultimate disposal of the undigested (inorganic), portion of the sludge and its potential use as fertilizer or soil conditioner, etc. (5) A study of the utilization of the concentrated digest as a fermentation adjunct, cattle feed (digest molasses), etc.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0783, EVALUATION AND DEMONSTRATION OF THE MASSIVE LIME PROCESS FOR THE REMOVAL OF COLOR FROM KRAFT PULP MILL WASTES

S.R. WILLIAMSON, Internat. Paper Company, *New York, New York* 10017

International Paper Company porposes to isolate wastes from the caustic extraction stage of Kraft pulp bleaching line and the unbleached decker of the pulp mill, and to treat these wastes separately and combined for the removal of color and reduction of biochemical oxygen demand by the Massive Lime Process over a period of 27 months.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
International Paper Company

5.0784, POLLUTION CONTROL OF BATHING BEACHES BY USE OF A PNEUMATIC CURTAIN

R.J. MOSHY, Natl. Pollution Control Found. , *New York, New York* 10017

To demonstrate the reduction of pollution levels at bathing beaches by enclosing the swimming area with a dense curtain of air bubbles emanating from perforated pipes laid on the bottom. This technique aerates the enclosed water and circulation patterns set up by the rising bubbles provide a barrier for floating debris, including oil.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
National Pollution Control Foundation

5.0785, COMPUTE SIMULATION OF DIFFUSION STUDIES

E. MEHR, New York University, Geophysical Sciences Lab. , *New York, New York* 10003

The objective of this grant is the study of Monte Carlo simulation models for both diffusive and turbulent phenomena, and their application to water pollution problems.

The Diffusion Simulation Model will simulate streams and estuaries in both one and two dimensions. Further the third dimension will be simulated by means of two or three depth layers. Results will be checked by means of available data.

The Turbulent Simulation Model - The classical approach to esturian diffusion problems essentially involves specifying initial and boundary conditions, assuming or calculating values for mixing coefficients and solving the resulting differential equations. In applications the problem is frequently solved for a wide range of conditions and values for mixing coefficients since these quantities may not be known to a high degree of accuracy. A detailed discussion of the advantages and disadvantages of this approach is not the purpose of this report. Suffice to say that alternate approaches to the problem are of interest.

The purpose of this phase of the research is to investigate an alternate approach. The approach is to develop a model for small scale velocity disturbances that can simulate the role of turbulence in esturian diffusion problems. The details on the structure of this velocity field is given in the next section; here a brief outline of the procedure is presented. The turbulent velocity field is simulated in the computer by specifying the flow characteristics in a combination analytic-random fashion. In principle the adequacy of the simulated turbulence can be checked by comparing the simulated Reynolds stress functions, velocity correlation functions and power and cross power spectral functions with observations from laboratory and field measurements. Once the simulation model has been judged successful then it can be applied to esturian diffusion problems.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0786, ENVIRONMENT AND VIRUS-HOST INTERACTIONS IN FISHES

A. PERLMUTTER, New York University, Graduate School, *New York, New York* 10003

A considerable literature exists on the relationship of aquatic pollution to fishes and the fisheries particularly in regard to the lethal effect of industrial pollutants and insecticides on juvenile and adult fish. However, there is little information on the sublethal effects of such substances and their possible influence on the progeny of animals which survive exposure to the substances. Also, although the literature indicates that embryonic stages of fishes are most susceptible to unfavorable environmental conditions, the relationship of embryonic development to sublethal levels of pollution is not well understood. Further, little attention has been given to the role of the viruses as pollutants in the aquatic environment.

Our research objectives are therefore directed towards study of the interrelationship of viruses, sublethal levels of chemical pollutants and insecticides, and other environmental factors on the tissues and embryonic stages of fishes. In its initial stage, the study will be restricted to tissue cultures of: rainbow trout gonad (RTG 2); inbred strain of platyfish, 163A; and zebrafish. Embryological studies will be limited to the latter two species. Zinc salts, chlorinated hydrocarbon and organophosphorus insecticides in common use, and a known fish virus, infectious pancreatic necrosis (IPN), will be tested under various conditions of temperature, pH and light to determine their individual and combined effects on fish tissue and developing embryos.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0787, THE SPREADING OF OIL FILMS

H.G. SCHWARTZBERG, New York University, School of Engineering, *New York, New York* 10003

One objective of the proposed research is to determine the effect of oil volume and physical properties on the area and rate of spread of area of oil films formed by the spilling of oil on quiescent water.

The second objective is to determine how oil film area and rate of spread of area and film travel are affected by the dynamic forces, such as wind, wave, current, and tide action, encountered at sea.

These objectives are designed to provide an ability to predict oil film spread and travel following accidental large scale spillages of oil at sea. This predictive ability is necessary for the effective use of available resources in combatting the pollution caused by such spills.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0788, PHOSPHORUS REMOVAL IN THE ACTIVATED SLUDGE PLANT

T.E. BRENNER, Soap & Detergent Association, *New York, New York* 10022

The overall objective of this project is to determine the feasibility of removing phosphorus in an activated sludge plant treating domestic waste water through chemical precipitation with aluminum ion and utilizing only the existing aeration and settling units of the plant.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Soap & Detergent Association

5.0789, HETEROGENEOUS OXIDATION OF POLLUTANTS IN WATER

J. LIPSIG, State University of New York, Graduate School, *Oswego, New York* 13126

An exploratory project has begun to determine whether organic pollutants can be removed from water by their partial or complete oxidation to carbon dioxide and water using a solid material as a catalyst and air as the oxidizing agent. Such a procedure would have economic advantages as air is inexpensive, but there are no known effective oxidation catalysts that operate under the desired conditions.

One reason for this has been the lack of investigation in this area. Therefore, the use of rare metal catalysts on supports and metal oxide catalysts, are being investigated. Also use will be considered of inorganic oxidants and of their regeneration after use.

Positive results with a system will determine which type of catalyst will receive the most study.

SUPPORTED BY State University of New York

5.0790, MICROFLOTATION AND FLOCCULATION OF NATURAL COLLOIDAL SYSTEMS

E.A. CASSELL, Clarkson College of Technology, School of Engineering, *Potsdam, New York* 13676

This grant will provide for theoretical and experimental studies concerned with the development of technology for removing suspended organic and inorganic colloids from aqueous suspensions by a unique microflotation technique. Electrochemical studies will be made of charge reversal and natural colloid flocculation in order to establish optimum conditions for microflotation. The engineering applicability of microflotation to water renovation technology will be determined by comparison with conventional flotation and coagulation and settling techniques.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

5.0791, THE SURFACE SHEAR VISCOSITY OF MONOMOLECULAR FILMS

F.C. GOODRICH, Clarkson College of Technology, Graduate School, *Potsdam, New York* 13676

Public awareness of problems of water pollution has been stimulated by the increasing presence of foams on natural surface waters. The objective of the proposed research will be to make a quantitative study of the rheological properties of matter in the boundary state, under the assumption that the behavior of thin films undergoing fluid flow plays an important role in the macroscopic properties exhibited by foams and emulsions.

Previous work in this area has been universally hampered by the lack of a suitable hydrodynamic analysis of the flow patterns in a fluid system in the neighborhood of a viscous interface, so that it has been impossible to disentangle the effects due to the viscosity of the bulk fluid from those due to the surface viscosity of adsorbed films.

The proposed program is based upon an already successful mathematical analysis of the hydrodynamic problem and would make the mathematical results of practical utility to experimenters. At the same time, an experimental program would be initiated which, together with the computer results, would permit for the first time a quantitative measurement of the absolute surface viscosities of monomolecular films.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0792, A DEMONSTRATION OF JOINT-MUNICIPAL-INDUSTRIAL WASTE TREATMENT IN THE ONONDAGA LAKE WATERSHED

J.J. HENNIGAN, Onondaga Co. Pub. Works Dept. , *Syracuse, New York* 13204

The objectives of the project are to demonstrate the establishment and operation of county government and industry-wide cooperative effort for joint-municipal-industrial total waste treatment on an entire watershed basis and to demonstrate the feasibility of chemical treatment of complex mixtures of industrial wastes in combination with domestic wastes. Also, the effects of the proposed changes to the waste management program of Onondaga County, New York will be evaluated.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Onondaga County Government - New York

5.0793, AQUATIC PLANT CHEMISTRY-ITS APPLICATION TO ECOLOGY

R.T. LALONDE, State University of New York, Graduate School, *Syracuse, New York* 13210

The demonstration that some aquatic plants produce protistostatic and antibacterial chemical materials strongly suggests that these plants could affect water quality through a mechanism of chemical interaction with other water organisms. While an adverse effect could possibly result from the poisoning of bacteria which consume organic material in the water, a beneficial effect could possibly result through elimination of undesirable organisms which in high populations would make water suitable for consumption, recreation or the support of wildlife.

Therefore, it is the objective of the proposed research to determine the chemical structure of known antiprotistic and antibacterial chemical materials, to search aquatic plants for new chemical materials, to isolate them and establish their chemical nature and at the same time to obtain information pertaining to the revelant biological activities of these new chemical agents and to determine their distribution in aquatic plants.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0794, EFFECTS OF DIFFERENT FOREST TYPES AND CONDITIONS ON STREAM REGIMEN AND WATER YIELDS

R.E. LEONARD, State University of New York, Graduate School, *Syracuse, New York* 13210

Object: To determine the influence of climatic, edaphic, and other environmental factors on hydrologic processes in relation to forest types and conditions.

Plan of work: This is a cooperative project with the New York State University College of Forestry. The project leader is determining the reflection of solar radiation by a conifer forest; conducting a study of snow interception by coniferous tree crowns and its disposition under climatic conditions of central New York; and the effect of land- use changes on streamflow in the Allegheny Plateau Region of New York state.

SUPPORTED BY U.S. Dept. of Agriculture

5.0795, BIOLOGICAL TREATMENT OF ACID MINE WATER

P.A. RICE, Syracuse University, Research Institute, *Syracuse, New York* 13210

A three-year study is proposed to test the feasibility and to gather basic process data on the treatment of acid mine water in an anaerobic biological reactor containing the species Desulfovibrio desulfoxidans. If initial experiments demonstrate the feasibility of biological treatment, a set of parametric experiments will be carried out to determine the relationships between the amounts of hydrogen, sulfate, ferrous, and ferric ions removed and the process conditions. Appropriate mathematical models will be developed to describe the relationships between variables and to indicate the mechanisms controlling the removal rate of ions under various operating conditions. These models will be useful in recttor scale up and in understanding the basic mechanisms of sulfate reduction.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0796, ATOMIZATION AND DROP SIZE OF NON-NEWTONIAN FLUID

C. TIEN, Syracuse University, School of Engineering, *Syracuse, New York* 13210

The main objectives of this work are: (a) To determine experimentally drop size distribution of non-Newtonian fluid for swirl- type nozzle using freezing technique. The system to be studied includes emulsion, aqueous polymer solution and substances exhibiting viscoelastic behavior.

(b) To analyse mathematically the fluid mechanical behavior of the liquid in atomization process. Attempts will also be made to predict theoretically the breakup of liquid sheet and the drop size distribution.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0797, MASS TRANSFER ANALYSIS IN REVERSE OSMOSIS OPERATION

C. TIEN, Syracuse University, Research Institute, *Syracuse, New York* 13210

The main objectives of this work are: (1) To obtain analytical expressions for the rate of production of pure water from waste water by reverse osmosis operation in terms of operating variables under turbulent flow conditions. (2) To study the effect of natural convection on a reverse osmosis system. (3) To determine the most promising geometrical configurations of the system and the most optimal operating conditions.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0798, THE EFFECT OF GAS BUBBLE MOTION ON FLUID MIXING IN AERATION PROCESS

C. TIEN, Syracuse University, Research Institute, *Syracuse, New York* 13210

The main objectives of this work are: (1) To study analytically the effective diffusivity in liquid phase due to bubble motion. (2) To determine experimentally the effective diffusivity and obtain a correlation between it and bubble parameters such as bubble size, bubble frequency and density. (3) To study the liquid phase mass transfer in a bubbling system.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0799, PIPELINE FLOW OF SOLIDS-LIQUID SUSPENSIONS

R.M. TURIAN, Syracuse University, Research Institute, *Syracuse, New York* 13210

The primary objective of the proposed research is to assess the effect of suspending medium characteristics and suspended solids properties on: 1. the steady state pipe flow behavior of the suspension, 2. pressure losses and other problems associated with the flow through pipe bends or other disturbances in the flow path, and 3. problems arising from sudden stoppage and subsequent start-up of the flow. The suspending medium characteristics will be varied using Newtonian liquids of different viscosities and densities, suspensions of solids fines of different concentrations and polymer average molecular weight. The suspended solids characteristics, on the other hand, will be varied using different concentrations of iso-dimensional particles, different solids densities, and different distributions of particle sizes and densities. Supplementary viscometric, settling, and other tests will be conducted to characterize the suspended systems investigated and their components. These supplementary tests will also serve to evaluate the utility and limitations of such measurements in the prediction of the pipe flow beharior of the suspension. The ultimate aim is to establish guidelines for optimum design and economic evaluation of a sludge or suspended waste pipeline or piping system.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0800, SYNERGISM OF PESTICIDES AND DETERGENTS

J.H. NAIR, Syracuse University Res. Corp., *Syracuse, New York*

We will be investigating whether a relationship exists between levels of alkylbenzene sulfonate (ABS) and linear-alkylsulfonate (LAS) detergents in water and the toxicity of selected pesticides. It is proposed to employ two species of fish as the test specimens. Although pesticides and detergents may exist simultaneously in the same bodies of water used by humans, little current research has been directed toward elucidating the effect of surface active agents upon absorption and metabolism of toxic pesticides.

Accordingly, fish will be exposed simultaneously to detergents and selected pesticides to measure survival and behavior. In subsequent exposures, selected liver enzyme activity will be measured during exposure to chlorinated compounds. Brain cholinesterase activity will be measured in relation to exposure to organic phosphate insecticides. From the behavior, survival and enzyme activity, a measure of the net effect of detergents upon the absorption and metabolic fate of selected pesticides may be determined.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0801, OXYGEN TRANSFER IN CONCENTRATED MICROBIAL SYSTEMS

D.R. WASHINGTON, Rensselaer Polytechnic Inst., School of Engineering, *Troy, New York* 12181

This project has at its immediate aim, the development of mathematical models to express the oxygen transfer, oxygen utilization for concentrated mixed microbial cultures. A major effort is being made to evaluate the coefficients appropriate for the models. The investigation involves the study of cultures ranging from 15 gm/l to 50 gm/l suspended volatile solids.

The long range objective of the research is to develop a biological process for the direct treatment of concentrated industrial wastes which are susceptible to biological degradation. Synthetic wastes (45% dextrose; 45% non-fat milk, 10% yeast extract) in concentrations up to 30 gm/l COD have been treated by this process with over 99% COD removal.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0802, INTERACTION OF HERBICIDES AND SOIL MICROORGANISMS

D.C. TORGESON, B. Thompson Inst. Plant Res., *Yonkers, New York* 10701

An investigation of the interactions of soil microorganisms and a group of chlorinated aromatic herbicides will be made. Specific objectives will be: (1) to isolate and characterize microbial species responsible for complete or partial herbicide degradation, (2) to characterize in relatively simple culture media the rates of degradation of this group of structurally related herbicides, (3) to study the influence of environmental factors such as clay, supplemental substrates, oxygen and pH levels and previous adaptation to structurally similar compounds, (4) to identify the routes of degradation and fate of degradation products, and (5) to determine if microorganisms capable of rapidly degrading a herbicide can be used to decontaminate soil and water.

Results from these studies should be helpful in the future design of molecules useful as herbicides but which will be degraded rapidly before they have an opportunity to pollute soil and water.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0803, ACCUMULATION OF RADIONUCLIDES BY VERTEBRATES

J.P. BAPTIST, U.S. Dept. of Interior, Radiobiological Lab., *Beaufort, North Carolina* 28516

Estuaries and brackish water areas provide a nursery ground and habitat for many commercially important fish. They also provide receiving waters for waste products, including radioactive effluents from power reactors, hospitals, and laboratories. Marine vertebrates can concentrate radioactive elements which could be harmful to them and render them useless as seafood for man. Since the marine environment is complex and each estuary is different, in some way, from all the others, various factors influencing accumulation must be studied under laboratory conditions.

The objectives of this project are to measure under controlled laboratory conditions, the accumulation and retention of radionuclides by marine fish; to study the importance of various factors which may affect accumulation; and to observe the feeding processes of commercially important fish through the use of radioactive tracer techniques.

Experiments are conducted with several marine fishes such as croakers, Micropogon undulatus; mummichog; Fundulus heteroclitus; pinfish, Lagodon rhomboides; bluefish, Pomatomus saltatrix; and flounder, Paralichthys sp. Accumulation of radionuclides both from sea water and from natural food containing radioactivity in known concentrations is determined.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

5.0804, ACCUMULATION OF RADIOACTIVITY BY INVERTEBRATES

T.J. PRICE, U.S. Dept. of Interior, Radiobiological Lab. , *Beaufort, North Carolina* 28516

The rapid growth of atomic energy industries and the increased use of nuclear reactors for power production have increased the possibility of the contamination of the marine environment with radioactive materials. Also, radioisotopes used in research and medicine may be disposed of in coastal waters, which are habitats for many species of commercial marine invertebrates.

Since many invertebrates are filter-feeders, omniverous predators, and scavengers, it is probable that these animals come in contact with most components of the ecosystem. If one or more of these components contain radionuclides, it is probable that this radioactivity eventually would become associated with these animals.

Laboratory research is being done to determine the uptake, accumulation, and retention of specific radioisotopes (zinc-65, iron-59, iodine-131 and others) by marine invertebrates, including clams, oysters, scallops, and crabs. From these experiments, one can ascertain the importance of various factors which may affect accumulation; observe the metabolism of specific elements by invertebrates through the use of radioactive tracers; and study the foods and feeding activities of marine invertebrates.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

5.0805, THE ACCUMULATION OF FISSION PRODUCTS BY MARINE FISH AND SHELLFISH

T.R. RICE, U.S. Dept. of Interior, Radiobiological Lab. , *Beaufort, North Carolina* 28516 (AT(49-7)-5)

The cycling of elements in the estuarine environment is being followed by observing the movement of radioisotopes in the water, biota, and sediments. Quantitative data on the cycling of radioactive elements are important since effluents containing radioactive elements often flow into estuarine waters. With such data, it should be possible to predict the pathways taken by the radioactive elements.

The potential importance of cord grass, Spartina alterniflora, in conveying radioisotopes of zinc, manganese, and iron into estuarine food chains was evaluated on the basis of its annual production, its content of the three elements, and its annual cycle of growth and decay. An environmental tracer experiment was carried out in which naturally-occurring fallout radioactivity in the estuary served as the tracer isotopes. In the laboratory, the influence of certain environmental factors on the concentrations of zinc 65 accumulated by an experimental community was tested. Finally, the interactions of radiation, salinity, and temperature on the physiology of the estuarine fish, the mummichog, was observed.

Spartina production was found to approach one-third the total phytoplankton net production of adjacent esturaies and is thus potentially important in estuarine food chains. The unusually high iron content of the dead material suggested that Spartina may be especially important in the movement of radioisotopes of iron from water and sediment into estuarine animal populations. Concentrations of gamma-emitting fallout radioisotopes were monitored in Rangia over a 30-mile stretch of river and a salinity range of less than 0.1 to greater than 15 parts/thousands. Ruthenium 106 and ruthenium 103 were concentrated more in Rangia from downstream stations (salinity range 6-15 parts/thousand), whereas cesium 137 was more abundant in the same species from fresher water (salinity range 0-8 parts/thousand. It was found that a high salinity and zinc concentration suppressed the concentration of zinc 65 in animals and sediment, while high temperature and pH had the opposite effect. In experiments testing the interaction of salinity, temperature, and radiation, it was observed that both salinity and temperature changed the LD-50. Above 20 degrees C. fish were more sensitive to radiation at high salinites, while below 20 degrees C. fish were more sensitive to radiation at low salinities.

SUPPORTED BY U.S. Atomic Energy Commission

5.0806, SEDIMENT MINERALOGY

D.A. WOLFE, U.S. Dept. of Interior, Radiobiological Lab. , *Beaufort, North Carolina* 28516

Sediments have the capacity to scavenge many radionuclides from sea water. There is, however, little agreement as to the effect of this phenomenon on the food web of the sea. Will this scavenging action enhance or reduce the uptake of radioactivity by the biota? If organisms have the capacity to utilize the organic matter in sediments as a source of nourishment, sediment-sorbed activity could be passed along the food web to eventually reach man. Conversely, by adsorbing radioactive materials from sea water, sediments could reduce the possibility of contamination in many pelagic animals.

In order to determine the role of sediments in the cycling of radionuclides in the estuarine environment and to gain some insight into sediment-animal relationships, experiments on sediment-sorption of radionuclides are being carried out in the laboratory and in the field. Observations are made on the capacity of natural sediments and selected clay minerals such as montmorillonite, to scavenge radionuclides (zinc-65, cesium-137, and chromium-51) from sea water of varying salinity. Also, the partition of these radionuclides between the sediments, and biota of outdoor ponds will be studied.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

5.0807, IMPROVE POLLUTION CONTROL BY REUSE OF PAPER MACHINE PROCESS WATERS

G. WACHTER, Champion Papers Incorporated, *Canton, North Carolina* 28716

This project is directed toward demonstrating the complete reuse of paper-machine process waters by removing these materials as stream pollutants. It is part of a long-term program to develop a method for essentially closed water use systems. The project will include: 1. Recovery of all usable materials from paper-making process waters. This work involves modifications to existing and new systems to increase recovery of paper making materials. Process-water effluent from this system will go to the treatment system. 2. Treatment of excess process water to allow its reuse in place of fresh water, thus greatly reducing the quantity of fresh water required for paper making. Coagulating chemicals and precipitating processes will be used. 3. Disposal of sludge, generated in the treatment process, in a non-pollutional manner. 4. Any excess water flow returning to the stream will be of a quality that it will not contribute to stream pollution.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Champion Papers, Inc.

5.0808, DEVELOPMENT OF FIELD TEST FOR FREE CHLORINE

J.D. JOHNSON, Univ. of North Carolina, School of Public Health, *Chapel Hill, North Carolina* 27514 (DA-49-193-MD-2442)

Tech. Objective - To develop a simple interference free field test to determine concentrations of free chlorine in drinking water.

Approach - Color produced by free chlorine and orthotolidine is stabilized by an anionic surfactant. Reducing agents and complementary tristimulus colorimetry set the level of a simple go, no-go test. Semipermeable membranes are being used to separate chlorine from interferences. An analog membrane disinfection indicator is being studied.

Progress - Mar 66 - Jun 67 - The laboratory procedure for the stabilized neutral orthotolidine short colorimetric methods for determining free chlorine, monochloramine, dichloramine and trichloramine has been finalized. The range of the method has been extended to above 10 mg/L and the number of reagents decreased to two. These reagents were made stable within the temperature range 5 degrees C to 40 degrees C. The method shows only slight product fading and breakthrough of the chloramines even at high temperature. The accuracy of the short procedure has been evaluated by comparison with ultraviolet spectrophotometry which agrees generally within 1 percent. A preliminary field test procedure is given for use with a color comparator. Field testing and procedure evaluation will be conducted with military personnel in the coming year. The development of an analog membrane disinfection indicator which integrates the effect of concentration, temperature, contact time and PH into a single value result simulating disinfection efficiency is being studied through the evaluation of characteristics of synthetic diffusion membranes. Preliminary ultraviolet spectrophotometric studies have been conducted on the chemistry of bromine and the bromamines for the purpose of determining whether these compounds are suitable alternatives of chlorine for water disinfectants. A new ultraviolet spectrophotometric method for the determination of the total amount of elemental bromine present in solution at any time has been developed using buffered potassium bromine for the formation of tri-bromide ion.

SUPPORTED BY U.S. Dept. of Defense - Army

5.0809, MICROBIOLOGY OF ANAEROBIC SLUDGE

R.A. MAH, Univ. of North Carolina, School of Public Health, *Chapel Hill, North Carolina* 27514

An ecological appraisal of the sludge fermentation is essential to an understanding of the contribution and significance of various physiological types of anaerobic bacteria participating in the degradation of organic compounds to methane and carbon dioxide. This investigation is concerned with an estimation of the total fermentation by whole sludge of certain carbohydrates, fatty acids, and amino acids. The significance of the bacteria which attack these compounds will be evaluated by isolation of pure cultures, estimation of their numbers in sludge, and determinations of their rates of fermentation of specific substrates.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0810, PIGMENT INDICES OF ENVIRONMENTAL OXYGEN STRESS

H.T. ODUM, Univ. of North Carolina, Graduate School, *Chapel Hill, North Carolina* 27514

In waters of low and fluctuating oxygen tensions, there must be some adaptation in the benthic fauna for obtaining or storing oxygen. Observations of animals in all types of water indicate that a respiratory pigment (in fresh water usually hemoglobin) serves this function. It is the purpose of this project to attempt to classify and quantify the relation between the presence of hemoglobin in benthic animals and the oxygen conditions of the environment.

The accomplish this, animasl are sampled from lakes, ponds, and streams, hemogenized in a Waring blendor, and then centrifuged at 37,000 G's. The absorption spectrum of the supernatant is then read on a spectronic '20.' By knowing the wet weight of tha animals homogenized, the concentration of the hemoglobin per gram of animal tissue may be roughly calculated. This value will then be compared with nocturnal oxygen values in the environment.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of North Carolina

5.0811, TRANSPORT MECHANISMS IN WATER FILTRATION

C.R. OMELIA, Univ. of North Carolina, School of Public Health, *Chapel Hill, North Carolina* 27514

The principal objective of the proposed research is to identify and quantitatively define the mechanisms by which suspended particles are transported to the liquid-filter interface in water filtration. More specifically, the research will attempt to develop a transport model for the filtration process and to test this model experimentally.

Development of the transport model will include the following steps: 1. Describe the force system acting on a single particle. 2. Based on such a force system, develop a differential equation describing the rate of change of particle concentration in a differential volume of fluid. 3. Consider the flow pattern of these fluid elements past a single collector. 4. From steps (2) and (3), describe the total flux of particles to a spherical collector, and determine the removal efficiency of a single collector.

It is anticipated that experimental testing of the transport model will concentrate on an evaluation of the influence of suspended particle size on the filtration process. Particular emphasis will be placed on defining the critical particle size range within which a minimum transport efficiency exists.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0812, EXCHANGE OF PHOSPHORUS SPECIES BETWEEN LIVING AND NONLIVING SYSTEMS IN FRESH WATER ENVIRONMENTS

C.M. WEISS, Univ. of North Carolina, School of Public Health, *Chapel Hill, North Carolina* 27514

Short-term cycling of phosphorus species (Total P, Orthophosphate, Organic-P) will be studied in several fresh water environments. The environments will be a small water supply impoundment, the runoff stream from the impoundment, which in turn receives a treated waste- water discharge and a series of pilot oxidation ponds being used to evaluate their effectiveness for tertiary treatment of the waste water effluent from a biological treatment plant.

In each of these invironments the relationship between the several chemical forms of phosphorus will be determined to establish the distribution of the total quantity of this element. High frequency sampling (at least 12 per hour) and analysis will be carried out using automatic analytical devices. A bioassay procedure will be used to determine how and to what extent the several phosphorus forms are available to algae as nutritional elements. Unicellular cultures of several species native to the specific environments will be introduced into water samples freed of particulate matter by membrane filtration. At end of growth period (10 days) residual distribution of P will be determined. Parallel sampling and analyses of Nitrogen states will also be carried out with automatic analyzers.

The variation in type and distribution of the phosphorus species in the exaggerated environment of the oxidation pond will be related to the total biological activity of the ponds.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of North Carolina

5.0813, WATER QUALITY MANAGEMENT OF IMPOUNDMENTS

C.M. WEISS, Univ. of North Carolina, School of Public Health, *Chapel Hill, North Carolina* 27514

The proposed investigation will establish potential levels of eutrophication in New Hope Lake following completion of New Hope Dam. This will be accomplished by a systematic water quality sampling in the Haw and New Hope rivers which will fill the basin behind the dam. Both rivers now carry a considerable pollution load. Since the proposed lake will undergo thermal stratification, during summer months, with rapid deoxygenation of deep levels, pilot studies will be carried out on University Lake, the near-by water supply reservoir of Chapel Hill, on which ten years of limnological data have been accumulated, to ascertain methods and procedures for destratification by air-lift or mechanical pumping. The information gathered on University Lake will be extrapolated to New Hope. In Phase II, a second three-year period, a suitably scaled-up installation will attempt to improve water quality by destratification of New Hope Lake.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of North Carolina

5.0814, REUSE OF PLANT EFFLUENT AND COOLING WATER BLOWDOWN AS PROCESS WATER

W.J. DAY, Fiber Industries Incorporated, *Charlotte, North Carolina* 28201

An existing facility provides treatment for the combined sanitary and equalized chemical process waste waters from a synthetic fiber manufacturing plant. Treatment facilities consist of extended activated sludge aeration basins, clarifier, polishing ponds, and aerobic sludge digestion basin, and a sludge holding pond.

The project will evaluate treatability of this waste in a plastic media trickling filter, feasibility of algae removal from the polishing pond effluent by use of microscreen filters, feasibility of BOD, COD, color, odor and taste reduction in the final effluent by use of powdered carbon for the purpose of ultimate reuse of the effluent as process makeup water, and chromate reduction of cooling tower blow-down to permit treatment in the waste treatment plant.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Fiber Industries, Inc.

5.0815, QUALITY OF STORM WATER DRAINAGE FROM URBAN LAND AREAS IN NORTH CAROLINA

E.H. BRYAN, Duke University, School of Engineering, *Durham, North Carolina* 27706

The objective of the proposed research is to determine the relationships between land use and the quality of storm water drainage in an urban area of North Carolina. The drainage basin selected for study will typify the pattern of land use in an urban and urbanizing setting in North Carolina. Quality of storm water from commercial, residential, industrial, public and institutional sub-basins with respect to selected parameters such as alkalinity, pH, chlorides, solids, nitrates, phosphates, pesticides, herbicides, coliforms, biochemical oxygen demand, organic carbon and others will be related to existing and changing patterns of land use. The project will be aimed at furnishing a background of information as to sources and amounts of pollutional substances contributed in a diffuse pattern to natural drainage channels.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Duke University

5.0816, QUANTITATIVE AND QUALITATIVE MEASUREMENT OF AQUATIC VEGETATION-CURRITUCK SOUND

T.E. CROWELL, State Wildlife Resources Comm. , *Raleigh, North Carolina*

The objective of this job is to determine the amount and distribution of aquatic vegetation in northern Currituck Sound with particular emphasis upon the apparent immediate and long-range effects upon that vegetation resulting from the salinity artificially created in Back Bay by the City of Virginia Beach, Virginia, and draining therefrom into Currituck Sound. Similar effects by seawater intrusions resulting from natural breaks through the Outer Banks will be determined should such breaks occur.

To accomplish this objective, three samples of aquatic vegetation, each two square feet in area, will be collected with modified oyster tongs at 500-yard intervals across Transect H (Virginia-North Carolina State Line), Transect I (Knotts Island to Bench Marsh), and Transect J (Knotts Island to Swan Island). These samples will be collected quarterly (August, November, February, and May.)

The percentage volume of each species present in each sample will be determined by an occular estimate and the total volume of aquatic vegetation in each sample will be obtained by displacement following soil removal. Data also will be compiled to provide: total milliliters displaced by each species on a square-foot basis, and the percent frequency of occurrence of each species.

Comparable sampling and data compilation will be effected in the general area of any breaks that may occur naturally through the Outer Banks and result in a sea-water intrusion of significant magnitude.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
North Carolina State Government

5.0817, STATEWIDE FISHERIES RESEARCH

E.H. SHANNON, State Wildlife Resources Comm. , *Raleigh, North Carolina*

The objectives of this job are to determine the relative toxicity, constancy, and susceptibility to detoxification possessed by the various commercial rotenone formulations used in fish management and to determine the effects of temperature, water quality, and other pertinent variables upon these factors.

Twenty-four hour TLm bioassays to establish the toxicity of commercial rotenone formulations under various conditions of temperature and water quality are being run at 78 degrees F. using 1-to 2-inch bluegills as test organisms. The individual determinations are being paralleled by similar bioassays to evaluate the speed and efficacy of detoxification by potassium permanganate under the same variables. The rotenone formulations to be tested will include Noxfish, Pro Noxfish, Chem-Fish Regular, Chem-Fish Regular O. F., Chem-Fish Synergized O. F., Chem-Fish Special O. F., Chem-Fish Collector, Chem- Fish T, C-Lamp, and Dri-Noxfish.

These studies will be made at the Commission's Fayetteville Water Quality Laboratory.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
North Carolina State Government

5.0818, STATEWIDE FISHERIES RESEARCH

E.H. SHANNON, State Wildlife Resources Comm. , *Raleigh, North Carolina*

The objective of this study are to determine the points at which temperature, both in shock and continuous exposure, adversely affects the development of striped bass eggs and fry.

Fertilized striped bass eggs of common inheritance will be water- hardened, incubated, hatched and the resulting fry retained for five days in constant water temperatures between 60 degrees F. and 85 degrees F. by 5 degrees F. intervals.

Striped bass eggs of common inheritance at the fertilized unwater- hardened stage, at the eyed stage, and approximately five hours prior to hatching will be subjected to temperature shock, by intervals of 5 degrees F. from the 65 degrees F. of incubation upwards to 85 degrees F. and downward to 60 degrees F. Two-day striped bass fry of common inheritance and produced at a constant 65 degrees F. during egg incubation, will be exposed to identical temperature shocks.

Appropriate controls of the same inheritance as the experimental fish will be maintained at a constant 65 degrees F. in all experiments.

Temperature shocks will be induced by changing incoming water temperatures, not by moving eggs or fry.

Effects will be judged by the comparative rates of mortality and/or deformity between the experimental groups and their respective controls.

This work will be done principally at a field laboratory at Weldon, N. C. Mr. Michael L. Bowling will assist with the field operations.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
North Carolina State Government

5.0819, WATER UTILIZATION AND WASTE CONTROL IN THE POULTRY PROCESSING INDUSTRY

W.M. CROSSWHITE, Univ. of North Carolina, School of Agriculture, *Raleigh, North Carolina* 27600

The purpose of this study is to evaluate economic alternatives for effective in-plant control of water utilization and discharge of waste from food processing operations. This will encompass a study of the totality of water use from water intake through final waste treatment. Specific objectives are to:

1. Determine the pattern of water use by plant processes. 2. Determine the origin, nature, and quantity of polluting matter for major processes. 3. Evaluate the impact of production methods, changes in technology, product quality requirements, conditioning of water and by-product development on water utilization and pollution. 4. Compare the relative costs of prevention and control of waste within the plant and treatments. 5. Formulate guides for the control of water utilization and pollution abatement in food processing plants.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
North Carolina State University

5.0820, CHANGES DURING EUTROPHICATION OF AN ESTUARY

D.B. HORTON, Univ. of North Carolina, School of Agriculture, *Raleigh, North Carolina* 27600

To measure quantitatively the effects of the pollutants and the ensuing eutrophication on the communities of the plankton, rooted aquatic plants, and the macrobenthos, and to determine the factors that influence the distribution and abundance of the various species. 2. To predict the effects of even greater pollution of this estuary and, if possible, to make suggestions to alleviate the eutrophication. 3. To demonstrate the value of field plot design for understanding the biology of an estuary and for predicting effects of a pollutant. 4. To determine if a measurement of the heterotrophic activity of the planktonic bacteria with radioisotopes is a useful method of indicating the degree of eutrophication and pollution.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
North Carolina State University

5.0821, PHOSPHATE MINING EFFLUENT IN ESTUARINE ECOLOGY

D.B. HORTON, Univ. of North Carolina, Graduate School, *Raleigh, North Carolina* 27600

As part of a broader program in estuarine ecology we propose here specific experimental studies of the effluent from phosphate mining operations and its effect on selected component species of the biota. Experiments will be on a scale bridging the gap between observational studies on the estuary as a whole and laboratory studies. At our Estuarine Laboratory a series of pools, and artificial estuaries, will be subject to experimental control, but still much more nearly natural than in the laboratory. This experimental facility will use the phosphate mining operations and the effluent settling basins through experiments described here, with measurements of four principal biological parameters; the bottom fauna; the periphyton, the plankton, and the rooted plants. Immediate experimental questions include: 1. What is the biological activity of untreated effluent of the mining operations as measurable upon these selected components of the biota? This integrates with our present investigations of chemical and physical characteristics. 2. What is the effect on biological activity, of suspended clays (principally Montmorillonite)? 3. Why does settling reduce biological activity of the effluent? 4. What is the effect of differing substrates upon biological activity of the effluent? Present investigations suggest that most primary production takes place on the bottom where we may expect the nature of the substrate to govern the effect of chemicals added to the system. 5. What is the biological effect of effluent from a sewage treatment plant on estuarine ecology, both alone and in combination with effluent from phosphate mining?

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0822, ROLE OF ANIMAL WASTES IN AGRICULTURAL LAND RUNOFF

D.H. HOWELLS, Univ. of North Carolina, School of Agriculture, *Raleigh, North Carolina* 27600

The principal project objectives are to (1) investigate the pollutional aspects of agricultural land runoff from confined and unconfined animals growing in well defined small watersheds (2) develop relationships between water quality and environmental factors such as animal pollution and hydrology for application to other areas with similar conditions.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0823, WATER CONTAMINATION BY FERTILIZER NITROGEN AND PHOSPHORUS

J.F. LUTZ, Univ. of North Carolina, School of Agriculture, *Raleigh, North Carolina* 27600

The objectives of this project are to determine the direct contribution of fertilizers to nitrogen and phosphorus contamination of surface and subsurface runoff, as affected by: (a) Form of fertilizer applied; (b) Time of application; (c) Rate of application; (d) Crop to which applied; (e) Soil physical and chemical properties; and (f) Meteorological and hydrological conditions. At different times during the period of study, different forms and rates of nitrogen and phosphorus fertilizers will be applied to two completely enclosed watersheds, and to surface runoff plots superimposed on them. Surface losses of nitrogen and phosphorus will be determined by analyzing the soil and water caught in the tanks at the bottom of the runoff plots. Total losses from the watershed will be determined by analyzing the water that passes over the weir at the bottom of the watershed. Soil and plant samples from the watersheds, and water from water wells on the watersheds, will be analyzed.

The two watersheds are on the branch Experiment Station of the North Carolina Agricultural Experiment Station at Waynesville, North Carolina. All analyses will be made in the Analytical Service Laboratory of the Soil Science Department, North Carolina State University, Raleigh, North Carolina.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
North Carolina State University

5.0824, FILTRATION OF KRAFT PULP LIQUOR THROUGH CHIPS

A.J. STUMM, Univ. of North Carolina, Graduate School, *Raleigh, North Carolina* 27600

The purpose of the project is to investigate the purification of Kraft wash water by utilizing wood chips as a filtering medium. The wash water, containing insufficient pulping chemicals for profitable recovery, will be contacted with wood chips normally kept as inventory stock. In addition to reducing the alkaline pH of the Kraft washwater and adsorbing water soluble chemicals, the wood chips will undergo a mild prepulping action as a result of the contact with the wash water.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
North Carolina State University

5.0825, RELATIONSHIP OF PESTICIDE PROPERTIES TO ADSORPTION

T.M. WARD, Univ. of North Carolina, Graduate School, *Raleigh, North Carolina* 27600

Investigations are proceeding of various physico-chemical properties of herbicide-like chemicals which can be related to their practical behaviors. These include determinations of: partitioning between polar and non-polar phases, dipole moments, vapor pressures, electrophoretic migration on various substrates, ionic equilibrium constants, keto-enol ratios in various solutions, and degrees of protonation. Models of the organic fraction of soils and of quantitative adsorption on these adsorbents are also under investigation. Factors effecting adsorption include: pH, temperature, and the variation in electronic nature of structurally related molecules. Bonding mechanisms are being investigated by means of IR and NMR techniques. Particular attention is being given to N phenylcarbamates, alkylamino-s-triazines, anilides, and carboxylic acid derivatives.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0826, THE DISPOSITION OF PESTICIDES IN THE SOIL

S.B. WEED, Univ. of North Carolina, Agricultural Experiment Sta., *Raleigh, North Carolina* 27600

OBJECTIVES: A. To determine the distribution of pesticides in selected soils and their drainage waters, using sites to which known amounts of pesticides have been applied. B. To determine the physical, chemical and biological processes, and soil characteristics which are important in the disposition of pesticides in soils.

DESCRIPTION: A Southern regional project in which North Carolina efforts will be directed towards Objective B: Adsorption isotherms will be constructed for organic pesticides on clay minerals. X-ray diffraction and infrared studies will be conducted to determine orientation and nature of bonding of the adsorbate on the clay. Pesticides used in initial studies will include diquat, prometone, systox, Sevin and parathion.

SUPPORTED BY U.S. Dept. of Agriculture
North Carolina State Government

5.0827, LIFE HISTORY OF THE GOLDEYE (HIODON ALOSOIDES) IN GARRISON RESERVOIR, NORTH DAKOTA

R. HEIB, State Game & Fish Department, *Bismarck, North Dakota*

Information obtained from gill netting records in Garrison Reservoir indicate that goldeye populations have increased during the past seven years. Presently the Reservoir goldeye population is not being utilized for commercial fishing. There is however, an increasing demand for the goldeye in Canadian markets. A large standing crop coupled with the possibility of a near-by export market indicates that commercial fishing for Goldeye could become a reality.

A knowledge of specific life history in Garrison Reservoir is important to an intelligent exploitation of a species. At the present time little is known about the habits of the goldeye in Garrison Reservoir. The proposed investigation will attempt to complete the following objectives (1) determine the principal spawning areas of the goldeye in the reservoir, (2) estimate the fecundity of the goldeye and length of spawning season and (3) establish the age class composition of the goldeye populations from spawning until late fall.

Procedure: The goldeye is known to be a pelagic spawning fish. Any determination of spawning sites will need to compare the number and age of eggs found within a given area. A Clark-Bumpus plankton net with a suitable sized mesh will be utilized to locate areas of egg concentration. After areas are located they will be sampled regularly during the spawning season. Presently semi-weekly samples are thought to be adequate, but sampling times and effort may be altered by field conditions. Sampling will be concentrated in the Mossit Bay area of the reservoir. Both diurnal and nocturnal sampling will be done.

Goldeyes will be captured by gill nets and frame nets. Specimens taken will be examined for sexual maturity, size, and condition of ovaries. Scale samples will be taken caterized for laboratory analysis. Ovaries will be removed and the number of eggs per female estimated throughout the spawning periods. In addition, determination of water temperature, wave action, turbidity and pH will be measured.

In this first project segment intensive sampling will be carried out from April, 1966 until June 1966. Age distribution studies of the goldeye populations will continue until September 15, 1966. A latin- square gill net will be utilized to capture different age classes in a random manner. Data obtained will be evaluated at the University of North Dakota with the aid of a high speed digetal computer.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.
North Dakota State Government

5.0828, EVALUATION OF METHODS DESIGNED TO PREVENT WINTER-KILL

A. KREIL, State Game & Fish Department, *Bismarck, North Dakota*

Objectives: To study methods of alleviating winter kill utilizing systems designed for lake circulation.

Procedure: 1. Lake Upsilon, Gravel Lake, Hooker Lake and Dion Lake are described in Job 8, Project F-2-R-12. Lake survey reports and maps of these lakes are on file in North Dakota Game and Fish Department office in Bismarck. 2. The circulation systems employed in this job are described in Job No. 5, Project F-2-R-8. 3. The circulation systems will be installed prior to freeze-up in all project lakes. They will be operated until spring over-turn and then all except those in Hooker Lake will be removed during the summer. The systems will be operated in Hooker Lake during the summer period. At the time of operation of all systems determination will be made of water chemistry, dissolved gas contents, vertical temperature profiles, circulation rates and B.O.D. will be determined during the summer project period. 4. Lake Upsilon, Hooker Lake and Gravel Lake now contain game fish populations. Dion Lake has been stocked with walleye. Inventories of the fisheries in each project lake will be made. 5. The circulation systems in Lake Upsilon will not be operated during winter of 1968-69. Physical and chemical data will be recorded for this lake without circulation.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
North Dakota State Government

5.0829, THE RELATIONSHIP BETWEEN TURBIDITY CURRENTS AND FISH MOVEMENTS IN GARRISON RESERVOIR

S. PETERSON, State Game & Fish Department, *Bismarck, North Dakota*

Turbidity currents constitute a unique environmental factor in reservoirs. The proposed project is an attempt to correlate turbidity currents and fish movements in Garrison Reservoir.

Procedure: Two sampling stations will be established at the upper end of Garrison Reservoir. Turbidity currents can be more easily measured before the currents spread out into small linear layers over the entire reservoir. Field studies will be centered in the Mossit Bay region.

Gill nets based on a latin square design will be utilized to detect fish movements. It is anticipated that 2 such nets will be needed. Nets will be 18 feet wide and 72 feet long. Panels of 6 different mesh sizes will be built into the net. The panels will be 3 feet square. They will provide a 6 x 6 matrix repeated 4 times. The six mesh sizes utilized will be 3/4', 1 1/4', 1 3/4', 2 1/4', 2 3/4', and 3 3/4'. The design is after that of Houser and Ghent (1964).

When completed the study will provide as accurate correlation between: depth and species captured, depth and size of fishes captured, and turbidity currents and species. Relative abundance of different species will also be determined.

The gill nets will be supported from floats and anchored in or near the main current. Times for running the nets will be established in the field. Initially, a 6-hour sampling period is proposed, but this may be altered by catch size. Sampling will start in June 1966 and continue until September 15, 1966.

Turbidity samples will be collected from a series of weighted closed bottles suspended from one edge of the gill net. The bottles will be opened simultaneously and the suspended solids will be measured. Other water chemistry tests will be made on the samples, depending upon the amount of field equipment available.

When completed the results will provide information that will aid in establishing the location of commercial fishes in relation to turbidity currents.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.
North Dakota State Government

5.0830, SECONDARY TREATMENT OF HOG WASTE IN AN ANAEROBIC STABLIZATION POND

R.G. BUTLER, North Dakota State University, School of Engineering, *Fargo, North Dakota* 58102

The object of this study is to evaluate the performance of and to provide parameters for the design of anaerobic ponds receiving effluent from settled hog waste.

This study will be conducted on a stabilization pond located at the Nutrition Center, North Dakota State University. The pond is 20 feet wide by 200 feet long having an average depth of 4.5 feet. A wooden partition separates the pond into two equal units (20' X 100') - the south unit will be used as a control, the experimental work will be done in the north unit. The waste from 80 to 120 hogs will be discharged into a 16,000 gallon septic tank, the effluent will be pumped into the pond.

The investigation will involve three phases which are preliminary, the physical-chemical and the microbiological. In the preliminary phase, potassium concentrations at various depths and location within the pond will determine number of samples and sampling stations.

Standard physical-chemical tests will be conducted on the effluent and on the liquid within the pond during the spring, summer, fall and winter if physically possible.

The microbiological phase will consist of work on total counts, coliform bacteria, photosynthetic bacteria and reducing bacteria.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
North Dakota State University

5.0831, SALINE WATERS AND LIVESTOCK PRODUCTION

W.E. DINUSSON, North Dakota State University, Agricultural Experiment Sta., *Fargo, North Dakota* 58102

1. To determine maximum and/or optimum tolerances of saline waters for livestock. 2. To evaluate the effect of the various salts and interaction of these salts on tolerances and efficiencies of livestock production.

Proposed to maintain livestock on standard rations and vary the concentration of salts of sodium, potassium, magnesium and calcium (sulfates, carbonates and chlorides) in the available drinking water to asertain minimum tolerances due to the salinity. Initial work to be with growing fattening swine, later to be expanded to ruminants.

SUPPORTED BY U.S. Dept. of Agriculture
North Dakota State Government

5.0832, QUALITY IMPROVEMENT OF SWIMMING POOL WATERS - KINETICS AND MECHANISMS OF THE CHLORINATION-DEGRADATION OF UREA AND URIC ACID

C.W. FLEETWOOD, North Dakota State University, School of Chemistry, *Fargo, North Dakota* 58102

The purpose of this study is to determine the fundamental step- by-step chemical reactions that take place in the 'purification' or 'decontamination' of swimming pool and potable waters when they are treated with elemental chlorine or with compounded chlorinating agents.

The kinetics and the mechanism of the chlorination-degradation reaction of urea and of uric acid in aquerous solutions 10-3 to 10-5 moles-per-liter concentration range, at pH values from 4 to 10, will be followed through the various intermediates to the final products of degradation, i.e. CO2, Na, H2O, and HCl.

The course of the reaction will be followed by the chlorimetric ortho-tolidine, the phosphomolybdate, the xanthydrol, the ultra-violet spectrophotometric, and by the pH versus time methods.

The data thus obtained will be subjected to a careful and detailed mathematical analysis to solve the complicated system of simultaneous and sequential chemical reactions into their individual first and second order stepwise component reactions.

The knowledge obtained will be used to develop better methods for the control of the amounts of chlorine to be added, and for reductions in the amounts of irritant intermediates present at any time.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
North Dakota State University

5.0833, WATER BALANCE IN SEWAGE STABILIZATION LAGOONS

G.O. FOSSUM, North Dakota State University, State Water Resources Inst, *Fargo, North Dakota* 58102

This project proposes to conduct field investigations and laboratory analysis aimed at determining the water balance for a sewage stabilization pond containing an appreciable loading of organic industrial wastes. It is also intended to trace lateral movement of seepage from lagoons, and its effect on the adjacent water table.

The water balance is to be determined by measuring influent and precipitation by meters and rain gages and comparing with effluent, evaporation, and seepage. Quantity of effluent discharged will be measured and evaporation losses determined from evaporating pans. Infiltrometers will be used to determine seepage from the lagoon bottom.

Observation wells surrounding the lagoon at varying distances are to be used for sampling ground water for laboratory analysis. Correlation with natural ground water in the vicinity will give indications of pollution and ground water travel. These wells will also be used for water table observations.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
North Dakota State University

5.0834, EFFECTS OF SUGAR REFINING LAGOON EFFLUENTS ON BIOLOGICAL, PHYSICAL, AND CHEMICAL PROPERTIES OF FARGO CLAY

B.R. FUNKE, North Dakota State University, Agricultural Experiment Sta., *Fargo, North Dakota* 58102

The proposed research plan involves use of soil columns and greenhouse experiments to determine the effects of applying sugar refinery lagoon effluents to Fargo clay. The chief objectives of the investigations will be to: 1. Determine any changes in the ability of Fargo clay to allow infiltration of sugar lagoon effluents, for example, slowing due to clogging from biological or other causes. 2. Determine the effectiveness of Fargo clay in eliminating biologically degradable components of these wastes. 3. Determine effect of such wastes on selected chemical properties of Fargo clay. 4. Determine the practicality of cropping soils treated with such lagoon effluents with various types of plants.

The methods to be used would involve application of liquid wastes to soil columns of Fargo clay, both cropped and uncropped, and determining any changes in infiltration rates. Tests would be aimed at correlating any clogging with biological accumulations and physical and chemical changes in the soil. The continuing effectiveness of the soil in purifying the wastes would be determined by testing for changes in Biological Oxygen Demand and Chemical Oxygen Demand. Greenhouse pot experiments would determine effects of waste applications on growth of various plants.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
North Dakota State University

5.0835, FARM ANIMAL WASTE DISPOSAL

G.L. PRATT, North Dakota State University, Agricultural Experiment Sta., *Fargo, North Dakota* 58102

Objectives: 1. Characterization of the physical, chemical and biological properties of livestock and poultry wastes. 2. Improvement in management systems with regard to handling, treatment and disposition of wastes.

Description of Work Proposed: A. An evaluation survey will be made of farms in North Dakota using liquid manure handling systems for hogs and poultry. B. The lagoon system of sewage disposal receiving liquid manure from a hog house will be studied in detail including temperature, odor, B.O.D., etc. C. Open pit septic tanks will also be studied.

SUPPORTED BY U.S. Dept. of Agriculture
North Dakota State Government

5.0836, A FEASIBILITY STUDY OF A LIVESTOCK WASTE DISPOSAL INVOLVING REUSE OF WATER

G.L. PRATT, North Dakota State University, Agricultural Experiment Sta., *Fargo, North Dakota* 58102

Objectives: (1) To compare and evaluate on the basis of available information the components needed to condition animal waste water for reuse. (2) To assemble pilot treatment systems to evaluate the performance of components in field use.

Description of Work Proposed: The initial phase of the study of the feasibility of reusing water in livestock waste disposal systems will involve a review of the types of components that are available for separating the solids from the liquid; for eliminating undesirable chemical elements; and for neutralizing pathogens. Commercially available components will be investigated. Available information on the quantity of materials that will have to be handled will be summarized. The evaluation of the mechanical performance of selected systems will be made in a pilot disposal assembly. Waste material will be collected from livestock and introduced into the test systems. During part of the laboratory testing, the rate of buildup of undesirable chemical elements in the reused water will be determined. After these rates have been established, the efficiencies of the equipment available for removing these chemical elements will be evaluated. The determination

of the efficiencies of the pathogen neutralizing equipment will be the final stage of the pilot test sequence.

SUPPORTED BY North Dakota State Government

5.0837, MICROBIOLOGY OF SEWAGE LAGOONS - EFFECTS OF INDUSTRIAL WASTES ON COLIFORM AND OTHER ENTERIC ORGANISMS

***J.W. VENNES*, Univ. of North Dakota, School of Medicine, *Grand Forks, North Dakota* 58202**

The proposed research involves laboratory and field investigations designed to determine the changes in coliform and other enteric organisms in lagoons receiving wastes from starch manufacturing (potato wastes), cheese manufacturing and domestic sewage. All lagoons to be studied will receive, in addition to the starch and cheese manufacturing wastes, domestic wates.

Laboratory investigations will employ the following methods: 1. Millipore filter counts of coliform, fecal coliform, enterococci and total bacteria. 2. Biological oxygen demand (BOD), pH, total and suspended solids and organic nitrogen.

Field studies will relate: 1. Temperature and loading of the several lagoons. 2. Aeration versus static methods as a treatment device and their relations to enteric and other organisms.

Major emphasis will be placed on the removal of coliform bacteria which indirectly relate to the removal of pathogenic bacteria.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of North Dakota

5.0838, A PILOT FACILITY TO DEMONSTRATE OFF-SHORE, UNDERWATER, TEMPORARY STORAGE OF STORM OVERFLOW FROM A COMBINED SEWER

***W.J. BANDY*, Karl R. Rohrer & Associates, *Akron, Ohio* 44311 (14-12-143)**

Combined sewer storm overflows are a source of water pollution. The proposed work is to design, construct, and operate a pilot facility to demonstrate off-shore, underwater, temporary storage of storm overflow from a combined sewer. The storage will be accomplished in large flexible (rubber) containers, anchored under water in a water body. The system will automatically fill during a stormy event, and a pump flush system will be used to empty the tanks into the interceptor sewer after storage for treatment at the treatment plant.

The system capacity is designed for a particular site according to climatological, hydrological, and topographic conditions.

The construction site is a 15 acre drainage area located in Sandusky, Ohio. The existing leaping weir overflow structure is at the foot of McEwen Street. The tanks will be installed in Sandusky Bay of Lake Erie. Two flexible tanks will be used, having a capacity of 100,000 gallons each. The 200,000 gallon capacity will completely store overflows from a 1-year storm.

Each tank is approximately 57.5 feet square and will have an 18 inch diameter pipe frame around the periphery. The point of flow entrance and exit is at the center bottom of each tank. One tank shall have a steel bottom and a neoprene-coated nylon top. The other tank shall have neoprene-coated nylon bottom and top. Both tanks will collapse when empty and inflate to a height of seven feet on filling.

Instrumentation will include a recording rain gauge, continuous flow recorders (two remote reading type, one magnetic), an automatic sampling device, and recording devices for tank volume and lake level.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0839, OPERATIONAL DEMONSTRATION OF OXIDATION DITCH METHOD OF WASTE TREATMENT

***R.M. KANESHIGE*, Ohio University, School of Engineering, *Athens, Ohio* 45701**

The project objectives are (1) to determine design criteria for the oxidation ditches based upon experimental and analytical evaluation of a currently available dual plant; (2) to determine most desirable operational procedures for obtaining maximum performance; and (3) to obtain an effectiveness comparison between the oxidation ditch and the lagoon methods of wastewater treatment.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Ohio University

5.0840, HIGH RATE TRICKLING FILTERS AND AERATION DEVICES FOR THE ADVANCED BIOLOGICAL TREATMENT OF INTEGRATED KRAFT PULP AND PAPER MILL EFFLUENTS

***V.A. MINCH*, Mead Corporation, *Chillicothe, Ohio* 45601**

The pulp and paper industry needs to find an alternative treatment process which is less expensive and difficult-to-operate than the conventional activated sludge process. As a step in this direction, this project will involve the continuous operation of a pilot treatment plant containing plastic trickling filter, brush-aerated oxidation ditch, conventional aerated lagoon, deep aerated lagoons, and two clarifiers in combinations and evaluate possible efficiencies.

The specific research objectives are to: determine the effect of influent quality on biological treatment; evaluate potential of plastic trickling filters alone and in combination with brush-aerated oxidation ditch, conventional aerated lagoon and deep aerated lagoon; and to achieve higher-than-conventional BOD removals from kraft mill wastes.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Mead Corporation

5.0841, PROCESS DEVELOPMENT FOR REMOVAL OF NUTRIENT MATERIALS FROM WASTEWATERS

***E.F. BARTH*, U.S. Dept. of Interior, Water Research Laboratory, *Cincinnati, Ohio* 45226**

Develop processes that more efficiently remove nutrient materials such as nitrogen, phosphorus, and sulfur from wastewater effluents; before dicharge to receiving water.

Biological populations are controlled by process modifications which enhance desirable reactions. Chemical additives which can simultaneously be used with the biological flora are also investigated.

Nitrogen: Currently nitrification is being controlled by a two-stage biological treatment. Carbon is removed in a high-rate activated sludge system with high sludge wasting; the effluent enters a nitrification stage which contains an enriched culture of nitrifiers. The enriched culture is a result of the nature of the feed, and separate sludge recycle systems in the two-stage process.

Biological dentrification of the nitrified effluent is possible by passing the effluent through an anaerobic system and the addition of methyl alcohol to force use of the nitrate oxygen. Again the enriched culture approach with separate sludge recycle is used in this unit process.

Sulfur: The sulfur cycle is to also be investigated in this integrated process.

Phosphorus: The efficiency of phosphorus removal by biological systems can be increased by adding chemicals that form slightly soluble phosphorus compounds directly to the biological reactor. Several compounds have been investigated and aluminum appears to be the most satisfactory for several reasons. The combination of biological activity with chemical supplements offers more consistent control that the biological system alone.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0842, QUANTITATIVE DETECTION OF SMALL AMOUNTS OF VIRUSES IN LARGE VOLUMES OF WATER

***G. BERG*, U.S. Dept. of Interior, Water Research Laboratory, *Cincinnati, Ohio* 45226**

Viruses of human origin present in waste, natural, and renovated waters are likely to be there only in small amounts, because they can multiply only in susceptible living cells. Since even a single virus particle may be capable of infecting a susceptible host, methods for detection and quantitation of small amounts of viruses in large volumes of water are needed if waters are to be

monitored effectively for the presence of viruses. A membrane filter procedure is currently under study for this purpose.

Poliovirus 1 and echovirus 7 in concentrations of 50-100 PFU/l have been quantitatively recovered on 0.45 micron Millipore membrane filters. Adsorption to filters is best at neutral pH in the presence of salts. Gelman membranes of similar porosity adsorb relatively little virus. Elution of the virus from membranes can be achieved with full strengh serum of with 3% beef extract (Difco). However, each lot of elutant differs in its capacity to elute a given virus, and a lot of serum or beef extract that completely elutes one virus, may elute another poorly. Studies continue in an effort to obtain a more uniform and efficient elutant.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0843, DESTRUCTION OF INFECTIOUS VIRAL NUCLEIC ACID BY IODINE

G. BERG, U.S. Dept. of Interior, Water Research Laboratory, *Cincinnati, Ohio* 45226

It has been reported that iodine destroys viruses by reaction with the protein coat, and that it does not react with viral nucleic acids. Since iodine is used as a water disinfectant, we have undertaken to determine whether viral nucleic acid, imprisoned in an inactivated shell, presents a hazard in disinfected wastewaters and renovated waters.

Poliovirus 1 (Mahoney) has been concentrated by ultracentrifugation. The viral RNA has been extracted with phenol from the intact virus, and purified by precipitation with salt-saturated ethanol. We have shown that the viral RNA is much more resistant to the disinfecting action of iodine than the parent virus from which the RNA was obtained.

A large volume of coxsackievirus A9 has been concentrated by ultracentrifugation, and its RNA will be extracted and tested for sensitivity to iodine.

Poliovirus RNA and coxsackievirus RNA will be tested for sensitivity to other halogens, also.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0844, WATER QUALITY REQUIREMENTS FOR AQUATIC LIFE

W.A. BRUNGS, U.S. Dept. of Interior, Fish Toxicol. Activities, *Cincinnati, Ohio* 45244

The primary project of the Newtown Field Station of the National Water Quality Laboratory is to help determine the water quality requirements of freshwater fish. This is being investigated in the laboratory by conducting chronic bioassays and relating the toxicant level at which there is no effect on reproduction or growth of fish to acute lethal toxicity data. By conducting a variety of tests with different species and different types of water, we hope to evaluate the use of this method to estimate safe concentrations for toxicants and species by means of acute bioassays. A natural stream study is being initiated to evaluate these laboratory results.

Autopsy methods are also being developed as a tool for investigating pollution-caused fish kills.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0845, CONTROL OF MINERAL CONSTITUENTS IN WASTE WATER BY ELECTRODIALYSIS

C.A. BRUNNER, U.S. Dept. of Interior, R.A. Taft San. Engin. Center, *Cincinnati, Ohio* 45226

Electrodialysis has been shown to be a technically feasible method for removing a sufficient amount of the inorganic dissolved solids from municipal waste water to restore it to a quality suitable for direct re-use. Although the process will work on biological-treated municipal waste water which still contains refractory organics, membrane fouling is a problem. Membrane fouling results in a decrease in the degree of mineralization during operation. This problem has been found to be due to the growth of microorganisms on the membranes. Disinfection methods are being studied to find one that is practical. Residual organics will be removed by carbon adsorption prior to electrodialysis. It is necessary to determine the economic feasibility of the process by operating a pilot-scale unit at a municipal waste treatment plant for a sufficient time to determine membrane life and operating costs. An electrodialysis stack has been constructed and is being operated for treating 50 gallons per minute of waste water. About 40 percent of the gross inorganic material (total dissolved solids) in the water is being removed. The fraction of the feed being used for concentrating and electrode streams is 0.086 or less. Appropriate pretreatment studies are being conducted . During the operation, the fractional removal of gross inorganics and selectivity of the removal process for various ions is being measured. Pilot work is being performed at Lebanon, Ohio.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0846, DISINFECTION OF RENOVATED WASTEWATER

R.L. BUNCH, U.S. Dept. of Interior, Water Research Laboratory, *Cincinnati, Ohio* 45226

In some areas the treatment of municipal wastewater for direct reuse is inevitable. Recreational use of renovated wastewater will also increase in areas which lack surface water. Regardless of the use of reclaimed water, the health needs for sewage purification and disinfection must be met at all times.

The primary objective of this project is development of methodology to produce a pathogen-free effluent from waste treatment processes. This process must be economically feasible, yield an effluent free of hazardous toxic components and as far as possible yield an effluent that does not introduce factors undesirable to aquatic environments.

The merits of chlorination, ozonation, Cl02-process, and any other promising and practical disinfection process will be evaluated in terms of efficacy, economy, practicability and relative freedmon from undesirable after-effects.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0847, IDENTIFICATION OF NATURAL AND SYNTHETIC ORGANIC COMPOUNDS IN RAW AND TREATED MUNICIPAL WASTES

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At the present time comparatively little is known of the organic content of domestic waste waters, either raw or treated, except as to a few classes of compounds such as carbohydrates, amino acids, crude lipids, etc. In particular, very little is known of the composition of secondary effluent. Such questions are now assuming importance because of greatly increased interest in the field of 'tertiary treatment' and surface water pollution in general.

The methods of organic separations and identification are directly applicable once suitable samples are available, and the problems unique to the field are those of sampling and purification. It is necessary to recover the organic compounds at trace concentrations and separate the components of interest from comparatively large amounts of accompanying materials, both organic and inorganic.

The most useful concentration methods are liquid-liquid extraction, adsorption on activated carbon, evaporation at reduced pressure, and freezing. The crude extracts are then partially purified by adsorption and partition column chromatography, steam distillation, gel filtration, and changes in solubility characteristics with pH. Final purification and identification are by more sensitive methods such as thin layer, paper, and gas chromatography and various forms of spectrophotometry.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0848, REMOVAL OF SUSPENDED SOLIDS AND PHOSPHATE FROM A SECONDARY EFFLUENT BY ALUM COAGULATION AND DUAL MEDIA FILTRATION

J.J. CONVERY, U.S. Dept. of Interior, Water Research Laboratory, *Cincinnati, Ohio* 45226

Clarification of secondary effluents has application in pollution control, direct reuse and as a pretreatment for other tertiary processes such as electrodialysis, reverse osmosis and ion exchange. Alum coagulation, sedimentation and dual media filtration remove essentially all of the suspended solids, phosphorus and BOD associated with the solids from a secondary effluent. The following operating conditions have been found to be optimum: 1. Overflow rate - 700 GPD/FT2 2. Alum Dose - 300 mg/l 3. Filter Media a) Anthracite - 18 in. of 1.4 mm b) Sand - 6 in. of 0.45 mm 4. Filtration Rate - 4 GPM/FT2

A flocculant aid such as activated silica is necessary to increase the strength of the alum floc and prevent the premature breakthrough of turbidity through the filters. A silica concentration of 3 mg/l as SiO2 is optimum. Filter runs averaged 17 hours for the above operating conditions. Operating costs based on a 10 MGD plant are estimated to be $0.08/1,000 gal.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0849, DISSOLVED INORGANIC REMOVAL--SELECTIVE ION AND ORGANIC REMOVAL BY ION EXCHANGE RESINS

R.A. DOBBS, U.S. Dept. of Interior, Water Research Laboratory, *Cincinnati, Ohio* 45226

The problems associated with the discharge of nutrients to receiving waters and the incremental build-up of dissolved inorganic salts with each use cycle make it imperative that technology to remove these pollutants be developed and demonstrated. In this area, ion exchange has operational, technical and possibly economic advantages over other processes for demineralization.

In recent years several new types of synthetic resins have been developed, and are commercially available, which are particularly suitable for the removal of selected ions and have the additional capability of sorbing organic matter. Resins, in contrast to activated carbon, can be regenerated in situ by suitable regenerants.

The objective of this study is to develop the use of synthetic ion exchange resins for the selective removal of inorganic ions as well as organic materials. Phase I of the study will include, 1) optimization of flow rates for the exhaustion and regeneration cycles, 2) evaluation of regenerants for imparting selectivity, 3) determination of optimum volume and concentrations of regenerants for imparting 4) performance of the resin after repeated cycles of operation and 5) cost estimates for the process. Phase II will attempt to screen a variety of resins for the above process.

Experimental apparatus consists of multiple 2' glass columns with associated pumps and pressure equipment.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0850, ULTIMATE DISPOSAL OF SLUDGES BY SURFACE SPREADING

J.O. EVANS, U.S. Dept. of Interior, Water Research Laboratory, *Cincinnati, Ohio* 45226

Land surface provides low cost dewatering and oxidation of organic sludges with additional benefits from added soil fertility. Certain insoluble mineral wastes such as calcium carbonate and phosphate are compatible with many soils and can also act as fertilizers. Since dewatering of sludges by sedimentation, centrifugation, or filtration is expensive, a study of wet sludge disposal on land surfaces has been initiated. Pipeline transport of sludges and stabilization to prevent nuisance odors will be studied. Distribution programs to minimize pollution from runoff and percolation will be devised. Long term effects of repeated sludge applications to various soil types will be evaluated.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0851, SUSPENDED AND COLLOIDAL SOLIDS REMOVAL--FLOCCULATION BY ORGANIC POLYMERS

S.A. HANNAH, U.S. Dept. of Interior, Water Research Laboratory, *Cincinnati, Ohio* 45226

The need for solids-liquid separation arises at a number of steps in the treatment of wastewater either by chemical or biologic processes. The newly developing organic flocculants represent the best currently available group of chemicals to 1) increase efficiency of solids-liquid separation 2) minimize sludge mass and 3) improve thickening and filtration properties of sludge.

The overall objectives of this study are to 1) investigate the application of new organic flocculants in waste treatment, 2) determine the mechanism of the flocculation by organic polymers and 3) develop methods for the control of dosage to obtain economic use of these relatively expensive compounds.

A wide variety of polymer compounds distinguished as to chemical composition, charge type, charge density and molecular weight will be studied. The polymers will be studied both alone and in conjunction with inorganic hydrolyzing chemicals such as aluminum or iron salts. Variables to be evaluated include polymers, dosages pH, ionic and solids characteristics of wastewater before and after treatment, effects of agitation and mode of addition of polymer. Experimental apparatus and instrumentation used in the study will include: jar test apparatus, miniature sand filters, microelectrophoretic techniques, colloid titration, amd streaming current measurement devices.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0852, DISSOLVED INORGANIC REMOVAL BIOASSAY OF ALGAL GROWTH POTENTIAL

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A major objective of some treatment processes of wastewater is to so reduce the concentration of nitrogen and phosphorus that the medium will no longer support a luxuriant growth of algae. While it is generally thought that phosphorus is the ion that limits growth, there is evidence that other, but unknown ions or compounds may be limiting as well. It is the objective of this study to develop an empirical but standardized biological assay to determine whether an effluent has been sufficiently treated to limit the growth of algae. The approach to the development of this bioassay will consist of culturing various algae species in purified cultures under controlled physical and biochemical conditions. Rate of growth and total population will be monitored by light-scattering techniques. Growth comparisons will be made of algae in the presence of 1) untreated water, 2) water treated by a tertiary process, 3) water intended to receive the effluent and, 4) various mixtures of treated and stream water. The project will consist of three distinct phases: 1) development of laboratory procedure, 2) evaluation of test under field practical usefulness and, 3) demonstration of the wide and general applicability of the test.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0853, QUANTITATIVE DETECTION AND ENUMERATION OF POLLUTION INDICATOR BACTERIA OF WASTE WATERS AND SEWAGE TREATMENT PLANT EFFLUENTS

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a. Methods to be perfected for the detection and enumeration of the pollution indicator bacteria, total coliforms, fecal coliforms, and the fecal streptococci will all be based on the latest and best available membrane filter methods.

b. The enumeration and quantitation of Salmonella species and Shigella species consists of a study of membrane filter and multiple tube methods to detect all pathogenic species present in waste waters and sewage treatment plant effluents. The methods thus far developed consist of (1) enrichment of membrane-filtered bacteria (on a variety of new media and on an established medium) on filter pads soaked with selective enrichment medium, incubated at 41 - 42 C. followed by (2) transfer of the membrane to a secondary medium for obtaining a differential colonial appearance of the pathogen for enumeration and picking to other media for identification. Counts on domestic sewage of Salmonella species have been obtained from as low as 9 to 18,000 per 100 ml. Laboratory cultures are not used in these studies, and all developmental work is based on naturally occurring Salmonella in the polluted waters tested. Three methods for the enumeration and isolation of the pathogen Pseudomonas aeruginosa, which is of increasing importance due to antibiotic resistance are being evaluated.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0854, SUSPENDED AND COLLOIDAL SOLIDS REMOVAL-nSOLIDS SEPARATION BY CHEMICAL TREATMENT AND FILTRATION

J.F. KREISSL, U.S. Dept. of Interior, Water Research Laboratory, *Cincinnati, Ohio* 45226

The separation of suspended solids, either those existing or created by chemical and biological treatment, from waste effluents is a recurring step in the series of processes for advanced methods of treating wastewaters. Plain sedimentation followed by surface or depth filtration have proved to be insufficient for the production of the high quality of effluents required for membrane or adsorption processes. Chemical treatment to obtain coagulation and flocculation followed by filtration appears to be the most promising approach for the complete clarification of wastewaters.

The overall objectives of this investigation is to develop a clarification process which will encompass the following 1) coagulation- flocculation in an upflow-solids contact clarifier, 2) filtration using depth filters such as sand, sand and coal or other media combinations.

The experimental apparatus will consist of a series of specially designed columns, approximately 1 foot square, in which the functions of coagulation-flocculation and rough sedimentation can be accomplished. Effluent from these treatment devices will be filtered in a variety of filter media columns. Some of the experimental variables will include 1) upflow velocity, sludge blanket depth, type of coagulant, coagulant dosage, mixing conditions, time of coagulation or flocculation, filter media and rate, etc. Performance of the process will be assessed by measuring such parameters as turbidity, coagulant ion, head loss, etc.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0855, REMOVAL OF NITROGEN COMPOUNDS FROM MUNICIPAL WASTEWATER

A.N. MASSE, U.S. Dept. of Interior, R.A. Taft San. Engin. Center, *Cincinnati, Ohio* 45226

A novel biological treatment process for reducing BOD and nitrogen content of a municipal wastewater is being investigated in a 100 gallons per day pilot plant at the Mill Creek Sewage Works, Cincinnati, Ohio. Primary effluent is treated by the contact stabilization process using abbreviated residence times for both contact and sludge reaeration. The product from this process is then nitrified aerobically in a separate aeration tank settler combination. The nitrifying sludge is kept in this system. The nitrified effluent flows to an anaerobic, mechanically-agitated denitrifying unit followed by a final settler. The source of organic material to the denitrifying bacteria is sludge from the contact stabilization operation. This sludge has a high BOD/NH3-N ratio, thus decreasing the amount of NH3-N put in the denitrifying section. The sludge from the denitrifying settler is returned to the sludge reaeration tank of the contact stabilization process. Parameters being investigated include residence times and sludge recirculation rates.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0856, USE OF GRANULAR ACTIVATED CARBON IN TREATMENT OF WASTE WATERS

A.N. MASSE, U.S. Dept. of Interior, R.A. Taft San. Engin. Center, *Cincinnati, Ohio* 45226

Granular activated carbon is being investigated as an adsorbent for the non-biodegradable materials in a well-treated municipal secondary effluent. A 300,000 gallons per day plant has been on-stream since May, 1965, at Pomona, California. Four down-flow carbon contractors, connected in series, act as both a filter and an adsorbent bed. When the final product quality exceeds specifications, the first column in the series is regenerated in a 6-hearth furnace and returned to the process as the last column in the series. Parameters being investigated include: a) relationship between contact time and removal of contaminants, b) carbon usage rate, c) effect of regeneration conditions on recovery of carbon capacity and d) attrition losses as a result of carbon handling and regneration. Side studies on a smaller scale include studies of: a) effect of contact time and mass velocity on adsorption rates and effectiveness, b) nitrogen removal capabilities of carbon columns and c) effect of hot water and steam treatment on regeneration frequency.

Ultraviolet absorption at 2537 Angstrom units of carbon-treated water is being investigated as a rapid control method for the evaluation of carbon column performance. A high correlation exists between UV absorption and organic matter in clarified water. The hydrogen flame detector is being adapted to determine organic matter at levels below 1 mg/l.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0857, POWDERED CARBON TREATMENT OF WASTEWATER

A.N. MASSE, U.S. Dept. of Interior, Water Research Laboratory, *Cincinnati, Ohio* 45226

Evaluate a two-stage, counter current pilot plant contacting system for powdered carbon treatment of primary and secondary wastewater effluents. Required amounts of powdered carbon and polymer must be determined as well as the standard design and economic criteria.

With a flow rate of 10 gpm (total residence time in the system of 2.7 hours) secondary effluent to which is added 200 ppm powdered carbon and 1.5 mg/l of organic polyelectrolyte, the total organic carbon removed has averaged 90%. When the influent turbidity can be maintained below 20 J.U., the product turbidity is less than 1 J.U.

When feeding primary effluent at 5 gpm to the system and adding 200 ppm carbon and 3 ppm polyelectrolyte, the total organic carbon reduction has averaged between 85 and 91%. The product turbidity is between 1 and 3 Jackson Units. In all runs on primary effluent, the product quality, as measured by total organic carbon and turbidity, has been better than that produced by the activated sludge process.

Evaluate several powdered carbon regeneration methods in conjunction with the powdered carbon process. Regeneration methods to be tested include: (1) microwave heating, (2) reaction furnace, and (3) fluidized-bed techniques.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0858, LIME SLUDGE RECOVERY AND REUSE

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Lime in doses of 200 to 500 mg/l as $Ca(OH)_2$ removes phosphates and suspended matter from secondary effluents. The resultant sludge consists of calcium carbonates and phosphates together with silicate minerals, magnesium hydroxide and organic matter. The lime values may be recovered by recalcining the dried sludge. Although the recovered lime may cost nearly as much as fresh lime, the problem of disposing of large volumes of sludge is solved. Waters differing in hardness and phosphate content have been treated through four cycles and the quantity and quality of the recovered lime has been measured. In soft waters calcium phosphate builds up until it represents over half of the wieght of calcined lime without exerting any deleterious effect provided that fresh lime is added to make up the losses. In hard waters calcium carbonate is removed from the water and must be continuously wasted along with low concentrations of calcium phosphate.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0859, PHYCOVIRUSES - THEIR NATURE, OCCURRENCE, AND APPLICATION

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Viruses have gained increasing acceptance as a promising approach to pest control. Under favorable conditions these viruses provide a valuable alternative to chemical treatment. The discovery of viruses capable of destroying certain freshwater algae may offer such an approach to the selective control of objectionable algal growths.

We have found that waste stabilization ponds provide a highly fertile source of phycoviruses which suggests that these agents may play a role in inducing natural fluctuations and dominance in algal populations. In some ponds, they represent an established population.

Preliminary laboratory tests on these phycoviruses have shown their possible application in controlling algal blooms. Efforts will be made to elaborate on their ecological significance and to isolate other phycoviruses since practicality of this biological control method is dependent on an intensified screening program that could eventually establish an extensive collection of these viruses.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0860, DISSOLVED REFRACTORY ORGANIC REMOVAL -- CARBON AS AN ADSORBENT AND FILTER MEDIUM

W.A. SCHWARTZ, U.S. Dept. of Interior, Water Research Laboratory, *Cincinnati, Ohio* 45226

Removal of non-biodegradable organic compounds from wastewater represents an important unit process in the treatment train to obtain a product water useful for a variety of purposes. The single most promising process is adsorption on activated carbon. The objective of this study is to develop a process for removal of organic materials from wastewater by using activated carbon. In addition to adsorption the carbon also lends itself to use as a filter medium in conjunction with other media such as sand.

Primary and secondary treated waste effluents will be subjected to a treatment sequence consisting of coagulation, filtration and activated carbon adsorption. These pretreatments to adsorption will be varied or omitted to provide a variety of influents for the adsorption step. Hydraulic loadings and carbon bed characteristics will constitute additional variables in the study.

Experimental apparatus will consist of 4' plastic columns. Performance will be judged on the basis of removal of organic matter and turbidity as well as head-loss measurements. The experimental equipment will be located at the Lebanon experimental facility.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0861, ENGINEERING ANALYSIS OF WASTE TREATMENT

R. SMITH, U.S. Dept. of Interior, R.A. Taft San. Engin. Center, *Cincinnati, Ohio* 45226

Mathematical models have been developed to describe both the performance and cost for all of the conventional water renovation processes. The goal of this work is to optimize a system of water renovation processes to meet any specific need for water treatment at minimum cost. Computation is accomplished with digital computer.

Models for the advanced processes such as carbon adsorption and electrodialysis are being developed and will be combined with the models for conventional processes to study water reuse systems. Much information is still lacking, however, for the advanced processes. A secondary goal of the work is to lend continuity and guidance to the experimental programs underway in the Federal Water Pollution Control Administration. Work is also underway to improve the quality of the capital and operating cost relationships now being used.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0862, A STUDY OF THE KINETICS OF THE ACTIVATED SLUDGE PROCESS

R. SMITH, U.S. Dept. of Interior, Water Research Laboratory, *Cincinnati, Ohio* 45226

Study the kinetic or time dependent performance of the activated sludge process for the purpose of finding practicable methods for automatic control of the process to minimize the variation of water quality in the effluent stream and to improve the average performance of the process. A mathematical model for the activated sludge process has been developed which computes the process performance as a function of time when the influent stream or the operating decisions or both vary with time. One digital computer program has been completed which simulates the time dependent behavior of the activated sludge process. This computation which is a numerical integration utilizing the Runge- Kutta fourth-order method integrates the Monod differential equations which express the growth of three classes of bacteria: Heterotrophic carbon users, Nitrosomonas which converts ammonia to nitrite, and Nitrobacter which converts nitrite to nitrate.

The aerator is sub-divided into ten sub-volumes, any number of which can be used to simulate mixing, and a sludge storage tank is provided in the sludge return line. A surge tank, in which no biological activity is assumed, is also provided upstream of the aerator. Sinusoidally varying flow and BOD concentration are applied to this system and the concentration of three classes of microorganisms and three substrates as well as flow are computed as a function of time at each of seventeen stations. Various control schemes involving pumping of sludge from the sludge storage tank to minimize the effect of the varying load on the plant or the use of the surge tank to smooth out the flow have been studied.

The ultimate goal of the time dependent model is to study methods for control of the activated sludge process to give optimum performance when the flow and BOD concentration entering the plant varies throughout the day.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0863, DEVELOPMENT OF AUTOMATED ANALYSES FOR THE SUPPORT OF ADVANCED WASTE TREATMENT RESEARCH PROJECTS

R.T. WILLIAMS, U.S. Dept. of Interior, Water Research Laboratory, *Cincinnati, Ohio* 45226

The effective evaluation of water treatment research is dependent upon obtaining accurate data concerning the constituents found in the waters and waste waters. The automation of analyses is the obvious means of coping with the increasing need for chemical analyses. The use of automation can increase an analyst's daily output manyfold and yet retain the necessary precision and accuracy.

This project is concerned with developing, modifying, or adapting water pollution analysis procedures for use with automated instrumentation. These procedures are represented by the sulfate, total phosphate, organic nitrogen, and others. Some of these procedures have been previously automated but are insufficiently accurate or are not applicable to wastewaters. Hence the need for development work in this area.

Ideally, the procedures will be completely automated and standardized so that all types of samples can be treated identically throughout. However, in some instances pretreatment of the samples may be necessary.

The use of automated instrumentation for the analysis of wastewaters can substantially increase the analytical laboratory's effectiveness in supporting wastewater treatment research.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0864, TREATMENT OF BEAN HOUSE WASTES FROM A VEGETABLE TANNERY

J.D. EYE, Univ. of Cincinnati, School of Engineering, *Cincinnati, Ohio* 45221

The objectives of the project are to demonstrate the feasibility of treating bean house wastes from a tannery and to obtain basic data for the design of full scale treatment plants. Excess lime from the lime bearing wastes will be removed with polyelectrolytes. The clarified lime wastes will be mixed with non-lime bearing wastes and neutralized with acid to a pH of 8.5 - 9.0. The organic material in the blended neutralized wastes will be reduced by a combined anaerobic- aerobic biological system.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
University of Cincinnati

5.0865, FISH OPERCULAR RESPONSE TO ENVIRONMENTAL VARIABLES

W.A. SPOOR, Univ. of Cincinnati, Graduate School, *Cincinnati, Ohio* 45221

To define water quality favorable for aquatic organisms it is necessary to know for each environmental component the range over which its concentration or intensity may vary without adverse effects, and how any one component is related to the rest within their permissible ranges, not only directly, but also indirectly through their effects on the organisms. Relatively little of the literature on the effects of various agents on aquatic life is germane to water quality criteria at present; the major deficiencies are (1) the tests have been acute, with endpoints (usually death) too crude to be relevant to life history and productivity, (2) the effects of combinations of environmental components have received relatively little attention, (3) few species have been tested extensively, and (4) even few have been studied at more than one or two stages of the life cycle. My research objectives are to help correct these deficiencies by using opercular movements* to detect and measure a fish's responses to changes in dissolved oxygen concentration, carbon dioxide and temperature varied alone and in combination. These three will be studied first because of their primary importance. The goldfish and the fathead minnow will be tested to begin with, the former because of its relatively slow opercular movements and because of the numerous papers on goldfish, the latter because it may be possible to relate short-term tests on opercular rate to long-term tests on life-history now being conducted at the Fish Toxicology Laboratory at Newton, Ohio. The study will include, also, an attempt to develop an improved method for measuring free carbon dioxide in water.

*The sensitivity and utility of the opercular response have been known for many years, but until recently technical problems have discouraged its use. Now that the frequency (and probably the amplitude) can be detected and recorded electrically without disturbing or damaging the fish, the technical problems seem to have been solved.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0866, WASTE TREATMENT FACILITIES FOR POLY VINYL CHLORIDE MANUFACTURING PLANT

A.R. SMITH, B.F. Goodrich Company, *Cleveland, Ohio* 44115

A development, demonstration, and evaluation project for the bio- chemical treatment of wastewaters from a typical poly vinyl chloride manufacturing plant, at a 0.85 mgd scale of operation.

The treatment system is to produce effluent to meet the receiving water standards (Delaware River) of greater than 87% removal of BOD, turbidity of not greater than 30 units above river water, and be free from taste and odor producing substances.

The process will consist of chemical pre-treatment with primary sedimentation, followed by activated sludge secondary treatment and a final polishing pond. Tertiary treatment studies with activated carbon are also contemplated to determine the extent to which the secondary effluent will lend itself to tertiary treatment as future Delaware River standards may require the equivalent of tertiary treatment.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
B.F. Goodrich Chemical Company

5.0867, A PROGRAM FOR DEMONSTRATING COMBINED SEWER OVERFLOW CONTROL TECHNIQUE FOR WATER QUALITY IMPROVEMENTS AND BEACH PROTECTION

R.A. ROTH, Cleveland Bur. of Ind. Wastes, *Cleveland, Ohio* 44118

This proposed demonstration project constitutes a unique experimental attempt to: reduce the quantity of combined sewer overflow discharges by (1) the introduction of polyelectrolytes into the sewers during periods of rain to increase the flow and (2) by periodically flushing the sewers during dry weather to reduce the accumulation of solids and organic matter: to disinfect the overflow and polluted stream waters by various methods of storage, feeding and application of sodium hypochlorite solution: to screen debris and floating solids from overflows: to create barriers for reducing the degree of mixing and contamination of shoreline waters by combined sewer overflow discharges: to control bacterial quality of water within these enclosures by (1) pumping water from 2,800 feet offshore, chlorinating, and discharging to the enclosure, (2) hand chlorinating from a boat, and (3) by displacing the water with potable water. The various methods, chemicals, and equipment used for carrying out the foregoing program will be evaluated.

The demonstration project is regarded as an experimental, interim program intended to provide improved water quality at the Lake Erie shoreline until permanent pollution abatement programs can be carried out. It is expected that the information gained from this project could be applied in many locations throughout the country where combined sewer overflows have a polluting effect upon receiving waters.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Cleveland City Government - Ohio

5.0868, THE USE OF ORGANIC POLYELECTROLYTES FOR OPERATIONAL IMPROVEMENT OF WASTE TREATMENT PROCESSES

J.J. WIRTS, Cleveland Div. of Watr. Pol. , *Cleveland, Ohio* 44114

The project objective is to determine the increased purification attainable in a full scale (123 mgd) activated sludge plant through the use of polyelectrolytes in the waste treatment process. Investigation will be made as to where and how the use of polyelectrolytes can be economically feasible in upgrading the operation of an established waste treatment facility. Polymers will be added to the raw sewage or the primary influent, and certain parts of the treatment plant will be given careful study to observe the improved purification from the use of coagulating chemicals. Procedures will be used so that the results obtained can be readily compared with established plant operation.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Cleveland City Government - Ohio

5.0869, PIPELINE TRANSPORT OF SLUDGE

B. RAYNES, Rand Development Corporation, *Cleveland, Ohio*

This program is designed to determine the factors required in pumping a digested sludge slurry from a sewage treatment plant through a six mile pipeline to a strip mine area for reclamation. The program entails research in the hydraulics of sludge transport, and the method of ultimate disposal of the sludge in a manner which has beneficial results in land reclamation. The program is being carried out a strip mine site in Morgantown, W. Va.

The program was started in FY67 and is anticipated to go through FY69 or FY70. The present state of the project is in the design and construction stage of the pipeline and associated pilot plant equipment to handle the sludge.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0870, SEWAGE TREATMENT, PILOT PLANT EVALUATION

B.C. RAYNES, Rand Development Corporation, *Cleveland, Ohio* (14-01-0001-483)

Under a three-year contract executed August 31, 1965, the contractor will build and operate a pilot plant utilizing pulverized coal to treat sewage and industrial wastes. The 10,000-gph plant will be used to verify the technical merits and practical economics of a process developed under earlier OCR sponsored work in which coal has been found to be effective as a filter aid and as an adsorbent.

In addition, bench-scale effort to improve the process will be continued, and effort will be made to find methods of pre-treating the coal to improve its effectiveness.

Coal and sewage wastes recovered from the process may be incincerated, used as a fuel for burning municipal garbage or for water desalination, or for general steam and heat generation purposes.

SUPPORTED BY U.S. Dept. of Interior - Off. of Coal Rch.

5.0871, RAPID-FLOW COMBUSTIBLE FILTER FOR TREATMENT OF COMBINED SEWER OVERFLOW

B.C. RAYNES, Rand Development Corporation, *Cleveland, Ohio*

The design, construction, operation and evaluation of a prototype rapid-flow combustible filter device to treat overflows by removing gross contaminants from combined sewer systems. Both influents to and effluent from the device shall be metered, sampled, and analysed.

Convenience, ease of maintenence and low-cost operation are important areas of concern in the evaluation of this device, and flexibility in design and operation are therefore provided for in the work program.

The prototype filter will be installed in an existing, operating combined sewer overflow outfall of the Cleveland Ohio system.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0872, HEAT TRANSFER STUDIES ON SLUDGE SUSPENSION

UNKNOWN, Rand Development Corporation, *Cleveland, Ohio*

The proposed project is a study of disgested sludge which is to be economically disposed of by transport in small diameter pipelines, and which can beneficially be used in land surface reclamation.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0873, MODIFICATION OF WHITTIER STREET STORM STANDBY TANKS

C.T. LINDBLOOM, Columbus City Government, *Columbus, Ohio*

This project consists of an evaluation of the pollution reduction effectiveness of storm overflow tanks modernized by installation of automated sluice gates and other equipment.

Physical features of the project consist of the renovation of three existing combined sewer overflow tanks having a capacity of 1.3 mg each. The renovation includes automatic controls for the tank influent sluice gates, new traveling bridge type sludge collectors and new pumps. One objective of the automation is to keep sludge levels by continuously removing it from the tanks and thereby preventing anaerobic decomposition and its resultant odors. Another objective is to control flows at the treatment plant by proper use of the automatically operated sluice gates. The improvements in tank efficiencies are expected to reduce bacterial contamination of the receiving stream, the Scioto River.

Evaluation will include studies of the efficiency of the tanks as treatment units as well as studies of the effect of the system on the river.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Columbus City Government - Ohio

5.0874, RELATIONSHIPS BETWEEN PHOSPHATE AND OTHER CHEMICALS AT THE WATERSUBSTRATE INTERFACE IN WESTERN LAKE ERIE

N.W. BRITT, Ohio State University, Graduate School, *Columbus, Ohio* 43210

This project is designed to determine the chemical and physical relationships between the water and sediment in western Lake Erie. Little is known about the seasonal or longterm changes which have occurred or are occurring at various depths in the sediment and the overlying water. The specific areas of investigation include chemical determinations of the total phosphate, organic content, iron, sulfate, and arsenic content of the sediment and overlying water throughout the year.

Determination of the physical composition of the sediment may give an indication of the rate and amount of siltation. Redox potential and pH determinations should give an indication of some of the chemical changes occurring in the sediments and overlying water.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Ohio State University

5.0875, A STUDY OF BIOLOGICAL SYSTEMS IN THE SCIOTO RIVER AS INDICES TO WATER QUALITY

J.H. OLIVE, Ohio State University, Graduate School, *Columbus, Ohio* 43210

The proposed research plan involves laboratory and field investigations directed toward developing biological indices to water quality conditions in the Scioto River (Ohio) basin and their application to other stream systems. A biological systems analysis approach is planned in which populations of representative organisms and communities of organisms will be intensively studied in relation to physical and chemical parameters. Species diversity indices will be developed and correlated with physical and chemical parameters.

Field investigations will involve: (1) Establishment of study stations in the Scioto River above and below present and anticipated zones of water quality influence. (2) Collection at two-week to four- week intervals of biological organisms in representative habitats. (3) Collection of water and soil samples at locations described in (2).

Laboratory investigations will include: (1) Laboratory identifications of organisms by taxonomic specialists and quantification of results. Correlations between biological organisms and physical and chemical parameters will be determined. (2) Laboratory determinations of trace elements by emission spectroscopy. (3) Species diversity indices will be derived by formulas developed by Patten (1962). (4) Field determinations of chemical conditions for alkalinity, dissolved oxygen, carbon dioxide, chlorides, iron, nitrates, phosphates, silicates, and sulfates.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Ohio State University
Ashland College

5.0876, THE CYCLING OF Cl-36 LABELED DDT IN NATURAL ECOSYSTEMS

T.J. PETERLE, Ohio State University, Graduate School, *Columbus, Ohio* 43210 (AT(11-1)1358)

The universal contamination of our environment by persistent chlorinated hydrocarbons is an established fact. Samples from the Arctic, from the pelagic fishes of the Pacific Ocean and from the fauna of the Antarctic have been positive for residues of DDT metabolites. Additional biological research has demonstrated that physiological and behavioral effects on certain organisms can be demonstrated in the laboratory at extremely low levels of exposure. The importance of environmental levels of pesticide residues, their translocation and bioaccumulation in natural systems, is self-evident. The production and distribution of DDT continues to increase, not only in the USA, but on a global scale. The rapid increase in human population density, the demand for increased food production and the more efficient control of insect disease vectors suggests the continued widespread use of pesticidal compounds. Additional information is necessary to ascertain their effect on natural environments.

Prior experience in the use of isotope-labeled pesticides has demonstrated that this is a useful and economical way for determining the transfer of these organic compounds in ecosystems. This project will attempt to determine the transfer of Cl-36 DDT through a terrestrial system. Radioassay procedures will be used to quantify the level of the insecticide and its metabolites in the various physical and biological components of the ecosystem. Since the radioassay procedures will assess only the labeled DDT applied, total body burdens will reflect only that DDT accumulated from the study area. Some artificial exposures in time and space will be made to determine rates of accumulation for the various species present on the treated area.

SUPPORTED BY U.S. Atomic Energy Commission

5.0877, INFLUENCE OF SUSPENDED MICROSCOPIC SUBSTANCES ON THE METABOLISM OF MICROORGAN-

ISMS RESPONSIBLE FOR BIOLOGICAL ENRICHMENT OF WATER

R.M. PFISTER, Ohio State University, Graduate School, *Columbus, Ohio* 43210

The proposed investigation is to study the interaction of environmental contaminants (defined as substance not formed biologically or naturally, and which are not normally indigenous to the water) on the microbial portion of the ecosystem. The particulate materials (detritus) will be examined on a physical, chemical, and biological basis, and the materials will be characterized using differential and gradient centrifugation in conjunction with electron microscopy. The characteristic fractions of suspended particulate material will ultimately be examined for ability to influence biological reactions. This particulate fraction of water is important to microbial relationships in the area of interfaces and biological activity. It is known that particles and molecules in solution accumulate at interfaces (this includes chemicals which can either act favorably (e.g., nutrients) or unfavorably (e.g., pesticides) to organisms) and that enzymatic reactions are concentrated at membranous surfaces. Therefore, it is of significant importance to study the capabilities of nonbiologicals that commonly end up in the waters on such colloidal or molecular interfacial systems.

The investigation will be confined to a small river or creek basin which enters into Lake Erie, and to the lake itself.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Ohio State University

5.0878, REMOVAL OF TRACE METALS FROM WATER BY ION FLOTATION

A.J. RUBIN, Ohio State University, Water Resources Center, *Columbus, Ohio* 43210

Contamination of domestic and industrial water supplied by trace metals is of increasing concern. The possible economic damage and potential health hazards of certain trace metals coupled with the difficulty in their removal requires a new approach in treatment process selection and design. Ion flotation, a new low gas flow -rate foam separation technique, offers promise as an effective unit process for the selective removal of such trace metals.

The general objectives of this research are to (1) investigate the variables affecting metal ion removal by ion flotation, and (2) establish design criteria for an ion flotation process. For the first year of the proposed research, the specific objectives are to study the kinetics and variables affecting the removal of lead (II) in batch ion flotation systems. Other cations will be investigated during the second year, and as time permits during the first year after completion of the lead (II) studies. These variables, which affect the rate and/or degree of removal, include the metal ion and collector surfactant concentrations, gas flow-rate , pH, and ionic strength. Interactions between variables will also be determined.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Ohio State University

5.0879, RELATIONSHIP OF ACTIVATED SLUDGE BULKING TO ORGANIC LOADING, OXYGEN AVAILABILITY, AND HYDRAULIC CHARACTERISTICS OF THE AERATION TANK

K.S. SHUMATE, Ohio State University, Water Resources Center, *Columbus, Ohio* 43210

The specific objectives of this research are to investigate the interrelationships between oxygen availability, organic loading, agitation intensity, and mixed liquor age distribution as factors contributing to sludge bulking in the activated sludge process. A physical simulation of the complete mix reactor-in-series model will be used to provide controlled variation of mixed liquor age distribution. Agitation in the aeration tanks will be controlled by the combined use of diffused air and mechanical stirring. Diffusor air flow rate will be varied as required, and the mechanical stirrers will be adjusted to control the total power input per unit volume, which will be used as the parameter of agitation intensity.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Ohio State University

5.0880, STUDY OF THE SULFIDE-TO-SULFATE REACTION MECHANISM

E.E. SMITH, Ohio State University, School of Engineering, *Columbus, Ohio* 43210

Objectives of this study are to determine the effects of timber harvest practices on the physical and chemical characteristics of coastal streams and on fixation of energy by stream periphyton and inflow of organic detritus. Mean levels and variabilities of suspended sediment discharge, stream temperature, net solar radiation, chemical water quality, primary production by periphyton, and inflow of plant detritus will be established during a two year pre-logging period 1966- 68. Studies will continue during logging in 1966 and for two years after harvest.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0881, A PILOT-SCALE STUDY OF ACID MINE DRAINAGE

E.E. SMITH, Ohio State University, School of Engineering, *Columbus, Ohio* 43210 (14-12-97)

The project activities are designed to establish a systems research approach to the investigation of acid mine drainage. The study will attempt to define the controlling factors and to assess the significance of acidic condtions in abondoned mines, currently inactive ones, and in future mining areas. Attempts will be made to assess the characteristics of acid formation, to establish systems to monitor adequately the variables selected, and to attack the problem with suitable abatement measures.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0882, PRECIPITATION OF PHOSPHATES FROM WATER WITH FERROUS SALTS

K. SVANKS, Ohio State University, School of Engineering, *Columbus, Ohio* 43210

The objectives of this study are to determine: 1) The mechanism of the reaction and optimal conditions under which ferrous hydroxide (applied directly or indirectly in form of ferrous sulfate) may be used to remove phosphates from water. 2) Methods of removing the insoluble phosphates and polyphosphates formed in the reaction, with particular emphasis on flotation processes. 3) The effectiveness of insoluble ferrous salts with or without flocculants to reduce the BOD and total nitrogen and the possible interference of these and other substances to the removal of phosphates.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Ohio State University

5.0883, CLADOPHORA AS RELATED TO POLLUTION IN WESTERN LAKE ERIE

C.E. TAFT, Ohio State University, Graduate School, *Columbus, Ohio* 43210

The proposed research involves mapping and quantitative studies of attached Cladophora along the shorelines and on shoals adjacent to the Lake Erie Islands, and of the detached Cladophora beds that drift across the lake bottom. The approach will determine the quantity of Cladophora on the basis of dry weight, its periodicity, the chemical composition relative to that of the lake water, and the relationship of Cladophora to oxygen concentrations over the beds. Studies to evaluate harvested Cladophora as special products such as fiberous filter material, food, and/or as a mulch will be initiated.

Field investigations include: 1) Aerial mapping of Cladophora beds. 2) Observations of periodic growth on the beds. 3) Quantitative measurements of Cladophora on attached and drifting beds. Laboratory invesgigations include: 1) Chemical analyses of Cladophera. 2) Chemical analysis of lake water. 3) Culture of Cladophora. 4) Suitability of Cladophora as a special filter medium. 5) Suitability of Cladophora as an animal food supplement. 6) Suitability of Cladophora as a speciality mulch.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Ohio State University

5.0884, DEVELOPMENT OF TILLAGE-REPLACING HERBICIDE SYSTEMS

G.B. TRIPLETT, Ohio State University, Agricultural Experiment Sta., *Columbus, Ohio* 43210

Objective: To develop herbicide systems for non-tilled crop production that control unwanted vegetation and minimize hazards: (1) to current crop, (2) to succeeding crops, (3) of soil and water contamination.

Herbicides will be screened to determine their value in controlling unwanted vegetation and their hazard of crop injury. Promising materials and combinations of materials noted in screening trials will be evaluated for their adaptability to non-tilled crop production following sod and clean tilled crops. The best systems emerging from this research will be evaluated for (1) contamination of crops, (2) injury to following crops, (3) contamination of surface water runoffs.

SUPPORTED BY U.S. Dept. of Agriculture
Ohio State Government

5.0885, THE EFFECT OF DIELDRIN ON SURVIVAL AND DEVELOPMENT OF FISH EGGS

R.A. TUBB, Ohio State University, Graduate School, *Columbus, Ohio* 43210

Dieldrin is the most commonly found insecticide in the major river basins of the United States (Breidenbach, 1967). Over 1.5 million acres in Ohio are treated annually with aldrin which is rapidly oxidized to dieldrin. Natural populations of fishes and fish eggs have been surveyed for dieldrin residues. Currently eggs from Stizostedion vitreum, Ictalurus punctatus and Polydictus olivaris are being subjected to concentrations of 0.05 ppb to 125 ppb dieldrin. The project was started in 1966 and will be completed in 1969.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Ohio State University

5.0886, THE UPTAKE OF DIELDRIN IN THE THREE RIDGED NAIAD, AMBLEMA PLICATA

R.A. TUBB, Ohio State University, Graduate School, *Columbus, Ohio* 43210

Amblema plicata occurs throughout the Ohio River drainage and is becoming increasingly important for export in the cultured pearl industry. Since this mollusk remains stationary for long periods of time, it can act as a pesticide monitor in streams. Recent studies have shown that naiads concentrate chlorinated hydrocarbons. This study is an attempt to find the levels of dieldrin in natural populations and experimentally determine the uptake and excretion rates of the pesticide. The project was started in June, 1968 and will be completed in 1969.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Ohio State University

5.0887, ALTERNATIVE ECONOMIC RESPONSES TO THE ACID MINE DRAINAGE PROBLEM IN SOUTHEASTERN OHIO

R.A. TYBOUT, Ohio State University, Graduate School, *Columbus, Ohio* 43210

A cost-benefit analysis from which additional inferences are drawn on selected levels of abatement. Costs are found in three parts: (1) costs of treatment; (2) costs of sealing; and (3) secondary costs. Costs of treating mine drainage, in terms of unit acid and iron content are derived from Pennsylvania's 'Operation Yellowboy'. Costs of sealing are based on the results of Moraine State Park Reclamation Project No. 1 (Butler County, Pa.), where 81 mines are currently being sealed. Secondary costs are those derived from unemployment and community loss of income resulting from inability to sell coal at prices that cover treatment costs.

A number of special studies were conducted preliminary to the above. First, employment, wage, price and production series were constructed county-by-county in an attempt to separate from other trends the unique effects of treatment costs on employment. Second, for the purpose of generalizing the costs to the states, the problem of predicting mine drainage was analyzed on the basis of (1) volume of drainage per ton of coal mined, by county, with subcases for deep and strip mining and with corrections for seam thickness and hydrologic conditions; (2) quality of drainage as affected by surrounding geological strata.

Benefits are found for (1) municipal water treatment; (2) industrial water usage and (3) recreation. Secondary benefits in the form of community impact of tourist expenditures are included. Conceptual limitations to the use of secondary costs and benefits are noted.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Ohio State University

5.0888, STRIP-MINING AND WATER QUALITY

J.P. VIMMERSTEDT, Ohio State University, School of Agriculture, *Columbus, Ohio* 43210

Since 1965 when strip mining began on Little Mill Creek Water Shed, weekly samples of storm water have been taken at four sampling points. Two of the points are receiving effluent from the strip mining operation and two are not. The water samples have been analyzed for concentration of manganese, iron, aluminum, sulfate, calcium, and magnesium. These chemical analyses have shown large differences in composition between those sampling points receiving strip mine drainage and those unaffected by these mining operations. Manganese and sulfate concentrations have shown the largest increases.

A sprinkling infiltrometer has been constructed and is being used to measure rate of rainfall in filtration on spoil banks of varied composition.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Ohio State University

5.0889, STRIP-MINING AND WATER QUALITY

J.P. VIMMERSTEDT, Ohio State University, Agricultural Experiment Sta., *Columbus, Ohio* 43210

Objectives: 1. To determine the changes in chemical composition of the water in Little Mill Creek following strip-mining for coal on the watershed. 2. To study the relationships between reclamation measures and water quality.

Description of work proposed: Periodic water samples taken at 4 weirs will be analyzed for chemical composition. Three of the weirs receive water from the mined area while one does not. Comparisons will be made between water from the mined and unmined area.

A portable rainfall simulator will be used to study runoff and erosion from the spoil banks, and infiltration of water into the banks.

SUPPORTED BY Ohio State Government

5.0890, HYDROLOGIC INFLUENCES OF STRIP MINING, BEAVER CREEK, KENTUCKY

R.J. PICKERING, U.S. Dept. of Interior, Water Resources Division, *Columbus, Ohio*

The purpose of this study is to determine the effect of strip mining for coal on the soil, water, and other natural resources. The main study area consists of two small stream basins in the headwaters of Beaver Creek tributary to Cumberland River in McCreary County, Kentucky. The study area includes one watershed in a natural state and the adjacent watershed which has been extensively strip mined.

Strip mining is a common operation in large areas of Kentucky and adjacent states. It is important to all phases of water development in the Appalachia Region to know the effects of strip-mining on the hydrologic system. This study is designed to determine both the nature and the magnitude of the effects.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

5.0891, TERTIARY TREATMENT BY FLOCCULATION AND RAPID SAND FILTRATION

D.F. TOSSEY, Dayton Department of Water, *Dayton, Ohio* 45402

The purpose of this project is to demonstrate the feasibility of tertiary treatment at a municipal trickling filter plant. Coagulation, flocculation, sedimentation and filtration principles will be applied to trickling filter effluent and final plant effluent utilizing an existing scale model unit. Tests will be conducted both with and without the use of chemicals. Various filter media and flow rates will be studied.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Dayton City Government - Ohio

5.0892, STUDY OF UTILIZATION AND DISPOSAL OF LIME SLUDGES CONTAINING PHOSPHATES

R.E. OPFERKUCH, Monsanto Research Corporation, *Dayton, Ohio* 45407 (14-12-199)

The technical and economic feasibiliry of utilizing the sludges obtained from the lime treatment of wastewater to remove phosphates will be determined. Economic, market, and engineering studies will be made on each potential large volume (sulfate fertilizers, wet process phosphoric acid, and phosphated fertilizers) outlet for phosphate sludge. Samples of recovered lime from a number of installations where classification of waste waters is carried out will be evaluated.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0893, TROPHIC TYPOLOGY OF OHIO LAKES

G.D. COOKE, Kent State University, Graduate School, *Kent, Ohio* 44240

On the basis of the number and kinds of species, nutrient content, biomass, chlorophyll, and rate of community photosynthesis, lakes are classified as oligotrophic, mesotrophic, and eutrophic. A central question in aquatic ecology is whether the eutrophic type has the properties of a mature or an immature ecosystem. The purpose of this investigation is to classify a group of lakes and reservoirs in Ohio on the above bases, and to then approach the question of the degree of maturity of a nutrient-rich eutrophic lake, in comparison to more oligotrophic types.

Dollar Lake, Portage County, Ohio is currrently being investigated as a representative of an extremely eutrophic lake. Preliminary studies on lakes which do not receive agricultural or septic tank effluent are underway.

SUPPORTED BY Kent State University

5.0894, ECOLOGICAL SUCCESSION IN A NORTHEASTERN OHIO RESERVOIR

G.D. COOKE, Kent State University, Graduate School, *Kent, Ohio* 44240

The purpose of the investigation is to study the structure and function of the plankton community down the length of Lake Rockwell, a long, narrow reservoir in Portage County, Ohio. The reservoir is fed by the nutrient-rich Cuyahoga River. It is hypothesized that the portion of the reservoir nearest the entrance of the river will be more eutrophic and therefore an ecologically more immature community, in comparison to that portion of the reservoir furthest from the input of nutrient-rich water.

Water s amples will be collected at stations along the river and reservoir, and analyzed for nitrate, phosphate, and chlorophyll, and for number, kinds, and biomass of plankton organisms. Community photosynthesis will be measured by light and dark bottle methods. Other data of limnological importance will be collected.

SUPPORTED BY Kent State University

5.0895, A FIVE YEAR LIMNOLOGICAL STUDY OF A NEWLY CREATED ACID MINE WATER IMPOUNDMENT

C.V. RILEY, Kent State University, Graduate School, *Kent, Ohio* 44240

A limnological study of a newly created 3.5 acid mine water impoundment is being conducted. The impoundment was created on the site of a former 'gob' waste dump and mine drainage ditch. Physico- chemical data concerning the mine drainage were collected prior to impoundment. Analyses have been continued on the impounded water, at various levels, as the waste materials were submerged. Analysis include, pH, specific conductance, total acidity, total alkalinity, dissolved O2, free CO2, dissolved solids, Fe, Zn, Al, Mn, hardness, Ca, Mg. etc. Monitoring equipment is to be installed in 1968. Continuous monitoring of pH, D.O., solids, total alkalinity and temperature will be included.

SUPPORTED BY Kent State University
Ohio Reclamation Association

5.0896, ELECTRODIALYSIS TREATMENT OF SECONDARY EFFLUENT

C.A. BRUNNER, U.S. Dept. of Interior, Leb. Adv. Waste Tmnt. Plant., *Lebanon, Ohio*

Electrodialysis is being pilot tested to determine the feasibility of the method for partially demineralizing municipal wastewater. The partial demineralization is necessary for removal of the increment of inorganic material added during use and becomes especially important when multiple reuse of the water is considered.

The pilot system consists of a 50-gpm electrodialysis stack. Feed to the stack is clarified and granular-activated-carbon treated municipal secondary effluent. The design value of the fraction of mineral removal is 40 percent. Concentrated waste rate is maintained at less than 10 percent of the product rate. During operation the degree of demineralization is monitored frequently by conductivity measurements of feed and product. Analyses of principal ions are obtained occasionally.

An operating problem that has been encountered is anion membrane fouling. The result of fouling is a decline in demineralization. Since the problem first arose, much of the experimental work has been aimed at overcoming it. Although fouling has been reduced by improved clarification, it has not been completely eliminated. The fouling materials can be removed by allowing the equipment to remain idle for several days.

In spite of the fouling problem, electrodialysis is considered to be technically feasible. Longer study is required to determine accurately the economic feasibility, but present estimates indicate the process is practical.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0897, SINGLE STAGE LIME TREATMENT WASTEWATER

C.A. BRUNNER, U.S. Dept. of Interior, Leb. Adv. Waste Tmnt. Plant., *Lebanon, Ohio*

In certain envisioned reuses of wastewater, it is essential to remove suspended material. Chemical clarification with lime is one possible method of removal. In this study, lime clarification is being used to treat municipal secondary effluent prior to granular activated carbon treatment and demineralization by electrodialysis.

Secondary effluent is supplied to a circular up-flow clarifier at a rate of 75 gal. per min. Lime slurry and secondary effluent are mixed in a rapid mix zone where precipitation occurs. The mixture passes through a sludge blanket and finally into the sedimentation zone. The effluent from the clarifier is further polished with two dual media filters (anthrafilt and sand). The total organic carbon, suspended solids or turbidity, alkalinity, hardness, and phosphate concentration of feed and product water are monitored. The most important operating variable is clarifier pH. Studies are being made over the range 9 to 10.5. Limited study has been made of flocculant aids.

Results indicate that good clarification can be obtained at pH values from 9 to 10.5 without a flocculant aid. Phosphate removal is also good over that pH range. Significant calcium and alkalinity removals occur at pH of 9.5.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0898, TREATMENT OF WASTE WATER - WASTE OIL MIXTURE

J. BARKER, Armco Steel Corporation, *Middletown, Ohio*

This project provides for design, operation, studies, and reports on a full scale demonstration facility to be built by ARMCO FOR THE TREATMENT of 4.6 mgd of oil-water emulsion wastes from a five-stand sold-rolling mill. A five chemical treatment method of coagulation, flocculation, dissolved air flotation for oil-water separation, and sludge incineration will be used. The project schedule provides one year for construction and one year for operating studies of parameters and reporting of results.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Armco Steel Corporation

5.0899, TREATMENT OF ACID RINSE WATERS

J. BARKER, Armco Steel Corporation, *Middletown, Ohio*

The project provides for construction, operation, tests, and reports on facilities to treat 1500 gpm of acid rinse waters produced by the hydrochloric acid pickling of strip-steel preparatory to cold- rolling. The treatment process will consist of limestone neutralization, aeration, coagulation, sedimentation, sludge recirculation, vacuum filtration of the excess sludge, and effluent equalization.

All or nearly all of the acid and the compounds of iron will be removed by the treatment process. The chloride content of the waste is not changed by this process and may be such that dilution with other available wastes will be required in order to meet the state's proposed standards regarding total dissolved solids.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Armco Steel Corporation

5.0900, THE EFFECTS OF ENVIRONMENTAL CONDITIONS ON THE SPAWNING AND SURVIVAL OF FRY OF THE WALLEYE

V.C. APPLEGATE, U.S. Dept. of Interior, Biological Station, *Sandusky, Ohio*

The recent decline of walleye stocks in Lake Erie following a man induced acceleration of the eutrophic process in the lake demands investigation of the many environmental factors which might influence the survival of young walleyes. Temperature monitoring stations have been established on three known walleye spawning grounds (reefs) in the western basin with the object of determining the effect of temperature regimes during spawning and fry development in the success of walleye hatches. These records will also be used to determine the effects of temperature on the timing and abundance of food organisms that may be essential to the survival of walleye fry when they first begin feeding.

Walleye fry have proved elusive and difficult to capture during their first 6 weeks of life. Measurement and recording of the direction and velocity of water currents on these reefs during the walleye spawning season have been instituted with the objective of casting some light on the dispersal of the fry.

Subsequently, automatic devices for the regular and periodic sampling of plankton organisms on and near the reefs will be devised and incorporated into this experiment. Qualitative and quantitative examination of these samples will be compared with the planktonic diet of fry captured during their first weeks after hatching.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

5.0901, SUBLETHAL INFLUENCE OF POLLUTANTS ON FISH METABOLISM

J.J. OHARA, Central State University, Graduate School, *Wilberforce, Ohio* 45384

The principle objective of the proposed research is to provide an adequate estimate of the alterations in the growth and standard metabolism of fishes caused by different, sublethal concentrations of pollutants commonly found in fresh waters. These measures are necessary to a basic ecological study on fish growth and energy balance and their interrelationship with the community productivity and energetics. Only by determining the influence of common pollutants can future work in fish energetics and population production be applicable to a wide variety of habitats.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0902, DETAILED CHARACTERIZATION OF SOILS AND VEGETATION AT SELECTED SITES TO SERVE AS BASIS FOR FUTURE EVALUATION OF RADIOACTIVE CONTAMINATION

J. HAGHERA, Ohio Agric. Res. & Dev. Ctr. , *Wooster, Ohio* 44691

Field, laboratory, and greenhouse investigation of soils and vegetation from selected sites in Ohio to aid in evaluating the role of soil fixation, leaching, run-off, erosion, and possible concentration by plants in the disposition of radioactive contamination.

Soil samples, plant material, and run-off from Sr90 and untreated plots will be analyzed for Sr90 as well as the determination of other soil properties and composition, the soil profiles of the various plots are being characterized and the inorganic and organic fractions of the soil are being studied to determine their influence on the retention or release of Sr90. Soils and vegetation of small watersheds are being analyzed for gamma emitting isotopes. The uptake of Sr90 by various plant species grown under different conditions is underway.

SUPPORTED BY Ohio State Government

5.0903, PHYSICAL AND CHEMICAL CHANGES IN WEATHERING COAL SPOILS-EFFECT ON WATER SUPPLY AND PLANT GROWTH

J.P. VIMMERSTEDT, Ohio Agric. Res. & Dev. Ctr. , *Wooster, Ohio* 44691

Objectives: To study the physical and chemical properties of weathering coal spoils. (1) To study the composition of ground water loaching from coal spoils as it changes with time. (2) To determine the distribution between runoff and infiltration of rain falling on spoil banks. (3) To study the composition of spoil air. (4) To follow the variation in spoil temperature with season, depth, and stage of weathering. (5) To measure the rate of settling of fresh spoil material and the change in particle size as the spoil weathers. (6) To determine the spoil factors affecting tree seedling survival, growth, and mineral composition.

Procedure: Lysimeter studies, by which objectives 1,3,4, & 5 have been pursued, will be continued. Field studies will incorporate objective 2.

SUPPORTED BY Ohio State Government

5.0904, EFFECT OF IMPOUNDMENTS ON WATER QUALITY

W.R. DUFFER, U.S. Dept. of Interior, R.S. Kerr Water Res. Ctr. , *Ada, Oklahoma* 74820

The purpose of this investigation is to optimize reservoir water quality with regard to disolved oxygen, excess nutrients, algal blooms, toxic chemicals, and releases to maintain flow and support stream life.

Pre-impoundmental data for the Arbuckle system have been collected at four stream stations since December 1965. Arbukle reservior was closed in January 1967, and biweekly sampling of chemical and microbiological paramenters continues at pre-impoundment stations. Background data also exist on benthic macroinvertebrate population structures for these stations. The four pre-impoundment stream stations will be used to monitor water quality changes after the reservoir fills and can be used for comparison with background data collected prior to filling.

When Arbuckle Reservoir fills, sampling locations and schedules will be established for monitoring reservoir water quality changes. The immediate objective of this project is to relate biological and chemical paramenters to the water quality of the reservoir by measuring the extent of their change in a relatively undisturbed system. Future studies will measure the extent of change in critical paramenter in reservoir systems receiving waste materials.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0905, STREAM REAERATION

W.R. DUFFER, U.S. Dept. of Interior, R.S. Kerr Water Res. Ctr., *Ada, Oklahoma* 74820

The purpose of this investigation is to correlate stream reaeration rates with parameters expressing stream geometry and flow. This work will esentially extend the work of other investigators from tidal estuaries and streams having large flows to low-flow streams which are more representative of the southwestern United States.

In addition, the study will lead to an evaluation of the acutal oxygen balance of the system with reference to photosynthesis, respiration, and diffusion. Further, the study will differentiate between these oxygen parameters in both the free-flowing stream and the benthos.

Present investigations are under way at the two test sites in Rock Creek, a stream of the Arbuckle impoundment system. One site is located upstream from a municipal sewage disposal plant, while the other is located downstream from the plant. Both section of Rock Creek are characterized by limestone substrate. Plastic chambers will be used to separate the effects of photosynthesis, diffusion, and respiration under conditions of very little organic enrichment (upstream) and heavy organic enrichment (downstream).

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0906, PIGMENT ANALYSIS FOR THE DETECTION OF ENRICHMENT

W.J. DUNLAP, U.S. Dept. of Interior, R.S. Kerr Water Res. Ctr., *Ada, Oklahoma* 74820

Enrichment of surface waters by fertilizing nutrients from waste effluents and other sources is of major concern in water pollution control. Quantitative assessment of the extent and effect of enrichment is, however, very difficult by presently available methods. Previous studies have indicated that pigment compositions, particularly carotenoids-chlorophyll a ratios, of phytoplankton may vary in a regular and predictable manner with changes in nutrients present in the aquatic environment. The purpose of this research is to determine if analysis of phytoplankton pigments may be conveniently utilized for detection and evaluation of enrichment in surface waters.

Current research involves development of improved methods for the qualitative and quantitative determination of phytoplankton pigments in aqueous media. Methods developed will be employed for study of the effect, under controlled environmental conditions, of single nutrients and mixtures of nutrients on pigment compositions of unialgal cultures, mixed algal cultures, and mixed bacterial-algal cultures. Emphasis will be placed on definition of pigment concentrations and ratios indicative of enrichment; possible utilization of phytoplankton pigment concentrations for prediction of impending nuisance algal blooms will also be investigated.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0907, STUDY OF MICROBIOLOGICAL-BIOCHEMICAL PHOSPHATE SORPTION MECHANISM BY ACTIVATED SLUDGE

W.J. DUNLAP, U.S. Dept. of Interior, R.S. Kerr Water Res. Ctr., *Ada, Oklahoma* 74820

Study the fundamental microbiological-biochemical aspects of the sorption of orthophosphate by activated sludge. Biochemical mechanism of uptake and release of orthophosphate by mixed cultures of bacteria comprising activated sludge. Concurrently predominant species of bacteria in activated sludge of high phosphate sorbing capability will be identified. Individual species found to predominate in phosphate sorbing sludges will be subjected to metabolic studies to determine mechanism.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0908, THE CHARACTERISTICS AND POLLUTIONAL PROBLEMS OF PETROCHEMICAL WASTES

J.A. HORN, U.S. Dept. of Interior, R.S. Kerr Water Res. Ctr., *Ada, Oklahoma* 74820

Preparation of a comprehensive report reflecting the status of present knowledge regarding pollutional problems associated with petrochemical wastes discharged to the aquatic environment and the effects of such discharges upon water quality of surface streams and groundwater resources in the United States.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0909, THE CHARACTERISTICS AND POLLUTIONAL PROBLEMS OF IRRIGATION RETURN FLOWS

J.P. LAW, U.S. Dept. of Interior, R.S. Kerr Water Res. Ctr., *Ada, Oklahoma* 74820

Preparation of a comprehensive report that will reflect the status of present knowledge regarding the pollutional problems associated with irrigation waste waters and their effects upon water quality of surface streams and groundwater resources in the United States.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0910, REMOVAL OF NUTRIENTS FROM ENRICHED FLOWS & WASTE EFFLUENTS BY THE HYDROPONIC CULT OF SUITABLE FORAGE PLANTS & GRASSES

J.P. LAW, U.S. Dept. of Interior, R.S. Kerr Water Res. Ctr., *Ada, Oklahoma* 74820

Hydroponic culture is a well-established method for growing many different types of plants. Normally, solutions are prepared with proper proportions of all required nutrients and are fed to the root systems of the growing plants. Algae have been grown for the removal of nutrients from lagoons receiving sewage effluents, but the difficulty of harvesting the growth makes this an undesirable approach.

It is proposed that higher plants can be successfully grown using a gravel-bed support in specially designed structures for the removal of nutrient materials remaining in waste effluents. Some of the principal objectives of this research are: 1. To improve the quality of surface streams receiving wastes and effluents by the removal of nutrients. 2. Finding the most suitable plants to be grown by this method. 3. Determine economic feasibility of the method, based on expected yield, cost of installation, operation, harvesting methods, etc. 4. Determine quantities of nutrients removed by the process. 5. Propose design criteria for application of the method to waste treatment installations.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0911, DYNAMICS OF RESERVOIR DESTRATIFICATION

L.E. LEACH, U.S. Dept. of Interior, R.S. Kerr Water Res. Ctr., *Ada, Oklahoma* 74820

This investigation is being carried out to determine the effective limits and direction of circulation of water using a compressed air diffuser system. A study will be made on systems of several sizes or a series of systems based on the physical characteristics of study reservoirs. Destratification studies have been employed only in relatively small impoundments. The present study is unique since it is being conducted in the central pool of a large reservoir, Eufaula Reservoir, near McAlester, Oklahoma, containing approximately 600,000 acre-feet at power pool elevation 585.0 and having an average depth of 60 feet.

The system used supplied compressed air to an arrangement of filter stones at a depth of 75 feet for 30 days. Vertical profiles of data concerning the kinetics of the system were collected at selected buoy stations prior to, during, and following artificial destratification. Natural thermal stratification was measured in non affected areas of the reservoir for comparative purposes.

The study was begun in June 1967, and it is continuing until the reservoir becomes isothermal due to seasonal conditions. Modifications of the compressed air diffuser system will be made following coliation and evaluation of 1967 data. The modified system will be installed and operated in the central pool of Eufaula Reservoir in the spring, summer, and fall of 1968.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0912, PHOSPHATE REMOVAL BY ACTIVATED SLUDGE PROCESS APPLICATION - PLANT SCALE DEMONSTRATION

L.D. LIVELY, U.S. Dept. of Interior, R.S. Kerr Water Res. Ctr., *Ada, Oklahoma* 74820

Objective - The positive confirmation of an imposed biological phosphorus removal on a sustained basis at a plant which had a prior record of limited removal of phosphorus.

Locate and study activated sludge sewage treatment plants which meet critical design criterion pertinent to biological phosphate removal. The plants are to be located in different geographical regions of the Continental U.S.A. Chemical and operational characteristics will be determined to ascertain what changes are necessary for such plants to serve as demonstration plants for the biological phosphate removal process.

Description - 1. Negotiate, establish, and monitor plant scale research demonstration for five municipalities to be operated for one full year. 2. Establish system to monitor three additional sewage treatment plants known to be removing phosphorus by the activated sludge process at the present time. 3. Conduct survey and amenability studies on four more activated sludge plants in the Northeast, Southeast, Northwest, and Southwest Regions of the FWPCA to complete scope of phosphate removal project in selecting plants and identifying parameters critical to mechanism, kinetics, operation, and sustenance of the process.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0913, MINING-POLLUTION CONTROL TECHNOLOGY - OIL PRODUCTION GROUND-WATER RECLAMATION BY SELECTIVE PUMPING

L.G. MCMILLION, U.S. Dept. of Interior, R.S. Kerr Water Res. Ctr., *Ada, Oklahoma* 74820

This is a field research project designed to develop and demonstrate a method for alleviating brine contamination in ground water reservoirs by selective development and pumping of the contaminated water. The contaminated area to be investigated is similar to many hundreds of other contaminated areas in the southwest, especially in West Texas and New Mexico where localized contamination has resulted from land disposal of oil filed brines. The project will develop guidelines for use by industry and governmental agencies in the correction of ground-water contamination and will report on the practicability of use of poor quality water for secondary oil recovery. Field site for the project is near Hobbs, New Mexico.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0914, RESEARCH NEEDS PERTAINING TO PETROLEUM WASTE WATERS

L.H. MYERS, U.S. Dept. of Interior, R.S. Kerr Water Res. Ctr., *Ada, Oklahoma* 74820

A state of the art paper will be written concerning the petroleum industry and its waste water problems. The report will encompass three sections in the petroleum industry--(1) production, (2) refining, and (3) transportation.

This report will contain research needs in the petroleum waste water field with priority to the most prevalent pollutants in each section.

The report is intended as a general source of information to administrators, scientists, and individuals involved in water pollution control.

A need exists to determine the magnitude, severity, and potential management of petroleum waste waters.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0915, PHOSPHATE REMOVAL BY ACTIVATED SLUDGE PROCESS SPECIFICATION - PLANT SCALE RESEARCH

F.M. PFEFFER, U.S. Dept. of Interior, R.S. Kerr Water Res. Ctr., *Ada, Oklahoma* 74820

Objective: The verification and quantification of the specific design and operational parameters which control phosphorous removal in activated sludge plants.

Description: Conduct one-year plant scale research program to meet objectives at a city of choice, known to be removing phosphate on a plant scale.

Define range and limits of operation and design parameters of phosphate removal process.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0916, POLLUTION IMPLICATIONS OF ANIMAL WASTE

M.R. SCALF, U.S. Dept. of Interior, R.S. Kerr Water Res. Ctr., *Ada, Oklahoma* 74820

This project is concerned with defining the chemical, physical, and biological properties of various animal wastes and describing the location and extent of the problem. In addition, present technology for collection, transportation, treatment, and utilization of animal wastes will be described along with past and current research. The final phase of the project is to indicate areas of future research.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0917, FATE OF POLLUTANTS IN GROUND WATER

M.R. SCALF, U.S. Dept. of Interior, R.S. Kerr Water Res. Ctr., *Ada, Oklahoma* 74820

Traditionally, it has been and continues to be the practice of water users in the High Plains area of West Texas and Eastern New Mexico to recharge aquifers with playa lake water. In doing so, the aquifer recharged risks contamination by chlorinated hydrocarbons and nitrates resulting from agricultural practices. It is of concern that chlorinated hydrocarbons, in particular, adsorb to aquifer material in the near proximity of the recharge well and then are released in high concentrations when that well is pumped. This project is being conducted cooperatively by the Robert S. Kerr Water Research Center of the Federal Water Pollution Control Administration and the Southwestern Great Plains Research Center of the U. S. Department of Agriculture. The experiment will be at the latter's installation at Bushland, Texas.

The scope of this project will be to determine the distance which pollutants travel in a fresh water aquifer under recharge conditions and the temporal distribution of these concentrations when that same well is pumped.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0918, BEHAVIOR OF WATER IN AN SOUTHWEST IMPOUNDMENT - LAKE THUNDERBIRD

E.H. KLEHR, Univ. of Oklahoma, School of Engineering, *Norman, Oklahoma* 73069

The watershed, reservoir and downstream of an impoundment will be considered as a system in an attempt to learn more about the effect of impoundment on water quality in the Southwest. Physical, gross chemical, and specific chemical analysis will be carried out over an extended period. Data taken will be correlated with climatic condition, watershed land use, history of reservoir, and intended uses of impoundment.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Oklahoma

5.0919, APPLICATION OF RADIOISOTOPO TECHNIQUES TO A CRITICAL WATER RESOURCES PROBLEM AREA (NUTRITIONAL POLLUTION)

G.W. REID, Univ. of Oklahoma, School of Engineering, *Norman, Oklahoma* 73069

The limiting growth factor of either nitrogen or phosphorus on the growth of algae in sewage treatment will be evaluated by using radioisotope tracer techniques. Phosphorus-32 tagging will be used to determine phosphorus assimilation.

The intermediate goal will be to provide basic data for selected nutrients in terms of the degree of sewage treatment to make possible the use of a mathematical model of nutritional pollution, and the final goal being to determine the dilution ratios based on the optimization of net benefits arrived at from nutritional, thermal and degradable pollution models.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Oklahoma

5.0920, DEMONSTRATING THE EFFECT OF NUTRIENTS IN OXIDATION POND RECEIVING STREAM

G.W. REID, Univ. of Oklahoma, Research Institute, *Norman, Oklahoma* 73069

Studies of receiving streams or drainages of operating waste stabilization ponds will be conducted to evaluate critically the fate of nitrogen and phosphorous, bacteria, algae and BOD of effluents subsequent to treatment by lagooning.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
University of Oklahoma Research Institute

5.0921, EVALUATION OF DISPERSED POLLUTIONAL LOAD

G.W. REID, Univ. of Oklahoma, Research Institute, *Norman, Oklahoma* 73069

The purpose of this proposal is to develop a technique of evaluating the dispersed pollutional load. Municipal and industrial outfalls; storm, and combined sewer discharges are point sources of pollution, where as natural pollution, rural runoff, and direct urban runoff represent dispersed sources of pollution. Considerable technological capability exists for dealing with the point sources. Large pollutional loads have been demonstrated resulting for urban run off--dispersed load and storm sewers and the pollution resulting from dispersed sources (including storm sewers as collectors of urban runoff) is not as amendable to control by technological means as is that from point sources. The few studies made of the quality of direct urban runoff demonstrates that this pollution potential is a part of the land-pollution central problem and that the major factor that determines the extent and nature may well be public conscience.

This proposal is concerned with the development of a technique of identifying the source of dispersed load, not the magnitudes as such, but as a byproduct. Once the sources are identified, remedial action can be instigated. The technique involves analytically determining the dispersed load for an urban area and then correlating it to the land use practices. The City of Greater Tulsa has been selected for this study. Analytical Data on waste quality is available and will be gathered at point discharges (sewage plants) and on the receiving stream (Arkansas) above and below the urban area. The city of Tulsa has available an elaborate data-retrival of land use practices starting in 1960 providing six years of records. To increase the data pool, the Tulsa area will be divided into eight sub-drainage basins.

The specific technique will be to identify the principle components of land use as they relate to the dispersed pollutional load (essentially these will be flush out periods minus the point source contributions). The load will be characterized by COD, BOD, Solids, Oil, Nitrogen, Chlorides, and Phosphate.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0922, DEMONSTRATION OF A FULL SCALE WASTE TREATMENT SYSTEM FOR A CANNERY

L.E. STREEBIN, Univ. of Oklahoma, Research Institute, *Norman, Oklahoma* 73069

The objectives of the 18 month study will be to conduct an economic and technical evaluation of a 1.5 mgd biological system employing a combination of both the minimal solids and extended aeration techniques to treat high strength, nutritionally unbalanced cannery wastes.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
University of Oklahoma Research Institute

5.0923, DEMONSTRATION PROJECT OF A PROTOTYPE TREATMENT PLANT DESIGNED TREAT WASTES FOUND AT A COMBINED SEWER OVERFLOW

R.G. PUGH, Rhodes Corporation, *Oklahoma City, Oklahoma*

The project provides for the complete demonstration of a prototype treatment plant to treat wastes typical of those found at a combined sewer overflow. The prototype treatment plant shall consist of screen, cyclone, air flotation unit and all auxiliary equipment including recording flow metering devices and provision for chemical flocculation, necessary for a complete demonstration. Complete demonstration shall consist of design, fabrication, construction, operation and evaluation of said prototype plant.

The work will be accomplished in four phases as follows: Phase I - Design. To include basic design criteria development for mechanical cyclones and dissolved gas flotation cells for high rate handling of sewage flows. Phase II - Fabrication and Construction. To include design, specification, fabrication and erection of a working demonstration plant. Phase III - Operation and Evaluation. Phase IV - Final Report.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0924, ASSESSMENT OF ENVIRONMENT FACTORS INFLUENCING THE DISTRIBUTION OF BOTTOM FISHES IN RESERVOIRS

R.C. SUMMERFELT, State Dept. of Wildlife Cons. , *Oklahoma City, Oklahoma*

The objective is to provide an assessment of the relationship between the distribution of reservoirs fishes, particularly bottom dwelling fishes, and the quantity and character of sediment in reservoirs. The study will be conducted in Lake Carl Blackwell, a 30- year-old, 3,000 acre impoundment in Payne County, Oklahoma.

The study will require six months of preliminary fishing gear evaluation and a preliminary sediment survey along established transect lines. Deep trap nets, modified hoop nets, slat traps, trammel and gill nets will be evaluated for selectivity and efficiency in collecting fishes in selected habitats in Lake Carl Blackwell. Sediments will be collected by use of a Phlager gravity corer with a two meter coring tube. Sediment will be analyzed for organic content, particle size distribution and a numerical count of benthic invertebrates. Sites for intensive study will be based on evaluation of preliminary studies and specific gear will also depend on preliminary gear evaluation. Intensive study of select habitates should commence in the summer of 1967. An analysis of fish distribution will be stratified according to species, season, and vertical variation in abundance.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.
Oklahoma State Government

5.0925, MICROBIOLOGICAL REMOVAL OF IRON FROM MINE DRAINAGE WATERS

R.C. ALLRED, Continental Oil Company, *Ponca City, Oklahoma*

The removal of iron from mine drainage waters using a two-step microbiological process will be investigated both in the laboratory and in the field. It is proposed to change iron from ferrous to ferric state using iron-oxidizing bacteria, followed by precipitation of a ferric sulfide using sulfate-reducing bacteria.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Continental Oil Company

5.0926, OPERATIONAL STABILITY OF THE EXTENDED AERATION PROCESS

A.F. GAUDY, Okla. St. Univ. of Agr. & Sci. , School of Engineering, *Stillwater, Oklahoma* 74075

Preliminary investigations on the stability of operations of the extended aeration process (no sludge wasting) over a period of nearly one year indicated that while the unit activity of the sludge dropped off during the operational period, the total waste purification capacity of the process remained extremely high. The proposed laboratory investigations are directed toward determination of the useful life of an extended aeration process and determination of the biochemical causation for breakdown, if such systems do eventually break down. It is also intended to determine the degree of stability of the process under changing environmental conditions and whether there is any useful parameter (s) which can be used to predict either impending upsets or continued efficient operation.

Laboratory pilot plants will be operated and all sludge except a small measured amount (plus or minus 2%) for analyses and batch experimentation will be returned to the aerator. Substrate removal efficiency, biological solids production, and sludge composition will be determined, and small sludge samples will be taken for measurement of unit activity with respect to oxygen uptake and substrate removal. Analysis of the data should permit useful conclusions concerning the utility of the process and possible ways to extend its use to a greater variety of waste water applications.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Oklahoma State University

5.0927, KINETICS AND MECHANISM IN ACTIVATED SLUDGE PROCESSES

A.F. GAUDY, Okla. St. Univ. of Agr. & Sci. , School of Engineering, *Stillwater, Oklahoma* 74075

The broad objective of the proposed research is the attainment of a more sound understanding of the basic chemical, physical, and biological factors underlying the kinetics and mechanisms involved in growth and substrate utilization in heterogeneous populations with particular reference to waste water purification in continuous and discontinuous activated sludge processes.

Since its initiation in 1962, the research has progressed toward accomplishment of this goal through the conduct of massive, long-term experiments under closely controlled conditions using a variety of steady, well-defined chemical and physical environments. A large number of analytical parameters have been determined and subjected to statistical analysis. Through continuation of this approach, the completion of the work should allow determination of the mechanistic and kinetic parameters which are of significance in formulations of predictive value for design and operation of activated sludge processes. During this renewal period all results obtained on this project will be integrated and consolidated with results of related studies conducted on the biological response to a changing environment (WP-00075) and with studies conducted on genetic and enzymic mechanisms of metabolic control applicable to heterogeneous populations (WP-00786).

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0928, AN EVALUATION OF RECENT APPROACHES FOR THE DESIGN OF BIOLOGICAL WASTES TREATMENT

Q.B. GRAVES, Okla. St. Univ. of Agr. & Sci. , School of Engineering, *Stillwater, Oklahoma* 74075

This is to be an evaluation of information which has become available since about 1959 on biological waste treatment from laboratory investigation, experimental waste plants, and actual operating plants which have been used to formulate design procedures. It is proposed to critically review the information available and compare it with the National Research Council formulations on design of biological waste treatment systems and with other procedures or formulations found in the manual 'Sewage Treatment Plant Design' prepared by a Joint Committee of the American Society of Civil Engineers and the Water Pollution Control Federation.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Oklahoma State University

5.0929, COMPARISON OF ENERGY FLOW PARAMETERS OF MIDGE POPULATIONS IN BIOLOGICAL OXIDATION PONDS

J.L. WILHM, Okla. St. Univ. of Agr. & Sci. , Graduate School, *Stillwater, Oklahoma* 74075

The proposed research involves a study of the effects of pollution on the flow of energy through populations of midge larvae (bloodworms). Midge larvae are extremely abundant in enriched areas and have a pronounced effect on the ecosystem. The experimental area is a series of 10 biological oxidation ponds which are the terminal treatment of effluent from an oil refinery in Ponca City, Oklahoma. Thus, it will be possible to compare bioenergetics of the populations under varying degrees of pollution.

The procedure includes the following: 1) Measure energy content in the diet items, in the standing crop of the different instar stages of bloodworms, and in the major predators of the bloodworms in four of the series of 10 ponds. 2) Measure aerobic respiration rates in the different instar stages of bloodworms inhabiting the different ponds. 3) With the data accumulated in the study and in a concomitant study of bloodworm populations, construct energy flow models for the bloodworm populations living under different levels of environmental stress. 4) Discern variations in water quality as reflected in energy flow and in ecological ratios in bloodworm populations.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Oklahoma State University

5.0930, STREAM CHANNEL STABILIZATION SEDIMENT CONTROL WORKS IN CHANNELS

W.O. REE, U.S. Dept. of Agriculture, *Stillwater, Oklahoma*

Object: To determine the relationships between flow characteristics and scour or deposition in channels; to measure the effectiveness of various vegetal and structural materials proposed for use in channel protection; to develop protective works for channel banks; to establish design criteria for systems of grade control structures for channel stabilization; and to evaluate the role of reservoirs on channel stability for the range of conditions encountered in agricultural watersheds.

Plan of Work: Measurements are made on natural stream channels to obtain data on rates, amounts and size distribution of transported sediment; rate and depth of flow and water temperature; bank and bed materials; vegetation on the bed and banks of the stream; hydraulic properties of the stream including cross-section, slope, and bed form, and on geologic, topographic or structural features which influence the course of the stream. The influence of any one of these factors under field conditions is obscured by the interrelationships involved and the complexity of the flow phenomenon. Flume studies made at the USDA Sedimentation Laboratory and elsewhere are used to help interpret field observations. Channel liners, both structural and vegetal, are placed in outdoor test channels and subjected to controlled test flows. These tests lead to establishing values of critical tractive force or permissible flow velocity to which channel liners can be subjected. Specific structures are tested by the use of small models in sand bed model basins.

SUPPORTED BY U.S. Dept. of Agriculture

5.0931, PRIMARY TREATMENT OF STORM WATER OVERFLOW FROM COMBINED SEWERS BY HIGH RATE FINE MESH SCREENS

S.S. LASSWELL, Cornell Howland Hayes & Merry. , *Corvallis, Oregon*

This project includes the design, construction, demonstration and evaluation of the performance of self cleaning, high rate, fine mesh vibrating screens for the removal of solids from combined storm and domestic sewage. The aim is to develop a compact and adaptable method which will allow a reasonable reduction of pollutional characteristics under the constraints of urban land use and low initial cost.

Several innovations in vibrating screen configuration and combinations will be investigated for contaminant removal and operating efficiencies.

If successful the method will find use in some industrial treatment plants as well as combined municipal collection systems.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0932, MODIFICATIONS TO PUMPING STATION AT SHAGOWA LAKE, FIELD SITE, ELY, MINNESOTA

R.W. BECKLEY, Nepture Micro Floc Inc. , *Corvallis, Oregon* 97330

Supplies and service are being furnished for modification of existing pumping station. The modifications include changes of chemical instrumentation, chemical control, demineralizer, and meters.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0933, SURVIVAL OF FOOD PATHOGENS IN RADIATION PASTEURIZED SEAFOOD

A.W. ANDERSON, Oregon State University, Graduate School, *Corvallis, Oregon* 97331

Previous studies were conducted under controlled conditions in order to observe the resultant survival patterns in solid crabmeat and in Hartsell's broth of Salmonella enteriditis, S. paratyphi A, S. cholerasuis, S. pullorum, Streptococcus pyogenes, and Staphylococcus auerus after individual exposure to Co60 irradiation. A 'tailing off' was found in the survival patterns of S. paratyphi A, S. pullorum, S. enteriditis, and S. aureus when irradiated in crabmeat, but was not found upon exposure in Hartsell's broth. However, S. cholerasuis and S. pyogenes showed a definite 'tailing off' in the broth while only weakly, if any, in the crabmeat. Thus this 'tailing off' phenomenon cannot be explained as a mere effect of the medium, but rather indicates a much more complex situation. The results indicate that predictable pasteurization doses usually based on D values would be quite inaccurate, since the projection is based on sigmoidal and linear inactivation curves.

In this investigation we have compared the irradiation resistance and observed the survival of moderate to low levels of inoculum using nonsporeforming food intoxication and infection microorganisms associated with seafoods. Previous experiments reported were designed to observe the effects of added water on influencing the tailing phenomenon, the effects of low levels of radiation on various types of seafoods inoculated with high levels of microorganisms.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0934, MATHEMATICAL AND COMPUTER SERVICES FOR THE ANALYSIS OF DATA AND DESIGN OF EXPERIMENTS FOR CERTAIN FWPCA PROGRAMS

D.D. AUFENKAMP, Oregon State University, Computer Center, *Corvallis, Oregon* 97331

The computer Center at Oregon State University is providing mathematical and computer services for the analysis of data and design of experiments for the following FWPCA programs: (1) fate of pollutants in coastal waters, (2) eutrophication, (3) power production, (4) paper and allied products, and (5) forestry and management. The project was started in fiscal year 1968 and will be completed in fiscal 1969.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0935, COMPUTER SIMULATION OF ESTUARINE DISPERSION

D.A. BELLA, Oregon State University, School of Engineering, *Corvallis, Oregon* 97331

In this research recently developed finite-difference procedures will be used to model several simplified estuaries. Through the use of these models, the importance of the tidal and seasonal hydraulic variations as dispersing mechanisms will be determined under a wide range of conditions. Procedures for estimating the important hydraulic variations will be checked on the finite-difference models and revised as needed. The accuracy and limitations of the currently used mathematical models which ignore these variations will also be determined.

SUPPORTED BY U.S. National Science Foundation

5.0936, EFFECTS OF CHEMICAL AND BIOLOGICALLY MODIFIED PULPING EFFLUENTS ON THE PRODUCTION OF FISH

R.O. BLOSSER, Oregon State University, School of Engineering, *Corvallis, Oregon* 97331

To determine whether various chemical and biological modifications of pulp mill effluent are effective in reducing their toxicity to finned fish.

Progress to Date: The effect of biological modifications of kraft effluents on short term acute toxicity has been initiated. This work will be expanded to include detailed characterization of other effluents and assessment of biological and chemical modification on short term acute toxicity and productivity of finned fish.

SUPPORTED BY Oregon State Government

5.0937, RELATIONS OF NUISANCE ALGAE TO FISH IN KLAMATH LAKE

C.E. BOND, Oregon State University, Agricultural Experiment Sta. , *Corvallis, Oregon* 97331

To determine ecological and other effects of nuisance blue-green algae on fishes in Kiemath Lake and other bodies of water which might be enriched by Kiemath Lake water, by (1) determining the seasonal and spatial distribution of fish species and the underlying reasons for any observed differential distribution and (2) determining the direct effect of algal toxins to fish as well as the indirect effects exerted through the food chain. Quality of fish and effects of export of algal material to Kiemath River will be studied.

Procedure: Standard limnological techniques will be employed to determine abundance of plankton and benthos. Gill nets and traps will be used in studying the distribution of fishes. Data will be obtained periodically at selected stations and evaluated for causative relationships. Effects of algal toxins will be studied by laboratory bioassays and by live boxing fishes in the lake.

SUPPORTED BY Oregon State Government

5.0938, INVESTIGATION OF AQUATIC WEED PROBLEMS AND MEANS OF CONTROL WITH EMPHASIS ON BRAZILIAN WATERWEED

C.E. BOND, Oregon State University, School of Agriculture, *Corvallis, Oregon* 97331

Objectives: 1. To determine means of controlling Brazilian waterweed and other nuisance aquatic plants. 2. To assess impact of control measures on recreational, industrial, and domestic uses of the bodies of water involved.

Progress to Date: Preliminary screening tests have been carried out to determine the effectiveness of a number of chemicals against Brazilian waterweed, and secondary tests using some of the more effective have been run at several concentrations. Cultures of aquatic vertebrates are being started.

SUPPORTED BY Oregon State Government

5.0939, DRAINAGE OF STRATIFIED SOILS

R.H. BROOKS, Oregon State University, Agricultural Experiment Sta. , *Corvallis, Oregon* 97331

OBJECTIVES: 1. To determine useful criteria for the design of subsurface drainage systems. 2. To develop new methods and materials for determining criteria for draining shallow soils. 3. To determine the drainage requirement of various crops in the Willamette Valley.

DESCRIPTION OF WORK PROPOSED: A number of proposed drainage sites on which a farmer expects to install drainage tile will be selected for subsequent study after tile installation. The sites will be selected based upon soil type, cooperation, and location. These drainage systems will be thoroughly studied and evaluated in an attempt to arrive at useful design information.

An additional site will be selected to study and develop new methods and materials for draining shallow soils, i.e., plastic drain pipe, vertical mulching, envelope materials, etc. This site will also be used to determine the drainage requirements for a few selected crops

SUPPORTED BY Oregon State Government

5.0940, PULP MILL EFFLUENT DISPOSAL

F.J. BURGESS, Oregon State University, School of Engineering, *Corvallis, Oregon* 97331

The proposed research is a continuation of 'Biological-Engineering Studies of the Rate and Effects of Kraft Pulp Mill Effluents in the Marine Environment', that has been initiated under project WP-524. The project objectives are twofold, these being to investigate the area and degree of biological influence from a typical ocean outfall from a kraft pulp mill by a combined engineering-biological study involving presently known methods for measuring or determining waste dispersion, degradation and/or reduction in BOD, COD, PBI and other physical measures with biological measures developed in previous research such as toxicity to the embryo of the bay mussel, the pacific oyster and other forms. The objective of this phase is to place an overall water quality impact interpretation on such an outfall installation which will incorpoate the bits and pieces of various projects by this and other investigators.

In this phase aerial photo interpretation of waste dispersion plumes will be attempted and compared with conventional dye studies in an attempt to utilize this recently suggested technique. The combined efforts to undertake the above objective are further supported by the biological objectives of the project which are the further development of bioassay methods and the interpretations that may be placed on bioassay findings. In this phase, it is hoped to relate short-term median tolerance limits (commonly used TL50) of kraft pulp mill waste to commonly used short-term bioassay organisms to concentrations that demonstratively impair growth and performance in juvenile English Sole Parophrys vatulus. Similar determinations for other commercially important fish will hopefully develop from this effort if successful.

The overall objective is to attempt an interpretation of bioassay findings in terms of the actual circumstances found during waste discharge.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0941, AIRPHOTO ANALYSIS OF OCEAN OUTFALL DISPERSION

F.J. BURGESS, Oregon State University, School of Engineering, *Corvallis, Oregon* 97331

The general objective of this research is to develop a remote sensing tool for the evaluation of dispersion of wastes from existing or proposed ocean outfalls. Since sampling from a boat is difficult and/or impossible much of the time in the near shore areas, it is proposed to investigate the feasibility of using photogrammetric and photo interpretation methods to determine dispersion patterns, diffusion coefficients, waste concentrations and near shore currents.

More specifically the aims of this investigation are: 1. To develop a set of characteristic airphoto pattern elements for estimating diffusion coefficients. 2. To determine the relationship between photographic film density and waste concentration. 3. To determine the optimum film-filter combination for flume delineation and waste concentration measurement.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0942, TEMPERATURE REQUIREMENTS OF SALMONIDS IN RELATION TO THEIR FEEDING, BIOENERGETICS, GROWTH AND BEHAVIOR

G.E. DAVIS, Oregon State University, School of Agriculture, *Corvallis, Oregon* 97331

Laboratory and model stream studies are proposed for evaluating the effects of temperature on the feeding, bioenergetics, growth and behavior of selected species of juvenile Pacific salmon and of steelhead trout.

Laboratory studies: A bioenergetic model will be used to determine the utilizations and losses of the energy of consumed food by fish kept during different seasons at different constant temperatures and at fluctuating temperatures varying in range and rate of temperature change.

Model Stream Studies: The effects will be determined of an incremental increase of the temperature regime on the growth, food consumption, behavior, size at migration and timing of migration of juvenile salmonids maintained in outdoor model streams.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Oregon State University
Oregon State Government

5.0943, TOXICOLOGY OF PESTICIDES IN THE ENVIRONMENT

S.C. FANG, Oregon State University, Agricultural Experiment Sta., *Corvallis, Oregon* 97331

The investigational program proposed under this grant is an interdisciplinary effort to evaluate the environmental toxicology of multiple pesticide residues. The investigational plan envisions the study of the behavior of pesticides in the environment, particularly in soil, as it relates to contamination of air and water. Persistence of pesticides in the environment as influenced by chemical parameters and parameters of the environment will be evaluated. These studies lead to assessing the magnification or attenuation of pesticide residues to the food chain of the highest organism. Studies will be performed on the effect of the pesticide residues on mammals or from the standpoint of pharmacology and histopathology. Since the effect of these pesticides will be often expressed at the cellular and subcellular level, biochemical studies on the effect of the pesticides on enzymes and the effect of pesticides on metabolic pathways will be studied.

The work as proposed above implies the three objectives of the project; namely, (1) to investigate and establish principles by which the biological effects of multi-chemicals in the environment can be evaluated, (2) to develop more reliable and systematic methods of analyses for pesticides in water, soil, air, and biological tissues and to provide analytical research assistance to an interdisciplinary group, (3) to assist the physical and chemical properties of pesticides and to relate these properties to the behavior of such compounds in the environment.

SUPPORTED BY Oregon State Government

5.0944, CHEMICAL BRUSH CONTROL - BIOCHEMISTRY AND TOXIC HAZARD

V.H. FREED, Oregon State University, Agricultural Experiment Sta., *Corvallis, Oregon* 97331

Objectives: 1. To improve the efficiency of herbicide action through a better understanding of the influences of additives, formulation, molecular variation and the various physiological and environmental factors as they affect absorption, translocation and metabolism of herbicides. 2. To determine the ultimate fate of herbicides, herbicide metabolites, and residues in plants, soil and water with respect to the extent and magnitude of the watershed contamination problem.

Description of the Work Proposed: 1. Radioactive herbicides will be used to investigate the factors outlined in Item 1 above, in laboratory, greenhouse, and growth chamber studies utilizing a variety of resistant and non-resistant brushy species. The principles developed in these studies will be further tested in the field. 2. An intensive water, soil, and air sampling program will be used to determine the magnitude of contamination resulting from brush control operations on forest lands. Radio tracer techniques, organic extraction and various types of chromatography will be used in the greenhouse and field studies to locate and identify the various herbicide metabolites and residues in the environment.

SUPPORTED BY Oregon State Government

5.0945, TOXICOLOGY OF PESTICIDES IN THE ENVIRONMENT

V.H. FREED, Oregon State University, School of Agriculture, *Corvallis, Oregon* 97331

The objectives of this research program are as follows: 1. To investigate and establish principles by which the biological effects of multichemical residues in the environment can be evaluated. 2. To develop more reliable and systematic methods of analysis for pesticides in food, water, soil, air and biological tissues and to provide analytical research assistance to other workers engaged in this field of research. 3. To assess the physical and chemical properties of pesticides and to relate these properties to the behavior of such compounds in the environment.

Studies include determination of pesticides in simple food chains in model aquatic systems to establish effect on elements of the food chain. Investigation of the effects of environmental levels of pesticide on total organisms include their pharmalogical effect, metabolism and alteration of metabolic patterns. Biological studies are being conducted to elucidate the effects of pesticides. The behavior of pesticides in the environment are also being studied correlating the other studies.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.0946, MACRO-FAUNA IN WASTE STABILIZATION LAGOONS

R.L. GOULDING, Oregon State University, School of Agriculture, *Corvallis, Oregon* 97331

Waste stabilization lagoons are man-made environments that are becoming a more prominent feature of land use. The fauna adapted to this habitat has received little attention. In view of the potential importance of the macro-fauna which may be beneficial in that they contribute to the biological breakdown of organic matter or harmful as potential disease vectors or nuisance organisms, it is imperative that a thorough ecological study of this habitat be carried out.

The long-term objectives of this proposal are to measure the contribution of the macro-fauna in the breakdown of putrescible organic wastes; to understand the pathways through which this is effected; and to assess the beneficial and detrimental results caused by the macro- fauna in lagoons of various designs.

The major emphasis will be a study of the production ecology of Glyptotendipes barbipes; the most abundant macro-invertebrate in the lagoons.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0947, EFFECTS OF LOGGING ON SALMON POPULATIONS IN COASTAL STREAMS

J.D. HALL, Oregon State University, School of Agriculture, *Corvallis, Oregon* 97331

Objectives: This segment of research is part of the Alsea Watershed Study, designed to determine the effects of Douglas-fir logging practices on the physical and biotic resources in small coastal watersheds. The objective of the research covered in this proposal is to determine the effects of two patterns of timber harvest (complete clear-cut vs patch-cut) on the abundance of coho salmon in these coastal streams. The work funded by this proposal would be concerned mainly with analysis, interpretation, and publication of results of the study.

Procedures: Three adjacent watersheds were selected for study in 1958. They are typical of the headwaters areas used for spawning and rearing by coho salmon in the coastal region. Seven years of intensive study preceded the logging operations, which were conducted in 1966. One watershed was completely clear-cut, another was patch- cut, and a third will be held as a control for the remainder of the study, scheduled for seven additional years. Data on abundance, growth, and survival rates of the coho salmon have been collected from the fish traps and by additional sampling in the streams over the entire period. The study will continue to gather and analyze comparable data following logging to determine the impact of the two patterns of harvest on the salmon populations.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

5.0948, STUDIES ON EFFECTS OF WATERSHED PRACTICES ON STREAMS

J.D. HALL, Oregon State University, Agricultural Experiment Sta., *Corvallis, Oregon* 97331

Objectives of this study are to determine the effects of timber harvest practices on the physical and chemical characteristics of coastal streams and on fixation of energy by stream periphyton and inflow of organic detritus. Mean levels and variabilities of suspended sediment discharge, stream temperature, net solar radiation, chemical water quality, primary production by periphyton, and inflow of plant detritus will be established during a two year pre-logging period 1966- 68. Studies will continue during logging in 1966 and for two years after harvest.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0949, ECOLOGICAL-PHYSIOLOGICAL INVESTIGATIONS OF LITTORAL DIATOM COMMUNITIES OF THE YAQUINA RIVER ESTUARY

C.D. MCINTIRE, Oregon State University, Graduate School, *Corvallis, Oregon* 97331

The long-term plan of the proposed research program is to study, through analyses of data obtained in the laboratory and field, the physiological ecology of littoral diatom communities of the Yaquina River estuary. A marine laboratory ecosystem and respirometer chamber have already been designed and partially contructed. The laboratory ecosystem is designed to maintain control over such environmental variables as light, temperatures, salinity, and period of inundation (tidal cycle), and the effect of these factors on primary production, community respiration, and the species composition of the diatom communities will be stressed. Ultimately an attempt will be made to interpret the laboratory data in terms of the results of field observations (i.e., the adaptive characteristics of the organisms, their distribution in nature, and previous history of the environment from which they were collected), therefore maintaining close contact with the realities of Yaquina estuary itself. After such fundamental information has been acquired, the program will be expanded to the study of trophic relationships between characteristic attached micro- algae and grazing animals as influenced by various environmental factors, including the effects of domestic and industrial use of this water resource.

SUPPORTED BY U.S. National Science Foundation

5.0950, EFFECTS OF PESTICIDES ON ESTUARINE ORGANISMS

R.E. MILLEMANN, Oregon State University, Agricultural Experiment Sta., *Corvallis, Oregon* 97331

1. To evaluate, through short-term bioassays, the acute toxicity to certain estuarine organisms of the insecticide Sevin. 2. To determine the effects of Sevin on a community of organisms in artificial mud flats. 3. To follow the residual life and metabolism of Sevin in estuarine organisms and in their environment. 4. To study compounds related to Sevin, as well as other pesticides, in the above manner.

SUPPORTED BY Oregon State Government

5.0951, PHYSICAL FACTORS AFFECTING OREGON COASTAL POLLUTION

V.T. NEAL, Oregon State University, Graduate School, *Corvallis, Oregon* 97331

The central aim of this research is to provide information on and an understanding of the physical factors that will control the pollution of certain Oregon coastal areas. These physical factors are primarily circulation and water density distribution (therefore salinity and temperature) in the nearshore region and the tidal regime in and near the mouths of estuaries. Dissolved oxygen will also be an important factor in determining 'safe' pollution levels. Therefore these factors will be measured and their variability determined at selected places.

The time variability of these factors will be determined as a function of seasonal and meteorological conditions.

All data forthcoming from this project will be made available immediately to the Pacific Northwest Water Laboratory at Corvallis, Oregon. Since the knowledge to be gained by this project is needed by that agency, the planning and operation of this program will be arranged in close cooperation with the personnel of that agency.

5. WATER QUALITY MANAGEMENT AND PROTECTION

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0952, STUDIES ON AQUATIC MYXOBACTERIA

R.E. PACHA, Oregon State University, Graduate School, *Corvallis, Oregon* 97331

Ecological studies are being carried out to determine the role and activities of myxobacteria in the freshwater environment. In particular it is of interest to ascertain the importance of these organisms in the decomposition of pollutional materials and their possible application in water quality surveillance and stream purification. Surveys of a number of streams receiving various types of pollutants are in progress to obtain information on the occurrence and distribution of myxobacteria in these habitats. The effects of environmental parameters on the myxobacterial population of water are being considered as well as the interrelationships between myxobacteria and other microorganisms present in water.

Taxonomic studies on a number of myxobacteria isolated from the aquatic habitat are in progress to permit qualitative determinations to be made on the myxobacterial flora of water. Additional studies on the nutrition and physiology of selected myxobacterial isolates are planned in order to obtain more basic information on this group of microorganisms.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0953, SEDIMENT-WATER-BACTERIA INTERACTIONS IN EUTROPHICATION

R.E. PACHA, Oregon State University, Graduate School, *Corvallis, Oregon* 97331

The major objective of this research is to investigate the microbial activity in lake sediments to determine the effect of this activity on eutrophication. In particular it is of interest to define the importance of bacteria found in bottom muds in the recycling of plant nutrients between sediments and overlying water. The physiological activities of various types of bacteria occurring in the bottom deposits of Upper Klamath Lake, Oregon will be studied in relation to their effect on the nutrient dynamics of the lake. This investigation will contribute to our knowledge of eutrophication and may provide insight into suitable approaches for regulating this process.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0954, STUDIES ON AQUATIC MYXOBACTERIA

R.E. PACHA, Oregon State University, Agricultural Experiment Sta., *Corvallis, Oregon* 97331

Objectives: 1. Determine the occurrence and distribution of myxobacteria in the freshwater environment. 2. Investigate the interrelationships between myxobacteria and other organisms in the environment. 3. Obtain basic information on myxobacteria.

Description of Work: Studies are currently in progress to determine the role and activities of myxobacteria in the freshwater environment. In particular, it is of interest to ascertain the importance of these organisms in the decomposition of pollutional materials and their possible application in water quality surveillance and stream purification. Surveys of a number of streams receiving various types of pollutants are in progress to obtain information on the occurrence and distribution of myxobacteria in these habitats. The effects of other environmental parameters on the myxobacterial population are also being considered.

SUPPORTED BY Oregon State Government

5.0955, THE AUTECOLOGY OF SOME BLUE-GREEN PLANKTON ALGAE

H.K. PHINNEY, Oregon State University, Graduate School, *Corvallis, Oregon* 97331

Autecological and synecological studies using both uni-algal and mixed cultures of selected species important in nuisance blooms. The study will determine 1) requirement for major and minor nutrient minerals, 2) effects of naturally occurring organic nutrients, and 3) possible biotic effects as antagonism and synergism or competition in mixed cultures.

Analysis of the effects upon growth of the factors under consideration will be by the following determinations: 1. Dry weight. 2. Percent organic matter. 3. Caloric value. 4. Pigment content. 5. Dry solids by interferometry. 6. Direct mineral analysis, and 7. Direct determination of production rates.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0956, RELATIONSHIPS OF AQUATIC FLORA TO WATER QUALITY AND POLLUTION

H.K. PHINNEY, Oregon State University, Agricultural Experiment Sta., *Corvallis, Oregon* 97331

Objectives are (1) to establish a continuing research program concerning the relation of the aquatic flora to quality of water supplies and to water pollution. (2) To determine by biological studies of aquatic habitats, the relation between biotic and edaphic factors that cause changes in the quality of water resources, and (3) to coordinate and extend studies in the general area of aquatic botany.

At present, effort is being directed toward three types of studies: a) the effect of water humus on the growth of algae in culture, b) the study of primary production in artificial streams under controlled light conditions, c) the study of primary production in a controlled flow woodland stream under conditions of moderate enrichment.

SUPPORTED BY Oregon State Government

5.0957, SURVEY OF CLOSTRIDIUM BOTULINUM TYPE E

K.S. PILCHER, Oregon State University, Graduate School, *Corvallis, Oregon* 97331 (FDA)

Nontoxigenic cultures of E-like organisms were exposed to chemical mutagenic compounds in an attempt to convert the survivors to the toxigenic form. Cultures were exposed to either 15 mg/ml of 2 aminopurine, 1 microgram/ml of azaserine, 0.05 mg/ml of acriflavine or 50 microgram/ml of 5-bromouracil. These concentrations killed 90% or more of the viable cells within an exposure time of 30 to 90 minutes. Cultures developing from the surviving cells were tasted for their toxigenicity. In no instance did these chemical mutagens convert the nontoxigenic E-like organisms to the toxigenic form. In addition to the chemical mutagens, the effect of gamma radiation on the nontoxigenic cultures was explored. Nontoxigenic cultures were exposed to 124,000 rads of gamma radiation in three successive radiation treatments. There was not evidence of toxigenic organisms arising from this treatment.

The feasibility of a micro scale immunodiffusion test for type E toxin shall be explored. Cultures shall be filtered and concentrated 25 to 50 fold by dialysis against a hydrophilic colloid. Concentrates shall then be tested by immunodiffusion in purified agar against very small volumes of type E antitoxin. If the method shows any promise with pure type E cultures and nontoxigenic E-like strains, various mixed cultures from natural specimens shall be studied. Immunoelectrophoresis of concentrates may be used in a limited way as a possible means of identifying the toxic component in diffusion tests.

The infrared absorption spectra of cultures of the various types of C. botulinum prepared as then films on the specimen plates shall be determined. Variables such as culture medium, age of culture, incubation temperature, and others that could influence chemical composition of the cells shall be controlled. The objective of this work is to explore the possibility of distinguishing between the different types of C. botulinum, and between toxigenic and nontoxigenic cultures by means of their infrared patterns. Additional experiments shall be carried out with the objective of trying to induce the appearance of a toxin forming mutant in cultures of nontoxigenic 'E- like' organixms. Other chemical mutagenic agents, not previously tested, shall be examined, and the effects of a single severe exposure, as well as concentration of the test compound, shall be determined.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - F.D.A.

5.0958, INFLUENCE OF LOG RAFTING ON WATER QUALITY

F.D. SCHAUMBURG, Oregon State University, School of Engineering, *Corvallis, Oregon* 97331

Findings of preliminary research conducted during the summer of 1967, indicate that log rafting and wet storage of logs is a potential pollution problem in rivers and estuaries (see page 10). The research proposed herein will examine the nature and extent of pollution caused by log rafting and storage practices and will provide quantitative information which can be used to assess this problem.

The overall objective is to evaluate the effect on water quality imposed by floating log rafts in estuarine and fresh water environments. The specific objectives of this project are two fold as follows: a) to evaluate the quantity, character and water pollution potential of soluble substances 'leached' from floating logs in raft storage; and, b) determination of the water quality effects caused by deposits of bark, fiber and debris that occur in the vicinity of the log rafts.

In one phase of this project, representative sections of Douglas fir and other prominent species of trees in the Pacific Northwest will be floated in water under controlled conditions of temperature, salinity and biodegradation. The water media will be monitored at regular intervals for accumulation of total organic carbon, BOD, COD, PBI compounds, carbohydrates and others. Bioassay tests will be conducted by cooperating biologists to evaluate the relative toxicity of leached substances.

The significance of benthal deposits in the vicinity of log rafting and raft storage areas on water quality will be determined during the second phase of this project. Bark and wood fragments are broken loose from logs during log dumping, raft construction, raft storage and related operations. Much of the material is lost in log raft storage areas due to the abrasive action between logs imparted by tidal motion.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0959, LIGNIN SULFONATES IN PULP MILL EFFLUENTS

H.A. SCHROEDER, Oregon State University, Agricultural Experiment Sta., *Corvallis, Oregon* 97331

Objectives: To add to the knowledge of the chemical structure of lignin sulfonates, a principal component of sulfite pulp mill effluents. To isolate, identify, and determine the structure of the low-molecular-weight lignin sulfonates present in the spent liquor from the sulfite pulping process. Individual lignin sulfonate monomers and dimers are to be completely characterized. Structures are to be proved by comparison with synthetic known compounds prepared in the laboratory.

Abstract of Procedures: The spent sulfite pulping liquor usually can be obtained as a dry powder, Using this powder as column packing, the low-molecular lignin sulfonates can be removed by eluting with methanol, moistened ethanol, or other solvent systems known to elute the desired material. The low-molecular-weight lignin sulfonate fraction will be analyzed by paper chromatography or by thin-layer chromatography. As a result of the evaluation of the chromatograms, individual substances will be isolated and purified. Ion exclusion column chromatography, paper column chromatography, and ion exchange column chromatography will be employed for the separation and purification of individual lignin sulfonates. The isolated and purified lignin sulfonate can be characterized to a considerable extent through ultraviolet spectroscopy. The synthesis of the suspected lignin sulfonate will afford postive identification.

SUPPORTED BY Oregon State Government

5.0960, EPIDEMIOLOGICAL RELATIONSHIPS OF PESTICIDE APPLICATION TO PESTICIDE RESIDUES IN WILDLIFE TISSUES AND HABITATS

B.J. VERTS, Oregon State University, Agricultural Experiment Sta., *Corvallis, Oregon* 97331

Objective: To relate the application of pesticides to the occurrence of pesticide residues in the habitats and tissues of terrestrial and aquatic wildlife in Oregon.

Description of Work Proposed: This research will assess the extent to which habitats and tissues of wildlife are contaminated by pesticides used in pest-control operations in Oregon and will provide a background of knowledge for establishing standards of pesticide use which are safe for wildlife and for those who consume wildlife as food.

SUPPORTED BY U.S. Dept. of Agriculture
Oregon State Government

5.0961, EFFECTS OF PULP MILL EFFLUENTS ON THE GROWTH AND PRODUCTION OF FISH

C.E. WARREN, Oregon State University, Agricultural Experiment Sta., *Corvallis, Oregon* 97331

The general objective of the proposed research is to develop principles and methods of determination of the limits of acceptable water quality change in streams receiving industrial effluents, particularly change that influences fish populations valuable to man. This is to be done by experimentally determining how and to what extent kraft process pulp mill wastes at concentrations that are neither acutely toxic nor severely oxygen-depleting influence the growth of fish in laboratory aquaria and receiving the streams and fish production in laboratory and outdoor artificial streams. The rates of food consumption and the efficiency of utilization of food for growth by salmonid fishes and changes in rates of production of their principal food organisms under the controlled experimental conditions will be determined and the findings related to field observations to be made on rivers receiving kraft mill wastes.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Oregon State University

5.0962, DISSOLVED OXYGEN REQUIREMENTS OF FRESHWATER FISH

C.E. WARREN, Oregon State University, Agricultural Experiment Sta., *Corvallis, Oregon* 97331

The long-term objective of this research is to provide the knowledge necessary for developing oxygen standards that are adequate to insure fish production in fresh waters will not be impaired by the introduction of excessive amounts of oxygen-depleting wastes. Before the results of laboratory research can be relied on for developing sound dissolved oxygen standards, results obtained under the relatively simple and biologically undemanding conditions of laboratory experiments must be interpreted in light of the results of studies of fish under more complex and biologically demanding conditions, such as those found in natural stream and pond environments. This research, in contrast with most previous experimental studies, will be more directly concerned with the influence of dissolved oxygen on the growth and activities of fish in their natural environments.

Our problem is to determine what reductions in dissolved oxygen in natural environment can measurably reduce the growth rates of fish below rates that would occur were oxygen not limiting, when the fish must expend energy to capture their food and utilize it for growth and maintenance and to carry on other normal activities under natural conditions. The problem can be separated into two distinct parts: (1) to determine the quantities of food fish consume in natural environments and the amounts of energy required for obtaining and utilizing this food, as well as for carrying on other normal activities; and (2) to determine the levels of dissolved oxygen at which fish would be unable to mobilize the energy necessary for obtaining and utilizing food in these amounts. Our approach involves complementary studies of fish in natural environments, in artificial streams and ponds, and in the laboratory, coordinated in such a manner as to exploit the strength of each kind of study.

5. WATER QUALITY MANAGEMENT AND PROTECTION

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0963, ECOLOGICAL STUDIES OF AN EXPERIMENTAL STREAM

C.E. WARREN, Oregon State University, School of Agriculture, *Corvallis, Oregon* 97331

Changes in streams, whether due to natural causes or the activities of man, bring about changes in the pathways by which energy from its various sources reaches organisms of interest to man. For about twenty years, biologists have been studying the pathways of energy transfer and efficiencies with which energy is transferred through aquatic communities. Because of the complexity of most biological communities, these studies have not progressed far. Nevertheless, certain of the approaches and methods that have been used in such studies have promising application in the solution of water pollution problems. The general objectives for our studies are (1) to identify key relationships between important organisms and their environments and determine how these are affected by pollutional changes, and (2) to find or develop and test practical approaches, parameters, and methods for utilizing these relationships in the solution of water pollution problems.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0964, PHARMACOLOGICAL AND ECOLOGICAL EFFECTS OF PESTICIDES

C.E. WARREN, Oregon State University, Agricultural Experiment Sta. , *Corvallis, Oregon* 97331

It is the overall objective of this broad and fundamentally oriented research project to provide, through studies of the pharmacological and ecological effects of pesticides and other toxic substances on freshwater organisms, information which will be of value in developing standards for the use of toxic substances that are adequate to protect the productivity of fresh waters for organisms of value to man. The production of an organism cannot be expected to remain unimpaired if environmental changes reduce its ability to survive, reproduce, grow and move, or if the production of its food organisms is reduced.

The following general objectives must be attained before the overall objectives of this research can be realized; (1) obtain understanding of how toxic substances influence the various biological functions of the individual organism; and (2) obtain understanding of how toxic substances influence food relations in biological communities.

The following general procedures will be used in attaining the objectives of this research: (1) classical pharmacological and bioenergetic approaches will be used in laboratory studies of the influences of toxic substances on the biological functions of aquatic organisms; and (2) food chains in simplified biological communities in the laboratory and in complex communities in nature will be studied to determine the influence of toxic substances on food relations.

SUPPORTED BY U.S. Dept. of Agriculture
Oregon State Government

5.0965, INFLUENCES OF WATER QUALITY AND OTHER ENVIRONMENTAL CHANGES ON FISH AND ASSOCIATED ORGANISMS IN INLAND WATERS

C.E. WARREN, Oregon State University, Agricultural Experiment Sta. , *Corvallis, Oregon* 97331

Influences of Water Quality and other Environmental Changes on Fish and Associated Organisms in Inland Waters.

It is the first objective of this rather broad project or program to provide fundamental understanding of the influences which generally occurring environmental changes have on fish and associated organisms in inland waters. The domestic, agricultural, forestry, industrial and other activities of man are continually changing the character of our inland waters and endangering their social and economic value. Understanding of the influences of these changes, to be of much scientific or social value, must be in terms of the ecology of the individual organism, its population and its community.

It is the second objective of this project to provide, where possible, methods by which understanding of ecological changes may be applied to the solution of problems arising when the activities of man endanger valuable aquatic resources.

Laboratory and field studies of physiological and ecological nature will be utilized in approaching problems selected because of their generality.

SUPPORTED BY Oregon State Government

5.0966, EFFECTS OF KRAFT PULP MILL EFFLUENTS ON THE GROWTH AND PRODUCTION OF FISH

C.E. WARREN, Oregon State University, Agricultural Experiment Sta. , *Corvallis, Oregon* 97331

The general objective of this work is to determine how and to what extent concentrations of kraft pulp mill wastes that are neither acutely toxic nor severely oxygen depleting may influence the production of fish populations.

Description of Work: (1) Determine the influence of effluents from kraft pulp mills on the growth of juvenile salmonids in the laboratory when food consumption rates and metabolic requirements of the fish are similar to those of fish in nature. (2) Determine the influence of effluents from kraft pulp mills on the food consumption, growth, and production of salmonids and on the production of their food organisms in simplified biological communities in laboratory streams. (3) Determine the influence of kraft mill effluents on the food habits, food consumption, growth, and production of salmonids, and on the biological communities of controlled experimental streams in which the concentrations of these wastes are controlled at levels below those known to be toxic or seriously oxygen depleting. (4) Determine through sampling studies above and below the points of entry of kraft pulp mill effluents into rivers the food habits and growth rates of salmonids and other fish.

SUPPORTED BY Oregon State Government

5.0967, SOIL STABILIZATION AND RUNOFF REGULATION IN CONIFER WATERSHEDS

J.S. ROTHACHER, U.S. Dept. of Agriculture, *Corvallis, Oregon*

Object: To determine how logging methods, road construction, and timber management practices can be improved to curtail erosion, prevent channel impairment, and regulate quantity and timing of runoff.

Plan of work: The project will continue to (1) measure soil movement on logged land and logging roads; (2) determine effects of road building, cable logging, forest removal, and slash burning on water quality; (3) investigate changes in streamflow caused by clearcutting and partial cutting; and (4) determine the role of vegetation on evapotranspiration. The project will begin new studies to include: (1) relating soil movement to soil, topographic, and vegetative factors; (2) development of erodibility indexes; (3) measurement of rate and quantity of subsurface water movement; and (4) determination of the hydrologic values of humus.

SUPPORTED BY U.S. Dept. of Agriculture

5.0968, FATE AND EFFECTS OF PESTICIDES IN FOREST SOILS AND WATER

R.F. TARRANT, U.S. Dept. of Agriculture, *Corvallis, Oregon*

Object: To determine how the unique properties of forest soil are affected by insecticide and herbicide residues and lead to their alteration and degradation; to determine how much and in what form residues are present in water coming from forest lands; and to devise guides for safe use of these pesticides in the forest.

Plan of work: The projects staff will continue to study (1) the litter production of alder and conifer stands in Oregon, (2) the movement of insecticides in soil and soil water, and (3) the disposition of DDT from a 55,000-acre spraying. They will initiate studies on (1) relationship between residues and soil micro-organisms, (2) residue movement across and through the soil, and (3) effect of residues on forest soil development.

SUPPORTED BY U.S. Dept. of Agriculture
University of Maine

5.0969, EUTROPHICATION - EFFECT OF FLOW AUGMENTATION

A.F. BARTSCH, U.S. Dept. of Interior, Pacific Nw. Water Laboratory, *Corvallis, Oregon* 97330

The immediate objective is to determine the effect on algal bloom production when a nutrient-rich lake is flushed with nutrient-deficient water. Ultimate objective is to decrease or eliminate algal blooms in Moses Lake, Washington. One of three branches of the lake will be flushed with low-nutrient water while the others remain as controls. After flushing during August and September, 1968, a year of no water diversion will follow to permit determing persistence of improvement. This approach will evaluate flushing as a remedial tool and will indicate the periods of future water diversion needed to permanently prevent bloom formation. Principal parameters to be investigated are as follows: 1. Water current studies at selected sites and depths. 2. Water budget studies to determine extent and efficiency of flushing. 3. Turbidity measurements and suspended solids analysis. 4. Chemical and physical parameters to determine existence and character of thermal stratification and also environment for algae. 5. Qualitative and quantitative determination of algae, including measurements of phytoplankton pigments, biomass, and species diversity. 6. Chemical analyses and oxygen demand studies of bottom muds.

Basic data collection and analyses will be conducted cooperatively by FWPCA and University of Washington personnel. Other cooperators will be the Bureau of Reclamation and a citizens group in the city of Moses Lake, Washington.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0970, EUTROPHICATION - EFFECT OF WEED HARVESTING

A.F. BARTSCH, U.S. Dept. of Interior, Pacific Nw. Water Laboratory, *Corvallis, Oregon* 97330

The principal objective is to evaluate aquatic vegetation harvesting as a means of effectively reducing algal nutrient availability. Harvesting and removal of aquatic vegetation is one of the potential control measures in combating eutrophication of bodies of water. It is a means of 'cropping off' part of the excess nutrients. Although weed harvesters have been used in the past, no really scientific investigations have accompanied their use. In cooperation with the Pelican River Watershed District, Minnesota, city of Detroit Lakes, and University of North Dakota the effectiveness of the procedure will be evaluated. Attempt will be made to answer such questions as: 1. What is the amount of nutrients actually removed from a lake by weed harvesting? 2. What happens to the energy flow of nutrients that originally went into the plant growth? 3. What is the pattern of regrowth of the vegetation after harvesting and do other species replace the original ones? 4. Does the phytoplankton population change after the higher aquatic plants are removed?

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0971, EUTROPHICATION - BIOLOGICAL CONTROL USING GRAZERS

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The objective is to determine if living organisms can be found which will harvest nuisance algae through grazing, or reduce them through disease and parasitism. A literature review will be made to determine the prospects for success and to identify North American or other species as prospective candidates for grazing trials. Promising animals will be evaluated in the laboratory or field as appropriate.

It was the consensus of most scientists attending the recent International Eutrophication Symposium in Madison, Wisconsin that this is a potentially fruitful area of research. It was felt that a biological control measure for algae could be found if sufficient effort were expended. This has not been done to date.

Much of the effort in F. Y. 1968 will be desk work to learn what has been done by other researchers and to determine who might be interested in doing work with grant research funds. Other activities will include preliminary laboratory evaluation of grazer candidates.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0972, EUTROPHICATION - PHYSICAL ECOLOGICAL CONTROL

A.F. BARTSCH, U.S. Dept. of Interior, Pacific Nw. Water Laboratory, *Corvallis, Oregon* 97330

The objective is to determine if algal production can be inhibited by preventing thermal stratification of a lake. Prior destratification experiments have sometimes decreased and other times increased primary production. Because of this seeming paradox, it is necessary to understand this phenomenon and to utilize it if possible, as a means of preventing algal bloom formations. If total algal growth can indeed be retarded by mixing, it is necessary to learn if a lake has to be turned over every year or at lesser or greater intervals to give permanent relief.

Principal areas of investigation will include: 1. Measurements of water movements at selected sites and depths in a lake. 2. Measurements of chemical and physical parameters that are of importance to algal growth. 3. Measurements of algal growth.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0973, COASTAL DIFFUSION OF POLLUTANTS

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The Georgia-Pacific Corporation, Toledo, Oregon currently discharges its kraft process pulp mill wastes to an ocean outfall which discharges approximately 6 million gallons per day through a diffuser section at a depth of 40 feet at a distance of 3000 feet off the Oregon Coast at Newport. The dilution achieved by the diffuser process and by the horizontally flowing field under the influence of natural forces will be investigated by frequent sampling of the near coastal waters, plus continuous monitoring of wind direction and speed. Current meters will be installed at various depths and at three locations in the near shore area to determine the relationship between the dilution of the field and the current structure. Additional surface current measurements may have to be made on the basis of drift cards or dye fields. Model tests will be performed in an 8-foot diameter, 3-foot deep tank to reproduce the hydrodynamic characteristics of the diffuser port and the density structure or the wind stress. This should, in addition to improving the methodology for describing jet diffusion, provide a method for estimating the influence of the non-steady current structure in the receiving fluid by comparing the observed performance in the prototype with the observed performance in the controlled model.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0974, ESTUARINE DIFFUSION OF POLLUTANTS

D.J. BAUMGARTNER, U.S. Dept. of Interior, Pacific Nw. Water Laboratory, *Corvallis, Oregon* 97330

The most general characteristic of pollutants which plays a part in the assessment of their fate is concentration. Since the concentration is a function of its dilution in the environment as a result of mixing and diffusion, as well as decay of the component, it is of considerable importance to be able to determine how the concentration of a pollutant will vary in the receiving water at various locations and perhaps at various times if the pollutant or the environment is not in steady state.

Uncertainty exists with regard to the value of the turbulent diffusion coefficient to be used in problem analysis. To provide a means of determining this value at points in time and space, as well as providing additional understanding of the forces which influence estuarine diffusion, a predictive model of salinity will be constructed on the basis of time series analysis of observations in Yaquina Bay, Oregon.

Continuous recording salinometers will be installed approximately every five miles along Yaquina Bay to obtain the record of the time variation of salinity at the surface. Once a week, vertical traverses of salinity will be obtained to provide information on the vertical stratification in the estuary. If necessary, additional salinometers will be placed near the bottom to obtain information on the vertical distribution. Fresh water inflow will be estimated by stream gauging of the three principal surface streams in the area. Direct runoff and direct rainfall can be estimated. Information on tide height and frequency will be obtained from three tide gauges, while continuous information on wind speed and direction will be obtained at the entrance to the bay and other locations if necessary.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0975, MARINE BIOLOGICAL ASSESSMENT OF POLLUTIONAL FATE

D.J. BAUMGARTNER, U.S. Dept. of Interior, Pacific Nw. Water Laboratory, *Corvallis, Oregon* 97330

In almost every pollution situation, a major consideration is the impact of the degraded water quality on the organism. This is especially true where it is suspected that the pollutant will harm aquatic organisms of primary importance to man. Interpretation of bioassay tests is complicated by the fact that there has been very little information obtained to relate the controlled observations in the laboratory experiments to the actual conditions existing in the environment in the absence of pollution. Attempting to overcome some of these difficulties, investigators have begun to consider and apply in situ bioassay procedures.

The difficulties associated with this approach are related to selection and maintenance of the test animals, knowledge of their population dynamics in the natural unpolluted environment, and determination that the observations obtained under the test conditions are due to a pollutional stress rather than artifacts of the experimentation.

The first step in developing a series of procedures for analysis of problem areas is determining the amount and type of information necessary to describe the natural environmental populations. This developmental work is being tried on Yaquina Bay, Oregon, along two approaches.

Information on fish usually associated with bottom or mid-water habitat will be obtained at each of ten sampling stations every two weeks by means of a trawl. Continuous recording of salinities on the surface at six stations covering the trawl areas will also be provided. In addition, weekly profiles of dissolved oxygen, temperature and salinity will be provided. Samples will be obtained for organic carbon analysis or PBI's or other appropriate analyses to determine possible pollutants. It will be possible to test some of the methods of analysis after collection of data for one year. The second method of observation pertains to collection of crustacea in standardized substrate boxes and on substrate media suspended in the water column. These samples are analyzed after exposure to the environment for five weeks. Sub- samples of the organisms obtained in both methods will be analyzed for maturity, weight distribution, and stomach contents.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0976, PHYSIOLOGICAL EVALUATION OF TREATED TOXIC WASTES

G.R. BOUCK, U.S. Dept. of Interior, Pacific Nw. Water Laboratory, *Corvallis, Oregon* 97330

The project seeks to evaluate the needed degree of waste treatment for Paper Trade Wastes. Various life stages of Pacific Salmon and steelhead trout are the test organisms and these are exposed to the above wastes for thirty days or more using continuous renewal of toxicant. Physiological tests include histopathology, autofluorescence of tissues, protein composition of plasma and tissues, enzymes in plasma and routine hematology.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0977, SLIME CONTROL ASSOCIATED WITH PULP MILL EFFLUENTS

M.D. KNITTEL, U.S. Dept. of Interior, Pacific Nw. Water Laboratory, *Corvallis, Oregon* 97330

The purpose of this investigation is to learn the minimum requirements of nutrients that support the growth of Sphaerotilus natans. Further, the project plans to define the carbon and nitrogen source that supports growth of this bacterium. This information will be helpful to those who must design effective waste treatment methods for industrial wastes.

A second major area of this project is to find, test and develop effective biological control methods for S. natans.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0978, MICROBIOLOGICAL TREATMENT OF POTATO WASTES

D.S. MAY, U.S. Dept. of Interior, Pacific Nw. Water Laboratory, *Corvallis, Oregon* 97330

In order to better understand the role of microorganisms in the biological treatment of potato processing wastes, several areas will be investigated. The processing waste streams will be characterized to determine chemical constituency with respect to nutrients, organic materials, and trace materials. Attempts will be made to isolate and identify the predominant organisms existing in present treatment systems and determine their role in stabilization of the waste. Using bench- top treatment chambers the growth of these organisms and the conversion of the waste will be followed closely by chemical and biochemical analysis. Organisms which provide good decomposition will be further studied under the influence of nutrient additives which may enhance microbial activity. The feasibility of incuding cultures of highly active microorganism will be investigated. Consideration will be given to the development of biological flocs which may be recovered from the system and used as food material for livestock.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0979, CHEMICAL AND ENGINEERING ASPECTS OF POTATO PROCESSING WASTES TREATMENT

L.J. NIELSON, U.S. Dept. of Interior, Pacific Nw. Water Laboratory, *Corvallis, Oregon* 97330

This investigation will evaluate the several potato processing wastes for treatment both as separate wastes and as a combined flow. Emphasis will be on increasing efficienty of waste treatment for protection of receiving waters and for reduction of treatment costs. Research will consider possible by-product recovery by use of polyelectrolytes and/or pressurized air flotation. The economics of dehydrating potato starch wastes for recovery of a useable product will be examined.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0980, PULP AND PAPER WASTE CONTROL AND TREATMENT

R.H. SCOTT, U.S. Dept. of Interior, Pacific Nw. Water Laboratory, *Corvallis, Oregon* 97330

Development of State of Arts Document covering principal segments of pulp and paper production, in-plant control and treatment for waste reduction, processes in-plant leading to destructive disposal, or utilization and by-product development. Consideration of available means for waste salvage for re-use, water conservation and in-plant concentration and distribution of waste fraction in weak waste streams. Review of present knowledge regarding waste treatment technology as practiced in the industry.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0981, EUTROPHICATION - PILOT OPERATIONS

L.P. SEYB, U.S. Dept. of Interior, Pacific Nw. Water Laboratory, *Corvallis, Oregon* 97330

As laboratory scale techniques are found for the control of algae in lakes, methodology must be developed for the scale-up of these techniques to use in field trials. Techniques of systems analysis and economics will be used in shifting from small scale to full scale demonstrations. It is an objective to plan the groundwork for this development.

It is anticipated that an engineer will be employed during the last quarter of F. Y. 1968 to work with personnel assigned to sub projects in the eutrophication program.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0982, EUTROPHICATION - SEDIMENT-WATER INTERCHANGE STUDIES

L.P. SEYB, U.S. Dept. of Interior, Pacific Nw. Water Laboratory, *Corvallis, Oregon* 97330

Objectives are to determine mechanisms, rates and conditions by which algal nutrients in lake sediment interchange with overlying water and to treat lake sediment to prevent interchange. Sediment will be removed from the lake and tested for its nutrient release capacity in the laboratory. While most ion exchange work on soil has been done with cations, techniques for this do not take into consideration the possibility of anion exchange with humic and other materials present in organic soils. Ion exchange capacity of lake sediment with reference to anions containing phosphorus and nitrogen will be examined Because the amount of humic acids in bottom deposits is a measure of the degree to which organic substances are stabilized in sediment and since dehydrogenase content of sediment is a measure of the extent of biological breakdown of organic substances, both parameters will be measured. Also, we may measure the vitamin B12 content since it has been proposed that this vitamin results from bacterial action in sediment.

Small areas of Klamath Lake which have shown dense algal blooms in past years will be isolated from the main body of the lake and used to determine the influence of sediment-water interchange on algal production and to evaluate procedures intended to prevent or impede interchange.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0983, POWER PRODUCTION

B.A. TICHENOR, U.S. Dept. of Interior, Pacific Nw. Water Laboratory, *Corvallis, Oregon* 97330

The project staff acts as a 'core group' for coordinating the FWPCA's national research effort in the area of thermal pollution resulting from power production. Two activities are presently underway: 1. Development of a mathematical model and associated computer program for the prediction of water temperatures in the Columbia River from Grand Coulee Dam to Bonneville Dam. 2. Preparation of a 'state of the arts' document describing the present and future problems, present and proposed solutions, and research needs in the area of thermal pollution from power production, with special emphasis on nuclear power plants.

Future plans include either 'in-house', contract, or grant research in the areas of: 1. Reservoir temperature prediction techniques (including stratification, density currents, release temperatures, design considerations for multiple level outlets, operating schedules for optimum downstream thermal conditions, etc.). 2. Dispersion of heat from power plant heated effluent outfalls, 3. New designs for cooling apparatus for thermal power plants, including improvements in methods such as cooling towers, cascades, sprays, cooling ponds, etc., 4. New operating methods or design changes for thermal power plants to produce cooler effluent, 5. Effect of heat on the biological, microbiological, and chemical quality of water.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0984, AEROBIC SECONDARY TREATMENT OF PLYWOOD GLUE WASTES

R.C. NEWMAN, Klamath Plywood Corporation, *Klamath Falls, Oregon* 97601

The project objective of this grant are to design, construct, operate and evaluate an extended aeration, activated sludge lagoon treatment plant on ureaformaldehyde glue wastes in order to provide data for others to utilize in efforts to abate water pollution.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Klamath Plywood Corporation

5.0985, MASS MORTALITY OF OYSTERS ALONG THE OREGON COAST

C.D. SNOW, State Fish Commission, *Portland, Oregon* 97201 (14-17-0001-1895)

Summary of Proposed Work: The Oregon Fish Commission is continuing the oyster mortality monitoring program begin in 1966 with slight changes to conform with the recommendations of the team of experts which reviewed the program in 1968. Sampling stations will be maintained in Tillamook, Yaquina and Coos Bays.

In Yaquina Bay, the number of sampling stations will be reduced from six to three to permit more intensive monitoring of both native and Pacific oysters. Observations will be made every two weeks, and samples will be collected every 4 weeks. Those and dead or abnormal oysters will be sent to the University of Washington for histological examination.

In addition to the sampling stations in Yaquina Bay, an observation station will be established at the dock of the Marine Science Center. Observations will be made each working day. Dead or moribund animals will be collected for histological examination.

There will be one station at Tillamook and Coos Bays. Sampling will be monthly with collections for histological examination from the control lots and the adjacent beds.

Water quality measurements at Yaquina Bay will include temperature, salinity, dissolved oxygen and turbidity plus supplemental information from the Federal Water Pollution Control Administration and Oregon State University. At Tillamook and Coos Bays measurements of temperature, salinity and dissolved oxygen will be taken during each sampling visit.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

5.0986, MOVEMENT OF RADIONUCLIDES IN THE COLUMBIA RIVER ESTUARY

D. HUBBEL, U.S. Dept. of Interior, Geological Survey, *Portland, Oregon* 97208

Two reaches of the estuary have been instrumented for discharge determination. These will be calibrated by direct measurements of flow from a boat at different stages and through several tidal cycles during the coming year. The data will then be fitted to a one dimensional mathematical model that has already been developed. If the mathematical model is determined to be reasonably accurate, two other reaches will be instrumented similarly. In addition water samples for salinity and other chemical characteristics and sediment content will be taken during all direct discharge measurements. Gross description of radioactivity in the estuary will be obtained by a sled mounted in situ radiation detector as well as from analyses of water and sediment samples. Data compilation and integration will be augmented by a study of typical environments such as islands, tidal flats and shorelines, which can be mapped fairly easily. The mechanics of sediment transport and deposition particularly under the influence of salinity changes and flow reversal will be studied to define empirical relations to be used in calculating sediment loads. The project was initiated in FY 1964 and is expected to be completed in FY'69.

SUPPORTED BY U.S. Atomic Energy Commission

5.0987, EFFECT OF SURFACE GROUPS ON ADSORPTION OF POLLUTANTS

R.W. COUGHLIN, Lehigh University, School of Engineering, *Bethlehem, Pennsylvania* 18015

Activated carbon is the most promising material which has been investigated for adsorbing biologically undegradable organic compounds from waters and waste waters. Of the many different commercially available carbons which have been used for these studies, some have shown markedly higher adsorptive capacities than others (two to three times on a per-gram basis). Presumably, these differences are due to varying specific surface areas, variable types of surfaces and different functional groups on the solid surfaces. It is proposed herein to investigate the influence of type of surface and nature of functional groups on the surfaces as they affect the adsorption of typical biologically undegradable organic compounds on activated carbon and on other promising adsorbents. The ultimate goal of this research will be to identify those functional groups and surfaces which are most efficacious for adsorbing specific compounds. This information will indicate how better materials can be designed for specific adsorption tasks, provide expanded and better means of surface regeneration and establish guides for selecting solid adsorbents to achieve a particular adsorption goal.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0988, TRANSPORT OF SOLID SUSPENSION IN CONDUITS

W.H. GRAFT, Lehigh University, School of Engineering, *Bethlehem, Pennsylvania* 18015

This proposal results from ideas formulated by the principal investigator during work on the project, 'The Transport of Solid Suspension in Conduits', sponsored by the Federal Water Pollution Control Administration of the U. S. Department of Interior (research grant - WP-00838). Essentially, this proposal outlines further research to be done as a continuation of the present project. The research will be divided into two parts: (1) Design criteria for minimum transport velocities of non-depositing solid - liquid mixtures in pipe lines will be investigated. Only recently, the progress report of ASCE's Combined Sewer Separation Project points out a complete lack of data in this area. The proposed research will try to provide a modest contribution to adequate combined-sewer design, focusing primarily on suspended pressure conduit. (2) Further development of the modified Venturi meter to measure mixture flow rate and concentration simultaneously is suggested.

It is believed that the proposed research will provide further knowledge about the design of conduits transporting solid - liquid mixtures.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0989, THERMAL AND INDUSTRIAL POLLUTION DELAWARE RIVER

B.W. PARKER, Lehigh University, Graduate School, *Bethlehem, Pennsylvania* 18015

In the seven mile stretch of the Delaware River from Riegelsville, N. J. down to river Milford, N. J., there are four paper mills which produce variable discharges into the river. About half way between these two limits is a steam-electric generating station which discharges heated water from condensers. At full capacity this station is generating 134 Megawatts. This corresponds to a waste heat rejection of about 6.7 x 10 to the 8th power B.T.U. per hour.

We propose to operate automatic monitoring stations at the bridges at Riegelsville and at Milford to develop comparative data for the river above and below the areas of cited pollution. Five diagnostic parameters would be recorded: Oxygen, Turbidity, pH, Conductivity and Temperature. Sunlight intensity at Riegelsville is useful as the primary index of photosynthesis and oxygen production. The automatic Water Quality Monitor Station at Riegelsville was developed and operated by Lehigh from 1958-61 under agreement with INCODEL. We also developed a portable monitor station which records the five parameters.

The Del. Riv. Basin Comm. has succeeded INCODEL in ownership of the monitor equipment. DRBC plans to reactivate the Riegelsville Monitor Station and to let us use the portable monitor station for this proposed research.

In addition to collection of information by automatic intrumental methods, we would employ standard field sampling methods such as: a. Collection of microscopic plants and animals by Millipore filter and immerser slide techniques; b. Observation of macroinvertebrates and determination of distributions in terms of types and relative abundance; c. Observation of distributions and types of rooted aquatic plants and algae; d. Measurement of Temperature and Sampling for B.O.D., C.O.D. and bacteriological counts.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.0990, PILOT PLANT DEVELOPMENT OF THE ION-EXCHANGE PROCESS FOR RECOVERY OF AMINO COMPOUNDS FROM POTATO STARCH FACTORY EFFLUENTS

W.L. PORTER, U.S. Dept. of Agriculture, *Chesnut Hill - Philadelphia, Pennsylvania* 19118

Object: To alleviate the problem of disposal of secondary wastes from potato starch factory effluents and reduce stream and air pollution; to obtain a cost estimate for the process; and to produce crude amino acid mixtures.

Plan of work: An evaluation will be made by pilot plant scale of the methods of recovery of free amino acids from potato starch plant effluent by ion-exchange treatment. The investigation will include: effect on process of variation in concentration of in-put solids from 0.5 - 3.0% solution; applicability of Dutch process for recovery of protein before ion-exchange treatment of effluent liquor; degree of clarification required before ion-exchange processing; disposal of solutions from regeneration of columns and selection of regeneration acid from this viewpoint; methods of stabilizing the amino acid product; and determination of composition, BOD and COD of effluent stream before and after processing. Cost estimates will be provided based on the data and final process layout, for a full-scale plant to recover nitrogen-containing materials from the 'protein water' effluent of a 10 ton per day and a 30 ton per day potato starch factory. A minimum of 500 pounds of dry crude amino acids will be delivered representing the typical product of the process for use in utilization studies and market development.

SUPPORTED BY U.S. Dept. of Agriculture

5.0991, INVESTIGATION OF SOAP-DETERGENT COMBINATIONS BASED ON INEDIBLE ANIMAL FATS

A.J. STIRTON, U.S. Dept. of Agriculture, *Chesnut Hill - Philadelphia, Pennsylvania* 19118

Synthesis of the different types of surface active agents will be explored, including the anionic, nonionic, cationic and amphoteric types, with greatest attention to the anionic and nonionic. The synthesis from tallow of surface active agents with increased solubility is a major objective. This may be reached in the form of sulfated, sulfonated or phosphated nonionics. Oxyalkylation and subsequent sulfation and phosphation will be investigated, starting with long chain fatty acids, alpha-sulfo acids, alcohols, amides and amines and epoxides.

Other reactions will include the alpha-sulfonation of nitriles, amides and dicarboxylic acids, the synthesis of alkanolamides and related nitrogen containing compounds. New surface active types will be investigated in a preliminary manner for relative ease of biodegradation before any commitment to an extensive program of synthesis and evaluation.

Detergents and surface active agents will be examined for aqueous solubility, conveniently measured by the Krafft point or cloud point, solubility in organic solvents, stability to hydrolysis and stability to calcium ion and heavy metal ions.

The work will include the formulation of solid and liquid detergent bars and soap-syndet combinations. Special attention will be given to the possible elimination of phosphate builders.

SUPPORTED BY U.S. Dept. of Agriculture

5.0992, BIODEGRADABLE DETERGENTS FROM ANIMAL FATS

A.J. STIRTON, U.S. Dept. of Agriculture, *Chesnut Hill - Philadelphia, Pennsylvania* 19118

Object: To develop new and expanded outlets for animal fats through studies on the biodegradability of alpha-sulfo acids and derivatives therefrom which have surface active properties.

Plan of Work: Biodegradability of detergents based on alpha-sulfo tallow acids will be studied by such recognized methods as the River Die Away test and continuous sludge digestion. Biodegradability sewage data will also be obtained on other derivatives of tallow which offer promise as detergents as well as on important competitive materials such as alkylbenzene sulfonate (ABS) and straight chain ABS. Continuous attention will also be given to the possibility for improving and standardizing the methods for measuring biodegradability or for the development of new methods for the purpose. Isolation of the intermediate products of the biodegradation of fat-based detergents may be undertaken in order to learn as much as possible about the actual mechanism of biodegradation. Finally, since so much of our detergents are disposed of through cesspools or septic tanks, attempts will be made to study the biodegradation of fat based detergents under anaerobic conditions.

SUPPORTED BY U.S. Dept. of Agriculture

5.0993, ESTIMATING ACID MINE DRAINAGE POTENTIAL FROM COAL BEDS BY USE OF THE SOXHLET EXTRACTOR

G.H. EMRICH, State Dept. of Health, *Harrisburg, Pennsylvania*

Acid mine drainage degrades many miles of streams in the coal mining regions of the United States. In order to properly design treatment facilities for acid mine drainage, the character of the mine drainage must be known before mining begins.

While many tests have been proposed, very few, if any, reproduce the natural conditions that produce acid mine drainage which this study will do. The study uses a Soxhlet Extractor packed with inert material and crushed coal. Distilled water is passed over the coal sample which is constantly being aerated. When the Soxhlet Extractor is filled with water, the water siphons back through a flask and is recirculated through the coal again. After four complete passes the fluids are analyzed for acidity or alkalinity, sulfate and iron. This is continued for a sufficient number of passes until the character of the mine drainage can be estimated. Preliminary results show close correlation of drainage from existing coal mines and estimated character of mine drainage.

Continuing research will also be performed to evaluate the effects of temperature, bacteria and sample size.

SUPPORTED BY Pennsylvania State Government

5.0994, CONSTRUCTION OF MINE WATER TREATMENT PLANT AT HOLLYWOOD, PENNSYLVANIA

D.R. MANEVAL, State Dept. of Mines & Min. , *Harrisburg, Pennsylvania* 17120

This project consists of the construction of a 500,000 gallon per-day acid mine water neutralization treatment plant and a program of experimental operations to evaluate performance and costs. The plant will have capability for five different process options.

Tests will be conducted to determine plant capacity and to evaluate the process elements such as flash mixing, settling, sludge disposal, sludge handling, filtration, influence of pH, effectiveness of catalysts, microbiological oxidation of iron, corrosion, and sludge scaling.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Pennsylvania State Government

5.0995, APPLICATION OF BACTERIOPHAGES TO ELIMINATE MINE ACIDS

D.R. MANEVAL, State Dept. of Mines & Min. , *Harrisburg, Pennsylvania* 17120

This project will demonstrate the feasibility of using inhibitory organisms to reduce the activity of acid producing bacteria. Included are the isolation, identification, and culturing of such bacteriophages.

If laboratory results prove to be feasible, then a large scale study will be undertaken.

The project site will be in Washington and Greene Counties, Pennsylvania.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Pennsylvania State Government

5.0996, USE OF LATEX AS A SOIL SEALANT TO CONTROL ACID MINE WASTE DRAINAGE

D.R. MANEVAL, State Dept. of Mines & Min. , *Harrisburg, Pennsylvania* 17120

This project will demonatrate the use of low cost rubber latex to form an effective soil seal which will prevent or reduce acid mine drainage without interfering with vegatative growth. The method consists of allowing a rubber latex to leach into the soil below the root line and then coagulating it either by the natural acid reaction of the soil or by an artificial acid plateau.

The seal will prevent surface water from leaching into abandoned mines and will restore normal surface runoff in the immediate area. The underground pools of contaminated water which presently exist because of uncontrolled seepage from above will remain static or eventually dry up, thus eliminating acid drainage into lower streams and rivers.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Pennsylvania State Government

5.0997, FEASIBILITY OF THE PURIFICATION OF ACID MINE WATER BY A PARTIAL FREEZING PROCESS

D.R. MANEVAL, State Dept. of Mines & Min. , *Harrisburg, Pennsylvania* 17120

The objectives of the proposed work are: 1) Assemble information pertinent to the purification of acid mine water from existing publications, reports and other scientific literature. 2) Obtain preliminary experimental test data on the yield and purity of quality product water that can be obtained by a partial freezing process operating on typical acid mine water. 3) Make preliminary flow diagrams and economic evaluations of possible freezing processes for purifying acid mine water.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Pennsylvania State Government

5.0998, CATAWISSA CREEK MINE DRAINAGE POLLUTION ABATEMENT PROJECT

D.R. MANEVAL, State Dept. of Mines & Min. , *Harrisburg, Pennsylvania* 17120

The project is designed to confirm previous estimates of mine drainage pollution abatement and to evaluate the at-source control method of the mine by plugging three existing drainage tunnels within an isolated pocket of coal known as the South Green Mountain Basin. Acid mine drainage is formed when water, air and pyrites react. The principle of inundation of the mine is to prevent this reaction by displacing the air with water.

The project site is in Schuylkill and Lugrene Counties, Pennsylvania.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Pennsylvania State Government

5.0999, OPTIMIZATION AND DEVELOPMENT OF IMPROVED CHEMICAL TECHNIQUES FOR THE TREATMENT OF COAL MINE DRAINAGE

D.R. MANEVAL, State Dept. of Mines & Min. , *Harrisburg, Pennsylvania* 17120

The proposed project will consist of initial laboratory studies to develop an improved process for the control and prevention of water pollution by drainage from coal mines. The proposed project will include a literature search, bench-scale studies and process design, evaluation and application. A future project will consist of pilot- plant construction and operation.

The project site location will be in Monroeville, Pennsylvania.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Pennsylvania State Government

5.1000, IN-SITU PRECIPITATION OF SLUDGE RESULTING FROM REACTION OF MINE WATER WITH LOW COST ADDITIVES TO PREVENT MINE DRAINAGE POLLUTION

D.R. MANEVAL, State Dept. of Mines & Min. , *Harrisburg, Pennsylvania* 17120

The project is to develop and test an in-situ technique for the injection of a mixture or slurry of various neutralizing and filler materials into an abandoned mine. This is to reduce the production of acid mine drainage by coating of the pyrites and reduction of the water flow. The initial phase of the study will involve a 4 month series of laboratory tests to confirm the technical feasibility of the method and an evaluation of site selection.

Phase Two will be the pilot installation and demonstration of the technique, treating part, for all of an abandoned mine.

Parsons-Jurden Company will perform the work. The project site is in Elder Township, Cambria County, Pennsylvania.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Pennsylvania State Government

5.1001, NEUTRALIZATION AND PRECOAT FILTRATION OF CONCENTRATION SLUDGES FROM MINE WATER

D.R. MANEVAL, State Dept. of Mines & Min. , *Harrisburg, Pennsylvania* 17120

The project is directed at providing a cost-effectiveness evaluation of various neutralization processes in the treatment of acid mine drainage. Sludge disposal problems will be studied with emphasis on precoat filtration. Field test will be accomplished on four abandoned mines in the Western Pennsylvania area.

Johns-Manville Company will perform the work. It is hoped that this method will provide significant information on economic feasibility of reducing acid mine drainage by neutralization.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Pennsylvania State Government

5.1002, EVALUATION OF POLLUTION ABATEMENT PROCEDURES IN THE MORAINE STATE PARK, BULTER COUNTY, PENNSYLVANIA

D.R. MANEVAL, State Dept. of Mines & Min. , *Harrisburg, Pennsylvania* 17120

The project is for the purpose of ascertaining the effectiveness of various remedial procedures which habe been applied to a large Western Pennsylvania State Park so that judgment may be made relative to wide spread application of specific pollution abatement projects. Water quality and quantity measurements will be made at sampling points throughout the Muddy Creek Watershed.

The project site is located in Moraine State Park, Butler County, Pennsylvania.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Pennsylvania State Government

5.1003, MICROSTRAINING PILOT TESTS OF STORM WATER OVERFLOWS FROM COMBINED STORM AND SANITARY SEWER SYSTEMS

E.W. DIAPER, Glenfield & Kennedy Inc. , *King of Prussia, Pennsylvania* 19406

Project Goal - determine the feasibility of microstraining an chlorination and/or ozonisation as a treatment process for storm water overflows from combined storm and sanitary sewer systems. The drainage area for this test is a 13.6 acre residential section surrounding 67th & Callowhill Streets, Philadelphia, Pennsylvania. During overflows, a 200 gpm sample will be extracted from a collection trough at the sewer outfall, and all water extracted will pass through the Glenfield & Kennedy Microstrainer. This is a rotary drum filter, 5 ft. diameter by 3 ft. long, fitted with a stainless steel screening fabric, having 35 micron apertures. Strained water will be chlorinated (up to 50 ppm) and collected in 1000 gallon tank for subsequent ozinisation. Samples will be automatically extracted before and after microstraining; after chlorination, and after ozinisation. Samples will be stored in refrigerated containers until collection and testing by the Philadelphia Water Commission, for pH, solids content, and biological and chemical properties. This process offers continuous, high volume processing and would eliminate the need for large volume storage tanks for storm water collection.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1004, SULFIDE TREATMENT OF ACID MINE DRAINAGE

R.A. GLENN, Bituminous Coal Research Inc. , *Monroeville, Pennsylvania*

This project involves laboratory process studies on the recovery of sulfide reagents from sludge, production of sulfides from coal refuse material and optimization of various unit operations. Engineering and costs evaluation of the system projected to full industrial scale operation will be made. If these evaluations are favorable, a pilot plant and later a demonstration plant may be considered.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Bituminous Coal Research, Inc.

5.1005, COMBINED SEWER STUDY FOR WASHINGTON, D.C.

J.A. DEFILIPPI, Roy F. Weston Incorporated, *Newton Square, Pennsylvania* 19073

The study has three main objectives: 1. To define the quantity and quality of combined sewer flows by field measurement, laboratory analyses, and desk top studies. 2. To perform studies of high rate filtration as a means of treating combined sewer flows. 3. Study alternative methods of solution such as tunnel storage, surface storage, and system modifications.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1006, BIOLOGICAL TREATMENT PILOT PLANT AND SLUDGE DISPOSAL FACILITY

W.E. HOOVER, Roy F. Weston Incorporated, *Newton Square, Pennsylvania* 19073 (14-12-167)

The scope of work of this contract requires the Designer to: A. Complete a detailed design of a dual stream 100,000 gpd per train biological treatment pilot plant as described in the attached specifications. B. Design a sludge disposal facility for the above pilot plant which includes: 1. Sludge dewatering systems which include: a. vacuum filtration b. centrifugation c. one other dewatering method to be determined. 2. Sludge incineration. C. Provide cost estimates for construction of scaled up plants of the above basic design with the following capacities: 1. One dual stream plant of 250,000 gal per day capacity per train 2. One dual stream plant of 500,000 gal per day capacity per train.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1007, A CONCEPTUAL STUDY OF THE DISTRICT OF COLUMBIA BIOLOGICAL TREATMENT PILOT PLANT

V.T. STACK, Roy F. Weston Incorporated, *Newton Square, Pennsylvania* 19073 (14-12-147)

To perform a study to develop the concept of the District of Columbia Biological Treatment Plant in accordance with the requirements set forth herein: I. Study Criteria A. Evaluate the process layout and hydraulic requirements of the two train (100,000 gpd per train) biological treatment pilot plant as described in the attached specification for installation at the District of Columbia Water Pollution Control Plant. B. Develop a sludge disposal system for the above pilot plant which includes: 1. Sludge dewatering systems a. vacuum filtration b. centrifugation c. experimental dewatering 2. Sludge incineration C. Prepare functional process layout for two larger pilot plants based on the design criteria and flexibility in above D. C. pilot plant and including sludge disposal facilities for plant sized with: 1. Two nominal 250,000 gal per day treatment trains 2. Two nominal 500,000 gal per day treatment trains D. Furnish a cost estimate for the (100,000 gpd/train) pilot plant in A above.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1008, FACTORS AFFECTING THE STRUCTURE OF DIATOM COMMUNITIES

R. PATRICK, Acad. of Nat. Sci. of Phila. , *Philadelphia, Pennsylvania* 19103

The program of research being carried out with the aid of grant WPa00475-04 is to study the effect of various environmental factors on the structure of diatom communities. To date these studies have been concerned with the effect of nitrogen (as NO3 or NH4) and phosphorus (P as PO4) in various amounts and combinations. Also the effects of these chemicals in the presence of various concentrations of iron, silica, glucose, manganese, and cobalt have been studied. The effects of various pH concentrations have also been determined.

These experiments have been carried out under semi-laboratory conditions. A portion of a natural river with its diatom flora flows through experimental boxes in a greenhouse. The flow and concentration of the chemical being studied are carefully controlled and monitored by chemical analyses. The general chemical characteristics of the river water are determined at frequent intervals, some of them being daily determinations. The general characteristics of the experiments have been developed so that under natural conditions 95-97% of the specimens compose the same species in each of the experimental boxes.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1009, POLLUTION OF SUBSURFACE WATER BY SANITARY LANDFILL

A.A. FUNGAROLI, Drexel Institute of Technology, School of Engineering, *Philadelphia, Pennsylvania* 19140

This study has as its overall objective the establishment of criteria for choosing landfill sites and the development of computer models for use in landfill design and evaluation. There are three long-range objectives:

1. To provide means for predicting the quantitative movement of contaminants to ground water from present and proposed sanitary landfills. 2. To appraise design methods and remedial procedures for reducing any undesirable contaminant movement to within specified limits. 3. To develop hydrologic criteria for evaluating site suitability for sanitary landfill.

An overall objective of this project is to meet these aims by development of mathematical design models that describe the hydrologic functioning of and the contaminant movement from a sanitary landfill in varied geological environments.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.1010, STREAM QUALITY PRESERVATION THROUGH URBAN LAND USE

R.E. COUGHLIN, Univ. of Pennsylvania, Graduate School, *Philadelphia, Pennsylvania* 19104

This proposal is part of an overall plan for management of water and land resources in the Upper Brandywine River Watershed. The staff seems well qualified and the available resources are more than adequate. Information gained from this project will assist other urban areas in the formulation of water pollution control programs.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1011, ECONOMICS OF WATER QUALITY IN A REGIONAL SYSTEM

W. ISARD, Univ. of Pennsylvania, Graduate School, *Philadelphia, Pennsylvania* 19104

Significance: Over the past several years, RFF has made considerable progress in furthering study of the economics of water quality management. In the early stages the staff and grant studies focused heavily upon clarification of concepts and empirical estimation of particular benefits and costs associated with improving water quality. Two books have already resulted from this effort and several other major reports are in preparation. In order to show the applicability and significance of the work already done, as well as to extend it, we have begun case studies of realistic situations characterized by differences in hydrology and in character and intensity of development. Two of these are under way dealing with the lower Potomac and the Miami tributary of the Ohio. The present study would be the third of the series. It would focus upon the Delaware Estuary. The Estuary is heavily industrialized, has a large contiguous population and severe water quality problem.

Specific Aims and Expected Results: The project would use and improve existing tools for analyzing the water resources and economic development of the area. This would be done in order to assess the benefits and costs associated with alternative quality management programs. These might include such elements as regulation of river flows into the estuary, high-level treatment at certain times and locations, artificial re-aeration of the estuary, transporting wastes away from critical areas, and regulating reservoir system analysis, and forecasting of waste assimilative and transport capacities would be used in an integrated fashion. This would give new power and depth to water quality management analysis. The funds required to execute this study go beyond those which could be made available by RFF. Consequently the principal participants have worked out arrangements to obtain supplementary funds for certain of the natural service and engineering aspects of the work from the U. S. Public Health Service. It is expected that the project will result in several articles in professional journals and a publishable monograph.

SUPPORTED BY Resources For The Future Incorporated

5.1012, WATER TRANSPORT ACROSS MEMBRANES BY ELECTRO-OSMOSIS

N. LAKSHMINARAYAN, Univ. of Pennsylvania, School of Medicine, *Philadelphia, Pennsylvania* 19104

Transport of ions and of water taking place when the system electrolyte solution through the membrane to and from electrolyte solution is subjected to the action of an electric field (d.c) will be investigated throughly as a function of current density using dilute solutions and well characterized membranes, both ionic and nonionic. The total volume of transport of water for the passage of a faraday of current, phenomenologically called electro-osmosis and composed of both ionic hydration and water transported by electroconvection, has been measured by a number of workers. The dependence of this transport on current density being the subject of some controversy will be investigated throughly. The effect of imposing an a.c. field on the volume of transport will be studied as a function of the frequency of the imposed field. It is hoped that these studies will shed light not only on the mechanism of water transport through different membranes but also to provide information about the quantity of water associated with a moving ion.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

5.1013, PARTICULATE-ORGANIC EFFECT - SENSORY QUALITY OF WATER

R.A. BAKER, Carnegie Mellon University, Graduate School, *Pittsburgh, Pennsylvania* 15213

Preliminary studies have shown that highly electronegative particulates of colloidal dimensions escape conventional coagulation treatment and carry over into the finished water supply. It is hypothesized that these particulates serve as condensation nuclei for organic constituents. Adsorbed microorganics are suspected to be responsible for taste and odor problems, particularly where formation of chloroorganic derivatives is possible. Laboratory studies will be conducted to test this hypothesis using selected organic-particulate- aqueous matrix systems. These waters will be coagulated under precisely-controlled conditions. The sensory, chemical and physical characteristics of the treated water and associated particulate-organic will be measured. A thorough understanding of the behavior of a known system must precede tests with natural waters in field paractice. There is an immediate need for such knowledge for control of microorganic contaminant content of potable supplies and this need will increase as water reuse intensifies. These results are expected to help control groups, industrial waste control and water-treatment plant operators, and chemical and environmental health researchers.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.1014, A SYNTHETIC COMPUTER LANGUAGE FOR SANITARY ENGINEERING

G. BUGLIARELLO, Carnegie Mellon University, School of Engineering, *Pittsburgh, Pennsylvania* 15213

A pilot version of a computer language for sanitary engineering and water resources ('HYDRO') is being extended to increasingly wide areas of the field of water resources and sanitary engineering. The procedures of the language are amplified to take into account newer computational developments in this field; the language is also re examined critically in order to provide specifications for the development of the most effective man-computer interface in the area of water resources and sanitary engineering.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1015, EFFICIENT SYSTEM OF WATER QUALITY MANAGEMENT FOR THE MIAMI BASIN

F.T. DOLBEAR, Carnegie Mellon University, Graduate School, *Pittsburgh, Pennsylvania* 15213

Significance: RFF has already mounted a substantial effort in water pollution research. Theory, methodology, and empirical information have been developed with respect to this problem. This research indicates that some of the most important opportunities for more effective and efficient management of water quality is in the smaller highly developed basins across the country. The proposed study will bring what has been learned to focus on such a basin--the Miami- -and contribute further to methodology and factual knowledge. The Miami not only is highly developed and has serious water quality problems but also has a respected organizational arrangement for providing flood control works which might be adapted to more or less precise management of water quality. Officers of this group--the Miami Conservancy District--have shown a strong interest in the proposed study. The project simultaneously provides an opportunity to test analytical approaches developed by RFF research and to contribute to the solution of an actual serious problem. Moreover, it provides an occasion for soundly-based interdisciplinary research which should develop and demonstrate approaches of wide applicability to pollution problems elsewhere. Because of the method of procedure used, the project will also contribute significantly to education.

Specific Aims: To make a detailed systematic engineering-economic anlaysis of alternative methods of water quality management in the Miami Basin and to make further contributions to the theory and methodology of analysis in the critically important field of water pollution.

Method of Procedure: Under a previous reconnaissance grant from RFF (10,000), Professors Dolbear and Kamien acquainted themselves with some of the essential details of water pollution and sanitary engineering, thoroughly investigated alternative possible case study areas, arranged for obtaining necessary data from various sources, and did preliminary work on analytical methods. Professor Day has a background in several subjects bearing directly on the problem including sanitary and hydraulic engineering, and hydrology. Among other things, Professor Day currently teaches advanced hydrology and has been involved in stream-flow simulation work. This type of analysis is essential to the project.

SUPPORTED BY Resources For The Future Incorporated

5.1016, A CONCEPTUAL STUDY OF THE DISTRICT OF COLUMBIA BIOLOGICAL TREATMENT PILOT PLANT

C. WOOD, Swindell Dressler Company, *Pittsburgh, Pennsylvania* (14-12-149)

To perform a study to develop the concept of the District of Columbia Biological Treatment Pilot Plant in accordance with the requirements set forth herein: I. Study Criteria: A. Evaluate the process layout and hydraulic requirements of the two train (100,000 gpd per train) biological treatment pilot plant as described in the attached specification for installation at the District of Columbia Water Pollution Control Plant. B. Develop a sludge disposal system for the above pilot plant which includes: I. Sludge dewatering systems. a. vacuum filtration. b. centrifugation. c. experimental dewatering. 2. sludge incineration. C. Prepare functional process layout for two larger pilot plants based on the design criteria and flexibility in above D.C. pilot plant and including disposal facilities for plant sized with: I. Two nominal 250,000 gal per day treatment trains. 2. Two nominal 500,000 gal per day treatment trains. D. Furnish a cost estimate for the (100,000 gpd/train) pilot plant in A above.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1017, USE OF COAL AS ADSORBENT FOR TREATING WASTE WATER

J.H. FIELD, U.S. Dept. of Interior, Coal Research Center, *Pittsburgh, Pennsylvania* 15213

The objective is to determine the effectiveness of coal and coal- derived materials such as char and flyash as adsorbents for the organic contaminants in secondary treated domestic sewage.

The degree of removal of organic contaminants from secondary treated waste water is under study in batch tests and continuous flow systems. The batch tests serve as a screening device for choosing the better adsorbents for further testing in the continuous flow system. Because the degree of contaminant removal obtained in batch tests could not be attained in continuous-flow glass column tests, a stirred contactor will be used.

A second part of the project concerns utilization of coal in sludge digestion. Bench tests have indicated that methane can be produced from bacterial (anaerobic) action on certain types of coal. Bacteria from sewage plant anaerobic digesters are used.

SUPPORTED BY U.S. Dept. of Interior - Bureau of Mines

5.1018, WATER CONTROL - CONTROL TECHNIQUES FIELD TESTING AND EVALUATION

N.N. MOEBS, U.S. Dept. of Interior, Mining Research Center, *Pittsburgh, Pennsylvania* 15213

The immediate objective of the Water Control program is to continue collecting and analyzing water effluents and air samples; obtain geologic, hydrologic, and mine data; and develop plans cooperatively with engineers of involved coal operations to reduce the quantity and improve adequately the quality of the water discharged from active mines. Monitoring the flow and quality of effluents from, and of air in, abandoned sealed underground mines above drainage is being continued.

Cooperative agreements with four coal companies are in effect, with encouraging prospects to seal and inundate 30 to 70 percent of the area of one mine to eliminate present treatment within 1 or 2 years after the mine is worked out; and to pipe a low acidity quantity of water generated in the active area of another mine (approximately one- half of the total discharged daily from the below drainage mine) to the main pump sump rather than permit it to flow first into the highly acid water in the main pool located within an old mined out area and, thereby, reduce the cost of treatment.

Also, the sealed 80-acre underground mine above drainage has shown a progressive decrease in the average total acidity for any month after sealing, compared to the same month of any year prior to sealing, indicating reduction in seasonal effects from year to year. Recent infrared imagery has detected a number of permeable zones which may be corrected.

Beginning with fiscal year 1969, the Drainage Control and Mine Sealing projects have been combined into one component (Water Control).

SUPPORTED BY U.S. Dept. of Interior - Bureau of Mines

5.1019, PLUTONIUM REMOVAL IN WATER TREATMENT

J.B. ANDELMAN, Univ. of Pittsburgh, School of Public Health, *Pittsburgh, Pennsylvania* 15213

The aim of this investigation is to study the effect of the various processes in current municipal water treatment practice on the removal of plutonium from a raw water supply, so as to be able to adjust these procedures for optimum removal. The major portion of the study will be concerned with studying the various treatment operations separately as to their effect on the state of plutonium and its ability to be removed in a given process or a subsequent or simultaneous one. When these are sufficiently understood, the operations will be combined into a bench scale pilot plant in order to interrelate them and attain the most efficient removal of plutonium. The oxidation state of the plutonium, the size and charge of colloidal and larger aggregates, the influence of added or natural occurring complexing agents, and coprecipitation phenomena will be of principal consideration. The operations to be studied will be chlorination, lime-soda softening, coagulation and flocculation, and sand and carbon filtration. It is expected that a thorough understanding of the role of each of these processes as related to the chemistry of plutonium will result in recommendations for reasonably and conveniently adjusting conventional water treatment processes so as to produce a water safe to drink, even in the event of gross contamination of plutonium in the raw water supply.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.1020, THE MICRODISTRIBUTION OF STREAM BENTHOS

K.W. CUMMINS, Univ. of Pittsburgh, Graduate School, *Pittsburgh, Pennsylvania* 15213

Continued investigations into the significance of trophic relations in determining the microdistribution and abundance of stream macrobenthos will yield highly detailed information on the trophic structure of a lotic community. Calculations and analyses are accomplished by computer programming. One program permits a highly refined calculation of community trophic structure relative to species distribution patterns. A second program combines all currently available ingestion data and produces summaries, by age class, for each species at the level of samples, transects (5 samples) and combined transects. A third program calculates standing crop data (numbers , weights and calories/square meter, again by size class, for each species at the sample as well as the transect level. A fourth program will be employed to correlate age-specific species standing crop data with the nature of the stream sediments (as analyzed according to the Wentworth Scale).

Standing crop production data are also being gathered on the stream periphyton and estimates will be made of the contribution of allochthonous detrital organics to the stream.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1021, CYTOPATHOLOGICAL CHANGES IN NATIVE FISH SPECIES EXPOSED TO STREAM POLLUTANTS

A. ANTHONY, Penn. State University, Graduate School, *University Park, Pennsylvania* 16802

Representative species of native fish will be collected in streams with varying degrees of pollution. Some will be killed for immediate cytochemical analysis of tissues; others will be maintained in aquaria under controlled conditions for use in recovery studies. Initially, main emphasis will be on measures of DNA profiles in both liver and gonads using the Feulgen nucleal reaction in conjunction with absorption microspectrophotometry. In addition, nuclear and cytoplasmic RNA and proteins will be analyzed using quantitative cytochemical staining and absorption microspectrophotometry.

In brief, studies will be directed toward spectral analysis of cellular elements of the liver and gonads of fish from unpolluted streams and from streams with known degrees of pollution. Subsequently, cytochemical characteristics of subcellular fractions separated by differential centrifugation will be compared with nuclear and cytoplasmic staining in situ.

On the basis of microchemical study of various organs it should be possible to predict: a. which species possess natural resistance to alterations in stream quality, b. which species are adapted to reproduce in streams with varying degrees of pollution, and c. the extent to which a stream must be improved to allow fish to grow and reproduce.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1022, DEVELOPMENT AND EVALUATION OF MEANS AND MEASURES FOR CHANNEL STABILIZATION

R.P. APMANN, Penn. State University, U.S.D.A. Ne. Watersh. Res. Ct. , *University Park, Pennsylvania* 16802

Object: To determine the relationship betwen flow characteristics, scour, and sediment transportation or deposition in channels, and the effectiveness of vegetal and structural materials proposed for channel protection; to develop protective works for channel banks, and design criteria for systems of grade control structures for channel stabliization; and to evaluate the role of reservoirs on channel stability for the range of conditions in land resource areas of the Northeast.

Plan of Work: The mechanics of sediment transport and the relation of channel flows that can be sustained without scour are measured in natural channels and the laboratory. Studies are made of variables such as depth and velocity of flow, rate of transport of bedload and suspended sediment, the soils of the channel bed, and irregularities of channel surface, cross-section, alignment, grade, size and distribution of sediment, character of the banks and channel bed, geology of the site, and of the geometry of natural streams. Hydraulic features are measured to locate points of critical erosion potential. Fluid shear stresses in natural channels are evaluated from field measurements and by model studies simluating channels of varying curvature under a range of flow conditions to establish information on erosive forces. Various means for stabilizing banks or natural channels are devised and evaluated.

SUPPORTED BY U.S. Dept. of Agriculture

5.1023, FEED AND WASTE HANDLING IN THE DAIRY OPERATION

H.D. BARTLETT, Penn. State University, Agricultural Experiment Sta. , *University Park, Pennsylvania* 16802

Objectives: 1. To evaluate and develop methods and equipment for mechanization of handling materials in dairy livestock feeding operations, particularly stall barns. 2. To evaluate and develop methods and equipment for handling and distribution of wastes from dairy production systems.

Procedure: 1. Studies will be made of existing feeding equipment installations to evaluate labor requirements and equipment costs for feeding dairy cattle in stall barns by mechanical feed carts and with various manger conveyor feeding systems. Work will be done on the development of mechanical feed conveying equipment that will be low in initial cost, dependable, durable, adaptable to handling both grain and chopped forage, and provide flexibility in relation to installation in barn arrangements. 2. Studies of dairy waste management will include handling of animal excrement and the waste water used in cleaning milk houses and milking parlors. The methods of handling to be studied will include animal excrements removal from paved areas and stall-barn gutters to a storage tank or direct application to fields. Handling the wash water directly to fields by sprinkler irrigation systems will also be studied to evaluate operational problems which may be encountered in the daily application on a year-round basis under Pennsylvania conditions.

SUPPORTED BY U.S. Dept. of Agriculture
Pennsylvania State Government

5.1024, THE BEHAVIOR OF SMALLMOUTH BASS AS RELATED TO ARTIFICIAL COVER

R.L. BUTLER, Penn. State University, State Coop. Fishery Unit, *University Park, Pennsylvania* 16802

Reason for study: Although cover is recognized necessary for the maintenance of many species, the characteristics of cover and the response of the organism to it have not been studied to any great extent. In some marginal streams the variability of cover may be the limiting factor for the bass population. If cover is a limiting factor, a species depended upon it may have low population levels even where food is abundant. Much money has been spent on ‘stream improvement‘ devices without knowledge of the preferences of fish for these structures. Since response to cover is a behavioral paramenter of a species, measures of it may be used for bio-assay.

Objectives: (1) To determine those components of cover that are attractive to smallmouth bass. (2) to demonstrate the effects of water velocity on the utilization of cover by smallmouth bass. (3) To test response to cover as a bio-assay for mine acid pollution.

Design of Project: An experimental stream trough will be built and placed in operation at a nearby impoundment. One fish at a time will be introduced into the stream trough and exposed to a series of cover objects designed to simulate various features of natural cover. Current velocity will be varied to determine its effect on utilization of the cover. The tests will be run in high carbonate and low carbonate water for baseline measures under unpolluted conditions. Bio-assay of mine acid water will be done at several stream sites offering various degrees of mine acip pollution.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Pennsylvania State University

5.1025, AN ECOLOGICAL STUDY OF AN ALKALINE STREAM WITH HEAVY IRON DEPOSITS ORIGINATING FROM TREATMENT OF MINE ACID WATER

R.L. BUTLER, Penn. State University, State Coop. Fishery Unit, *University Park, Pennsylvania* 16802

Reason for Study: Mine acid polluted waters from the Susquehanna River are pumped into an abandoned mine. On leaving the mine and entering Beaver Run, the alkalinity is increased and a heavy precipitate of iron salts results for some three to four miles downstream. These conditions are also noted in streams artificially treated with lime to reduce acidity resulting from pollution. Understanding how the biota in Beaver Run are affected by the increased alkalinity and the iron-salts precipitate will assist in evaluating the lime treatment projects currently in operation as well as those being recommended for control of acid pollution in many Appalachian streams.

Objectives: 1. Determine the structure of the ecosystem in Beaver Run and Little Beaver Run. 2. Determine the effects of increased alkalinity and iron-salt deposits on the aquatic community in general and the native fish and brook trout egg development in particular.

Design of Project: Invertebrates will be sampled periodically at 10 stations. They will be analyzed as to species diversity and relative abundance. Physical and chemcial analyses for the stations will be recorded. At several stations, population estimates of the native trout will be determined. Brook trout eggs will be 'planted' in the stream during the fall of the year and the percentage survival will be computed.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Pennsylvania State University

5.1026, THE DISTRIBUTION OF FISH IN PENNSYLVANIA AS RELATED TO MINE ACID DRAINAGE

E. COOPER, Penn. State University, Graduate School, *University Park, Pennsylvania* 16802

Reason for Study: The Bureau of Sport Fisheries and Wildlife in cooperation with the Pennsylvania Fish Commission has obtained from 280 stream sections in Pennsylvania samples of fish populations. When these collections were made measurements of water quality were also taken. These fish samples provide a baseline on fish populations in relatively unpolluted habitats. Collections need to be made in streams and lakes exposed to various levels of mine acid pollution. Parameters such as species composition, growth mortality, food habits and fecundity of the species collected in polluted water may reflect the stress of these environments.

Objectives. 1. Determine the species of fish and their abundance in waters exposed to different concentrations of mine acid. 2. Measure the effects of various levels of pollution on each species through growth, natural mortality, fecundity and food habits.

Design of Project: A field crew of men will obtain fish samples from local sections of Pennsylvania streams and reservoirs exposed to mine acid. Physical and chemical measurements of the water at the time and place of sampling will be made. The measurements will include calcium hardness, total hardness, total acidity, pH, conductivity, temperature, stream flow, and stream and lake morphometry. All samples obtained of fish will be preserved for laboratory studies of growth, natural mortality rates and food habits.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Pennsylvania State University

5.1027, EFFECTS OF ORGANIC POLLUTION ON HATCHABILITY AND SURVIVAL OF BROOK TROUT, SALVELINUS FONTINALIS, AND GROWTH OF BROWN TROUT, SALMO TRUTTA

E. COOPER, Penn. State University, Graduate School, *University Park, Pennsylvania* 16802

Reason for Study: Spring Creek below State College, Pennsylvania, was once known as an outstanding trout stream. Following the construction of a sewage treatment plant to service the University and State College, there was a marked decline in the trout population from State College to Fisherman's Paradise. The effluent does not have a high B.O.D., however, considerable enrichment is provided the stream through the addition of phosphates and nitrates. Aquatic plants have developed excessively below the plant. The University has been applying to land areas approximately 300,000 gallons per day of the effluent. Since this practice was started, there is some thought that the stream has improved for the benefit of trout. It would be desirable to know to what extent the stream can support trout under these present conditions.

Objectives: 1. To determine the present status of trout populations in Spring Creek through an analysis of natural reproduction, population size, growth rates, and mortality. 2. To relate the objective no. recovered) of the stream for investigation. 3. To determine the success of hatching of brook trout eggs in Vibert Boxes in the three areas and relate hatching success and survival to oxygen, water temperature, and turbidity.

Design of Project: Trout will be collected with electro-fishing gear in the three sections of Spring Creek. Springs and ground water seeps in the stream will be located in the three study areas and will be used as locations for planting brook trout eggs. Eggs placed in Vibert Boxes will be located above and below the springs and seeps. Each of these stations will be monitored for oxygen, temperature, and turbidity.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Pennsylvania State University

5.1028, ABUNDANCE AND DISTRIBUTION OF BENTHIC MACRO-INVERTEBRATES IN A STREAM RECEIVING OIL-FIELD WASTEWATERS

E. COOPER, Penn. State University, Graduate School, *University Park, Pennsylvania* 16802

Reason for Study: Inorganic salts, such as those present in oilfield brines, are common pollutants from oil production facilities and other industrial operations. A more thorough knowledge of the specific effects that these substances may have upon aquatic systems should lead to a more intelligent management of our water resources.

Objectives: 1. To correlate the abundance and distribution of several benthic macro-invertebrates with the environmental levels of dissolved solids (salts). 2. To determine the actual tolerance levels of certain of these organisms to brines of known composition under laboratory conditions.

Design of Project: Bio-assay precedures will be performed in the laboratory to determine specific tolerance limits of specific organisms towards the wastes under investigation. A program of chemical and biological sampling will be conducted in the field over a period of one year to apparaise the effects of the wastes upon a natural aquatic intertebrate community.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Pennsylvania State University

5.1029, CHANGES IN STREAM COMMUNITIES ASSOCIATED WITH EFFLUENT - INDUCED EUTROPHICATION

E.L. COOPER, Penn. State University, Graduate School, *University Park, Pennsylvania* 16802

Reason for Study: Secondary sewage treatment plants that remove nearly all BOD but leave much of the inorganic nutrients in the effluent are being used in an increasing number of municipalities to arrest organic pollution. Stream enrichment, however, alters predator-prey trophic systems culminating with fish. In naturally fertile streams further fertilization can result in high plant standing crops and decreased fish standing crops. The biological changes in intermediate trophic transfers between the plants and fish probably play a significant role in decreased fish standing crops. Evaluation of community alterations by eutrophication are necessary for satisfactory stream management.

Objectives: 1. To determine changes in species diversity and abundance of macro-invertebrates associated with eutrophication. 2. To determine changes in production of aquatic plants and macro invertebrates associated with stream eutrophication.

Design of Project: Samples have been collected from two areas in Spring Creek which are similar except for the presence of treated sewage effluent in the lower area. Gross primary production is being estimated by measuring 24-hour changes in dissolved oxygen. Fish exclosures were placed in riffles and the silted edges of pools and sampled monthly to determine macro-invertebrate production. Seasonal samples have also been taken from four similar riffles to compare community structural properties above and below the source of effluent.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Pennsylvania State University

5.1030, SUBSURFACE WATER POLLUTION FROM SANITARY LANDFILLS IN CARBONATE ROCK TERRAIN

G.H. EMRICH, Penn. State University, Graduate School, *University Park, Pennsylvania* 16802

Ground water pollution from land disposal of wastes in carbonate rock terrain is a widley occurring problem throught the humid United States. Critical information is still lacking of the physical parameters to be evaluated at land disposal sites.

Sample collecting equipment has been installed at a sanitary landfill located in central Pennsylvania. The site has at least 50 feet of sandy loam soil derived from the underlying Gatesburg dolomite. Ground water occurs at a depth of approximately 200 feet.

Liner was placed in the bottom of the sanitary landfill trench. The liner collects and directs all the leachate from the landfill to one side of the trench, where it is evenly spread through the soil. Seventeen suction lysimeters have been placed in the soil at depths up to 34 feet to monitor and collect samples of the leachate. The landfill and monitoring equipment were emplaced in November of 1967. Water was spread on the top of the landfill in order to quickly generate leachate. First leachate production occurred in January 1968 and has moved down to a depth of 12 feet. Chemical analyses of the leachate indicate high concentrations of iron, chloride, sulfate and B.O.D.

SUPPORTED BY Pennsylvania State Government
Pennsylvania State Government

5.1031, ANALYTICAL METHODS FOR PESTICIDES AND PESTICIDE DEGRADATION PRODUCTS

C.D. ERCEGOVICH, Penn. State University, Agricultural Experiment Sta., *University Park, Pennsylvania* 16802

Development of improved analytical methods for residues of pesti- cides and their degradation products.

Existing methods for the determination of pesticide residues and degradation products will be critically examined for sensitivity, accuracy, reproducibility and simplicity. Attempts will be made to improve those which appear to be lacking in one or more of these qualities. Special emphasis will be placed on pesticides in common use, and on pesticide degradation products which may result from metabolic and other decomposition processes which take place in living organisms, soil, water, and other media.

SUPPORTED BY U.S. Dept. of Agriculture
Pennsylvania State Government

5.1032, FATE AND PERSISTENCE OF PESTICIDES AND PHYSIOLOGICALLY ACTIVE DEGRADATION PRODUCTS

C.D. ERCEGOVICH, Penn. State University, Agricultural Experiment Sta., *University Park, Pennsylvania* 16802

1. Follow the disappearance of pesticide residues in media other than raw agricultural commodities. 2. Qualitatively and quantitatively identify the degradation products resulting from the breakdown of pesticide residues in media other than raw agricultural commodities.

Procedure Objective 1. Measure quantitatively the amounts of pesticide residues remaining at known time intervals following application in various types of soils, still and flowing water supplies, processing plant by-products, silage, processed dairy products, feedingstuffs and other processed agricultural products. This will be done by gas chromatographic methods, using various types of detectors.

Procedure Objective 2. Identify and measure any pesticide degradation products which may result from hydrolysis or decomposition caused by heat or processing or other physical or chemical forces. These will be separated by thin layer, column or gas chromatographic means and identified by infrared or other spectral analyses and the use of labelled compounds.

SUPPORTED BY U.S. Dept. of Agriculture
Pennsylvania State Government

5.1033, THE SPECIES DIVERSITY OF AQUATIC INSECTS AS RELATED TO MINE ACID POLLUTION

D.C. HALES, Penn. State University, State Coop. Fishery Unit, *University Park, Pennsylvania* 16802

Reason for Study: While it is generally understood that aquatic insects are affected by lower concentrations of pollutants than are fish, little is known about the sensitivity of aquatic insects to mine acid pollution. If species of fish are markedly restricted at pH 5 to 6 as evidence indicates, one may expect fish food organisms to be markedly reduced. The absence of critical species of stream insects may in fact be a limiting factor in the abundance of fish species.

Objectives: Determine the biotic index (an index based upon the abundance of species on a sliding scale of types assigned to polluted and unpolluted and clean water areas) of aquatic insects from selected waters representative of clean soft and hard water conditions and streams with varying levels of pH.

Design of Project: Field crews will sample selected streams representative of clean soft water and clean hard water conditions, a stream with pH less than 5.0, and four to six streams with pH ranging from 5.0 to 6.0. Seasonal variations in species will be determined. Relative species diversity will be determined by analysis in terms of log normal curves.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Pennsylvania State University

5.1034, SENSITIVITY OF SELECTED INSECT SPECIES TO DEPRESSED LEVELS OF PH

D.C. HALES, Penn. State University, State Coop. Fishery Unit, *University Park, Pennsylvania* 16802

Reason for Study: One of the principal environmental changes resulting from mine acid pollution is a decrease in pH. In streams that are highly polluted with mine acids, there is a notable lack of insect fauna. Yet there is little information available concerning the sensitivity of insect fauna to depressed pH levels. The absence of critical species of insects in mine acid polluted streams may be a limiting factor to fish.

Objectives: Determine the levels of pH to which selected species of the order Ephemeroptera, Plecoptera and Trichoptera are sensitive.

Design of Project: Continuous flow bioassay techniques will be used to determine the 96-hour TLm of the selected organisms. Water of similar quality to that most severely affected by mine acids (low alkalinity and dissolved solids) will be used. Metering pumps will provide continuous flow. Sulfuric acid, the primary component of mine acids, will be injected into the system to obtain the desired test levels of pH.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Pennsylvania State University

5.1035, CONSERVATION AND RENOVATION OF WASTE WATER

L.T. KARDOS, Penn. State University, Agricultural Experiment Sta., *University Park, Pennsylvania* 16802

To determine the effect of irrigation with sewage plant effluent on the yield and other plant response parameters of agronomic and forest vegetation. 2. To determine to what extent agronomic crops, trees, and the soil mantle can renovate sewage plant effluent and permits its recharge to the ground water. 3. To determine the effects of the application of sewage plant effluent on the physical, chemical and biological properties of the soil. 4. To compare the effectiveness of various surface and sprinkler distribution methods for the disposal and renovation of sewage plant effluent.

Agronomic and forested areas will be irrigated with chlorinated sewage plant effluent at weekly intervals with sufficient quantities to secure recharge to ground water but at rates of penetration which will permit renovation of the effluent in the biologically active portion of the soil mantle prior to its recharge to the ground water. Effects of the effluent on crop and tree growth and on soil properties will be determined. Engineering studies will compare several methods of applying the effluent to determine their effectiveness as distributing systems on a year round basis.

SUPPORTED BY U.S. Dept. of Agriculture
Pennsylvania State Government

5.1036, CRUSHED LIMESTONE BARRIERS FOR NEUTRALIZATION OF ACID STREAM

R.R. KOUNTZ, Penn. State University, School of Engineering, *University Park, Pennsylvania* 16802

Many small streams and creeks are lost to recreational use because of the acid quality of their water. Neutralization of this acid content would premit these streams to be enjoyed.

Work performed by numerous investigators during the previous 15 years indicates that such neutralization is possible providing the limestone is low or non-existent in its magnesium content. Unfortunately these studies were never carried to the point of such parameters as flow rate vs. stone size vs. acid concentration.

It is proposed to secure, samples of 'pure' calcium limestone from one of the area quarries in the different commercial sizes available that would be suitable for a creek barrier. These samples would be subjected to various flow rates of various concentrations of acid in the laboratory so as to evaluate the amount of acid neutralized as a function of stone size, fluid velocity, and acid concentration.

It is expected that these data would permit the design of barriers in an acid creek or stream that would neutralize the acid in the water, and restore the recreational value of the water resource.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Pennsylvania State University

5.1037, SOLUBLE PHOSPHORUS REMOVAL IN THE ACTIVATED SLUDGE PROCESS

R.R. KOUNTZ, Penn. State University, School of Engineering, *University Park, Pennsylvania* 16802

This project will develop a process for the removal of phosphorus from municipal waste waters utilizing chemical precipitation of the phosphorus within the aeration and settling units normally used in the activated sludge process. The work will be conducted at the waste water treatment plant owned and operated by The Pennsylvania State University. Studies will be conducted to determine the relative merits of sodium aluminate and filter alum as precipitating agents, the efficiency of the coagulant in removing phosphorus over a one year operating period, the effect of the sludge digester on the inorganic precipitate. Costs and operating information for a 2.1 mgd domestic waste plant will also be ascertained.

SUPPORTED BY Soap & Detergent Association

5.1038, TREATMENT OF COAL MINE WATERS TO MEET CURRENT COMMONWEALTH WATER DISCHARGE REQUIREMENTS

H.L. LOVELL, Penn. State University, Graduate School, *University Park, Pennsylvania* 16802

The detailed engineering design and plans are complete. Construction for phase 1, excavation and construction of lagoons at the site near Hollywood, Clearfield County, Pennsylvania is essentially completed.

Phases 2,3,4, and 5 (the installation of unit operations and instrumentation) has been bid and work will proceed shortly. Completion of construction is anticipated by spring 1969.

The plant will encompass a highly instrumented series of unit operations so designed that it will be capable of functioning through at least six different flow sheets. Emphasis is being placed on solid- fluid separations which comprise the highest cost operations, both capital and operating, and which offer the most difficult technical and engineering problems.

SUPPORTED BY Pennsylvania State Government

5.1039, SUITABILITY FOR SEPTIC TANK DISPOSAL SYSTEMS AND PRODUCTIVITY POTENTIALS OF PENNSYLVANIA SOILS

R.P. MATELSKI, Penn. State University, Agricultural Experiment Sta. , *University Park, Pennsylvania* 16802

To determine and predict the soil factors responsible for adequate septic tank usage. To identify the soil properties responsible for observed variations in productivities.

DESCRIPTION OF WORK PROPOSED: Field measurements and later laboratory soil determinations of the effect of seasonal variation, perched water tables and the variability within a mapping unit on waste water movements will be studied to predict efficiencies of septic tank tile disposal fields. The field percolation tests will be studied and improved. Yields of important crops on soils with variations in slope, erosion, fertilizer treatments and management will be measured and evaluated. Soils will be characterized in the laboratory to determine the soil factors contributing to yield variation.

SUPPORTED BY Pennsylvania State Government

5.1040, THE EFFECTS OF NUTRIENTS ADDITIONS AND STREAM DYNAMICS ON STREAM EUTROPHICATION

A.J. MCDONNELL, Penn. State University, School of Engineering, *University Park, Pennsylvania* 16802

The purpose of this research is to measure under different environments of nutrient influx and hydraulic regime, the combined effects of induced nutrients and stream dynamics on stream productivity.

Productivity in selected stream reaches will be measured by plankton and aquatic weed growth and by photosynthetic activity as determined by net oxygen production.

Measurements of a number of nutritive stimulants including soluble phosphorous organic and inorganic nitrogen and the stream reach hydraulic characteristics of flow, velocity and turbulence will define the causal agents. Where feasible multiple correlation techniques will be utilized to establish the relative significance of each of the selected variables in promoting stream productivity.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Pennsylvania State University

5.1041, RESPIRATION OF AQUATIC MACROPHYTES IN EUTROPHIC SYSTEMS

A.J. MCDONNELL, Penn. State University, School of Engineering, *University Park, Pennsylvania* 16802

The growth of algae and rooted aquatics in natural waters is becoming a water resource problem of increasing importance. Information is lacking as to the mechanisms by which these plants affect the oxygen resources of a water body. The purpose of the proposed study is to delineate the environmental factors which affect the respiration rates of selected aquatic plants.

Laboratory studies will include: 1. A determination of plant respiration rates under various levels of oxygen concentration, temperature and plant maturity. 2. Manometric studies to determine respiration response of clean stream plants to exogenous nutrient additions.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Pennsylvania State University

5.1042, HIGH-RATE, MULTIPLE MEDIUM FILTRATION FOR SECONDARY TREATMENT OF MUNICIPAL WASTE WATER

J.B. NESBITT, Penn. State University, School of Engineering, *University Park, Pennsylvania* 16802

This project will study the treatment capability and economic feasibility of a high-rate, multiple medium filter for the secondary treatment of municipal waste water. The study will be conducted on a model filter constructed at the Pennsylvania State University sewage treatment plant. Effluent from the primary settling basins in the plant will be chemically coagulated and passed through the model filter.

The following analyses will be made of the influent to and effluent from the filter: (1) biochemical oxygen demand (BOD), (2) chemical oxygen demand (COD), (3) soluble and total phosphorus, (4) ammonia and nitrate nitrogen, and (5) turbidity.

Studies will be made to determine: 1. the effect of size of the top medium and different coagulants on effluent quality as measured above and on the length of filter run. 2. the washing rate and time of wash that will produce the most economical operation. 3. the feasibility of vacuum filtration for the disposal of filter wash water. 4. the economics of a waste water disposal system utilizing primary treatment; high-rate, multiple medium filtrations; and separate sludge digestion with vacuum filtration of digested sludge.

SUPPORTED BY Pennsylvania State University

5.1043, PULVERIZED ANTHRACITE COAL AS A MEDIUM FOR PRECOAT FILTERS

J.B. NESBITT, Penn. State University, School of Engineering, *University Park, Pennsylvania* 16802

A small commercial vacuum type precoat filter is being used to determine the feasibility of using pulverized anthracite coal rather than diatomaceous earth as a filtration medium for the filter. Studies will be made to determine the effect of precoat and body feed doses on the removal of several different types of suspended matter. Effluent water quality, length of filter runs, and terminal head loss are being investigated. Runs will be made with several size gradations of coal and the results compared with those obtained using diatomaceous earth.

SUPPORTED BY Pennsylvania State University

5.1044, FACTORS AFFECTING MINE DRAINAGE AND THE GROUND WATER INTERACTIONS IN SELECTED AREAS OF WESTERN PENNSYLVANIA (PART 2)

R.R. PARIZEK, Penn. State University, Graduate School, *University Park, Pennsylvania* 16802

As shown by a previous study, a stratification of ground water flow in the strip-mined bituminous coal field of Pennsylvania may exist that may effectively divert acid mine drainage pollution from deep ground water reservoirs. Further, opportunities for neutralization were shown to exist. These considerations may lead to the establishment of a potable ground water supply in an area afflicted with surface acid mine drainage. To test these hypothesis a specialized water monitoring system will be installed to accurately evaluate the aquifer characteristics, to determine the aquitards in the area and to sample the ground water for chemical analyses to determine the extent and effect of acid mine drainage pollution.

A related study will investigate the field conditions under which pyrite remains stable and does not decompose to produce acid mine drainage. Samples of iron disulfide from an area containing strip mines yielding alkaline drainages will be analyzed to determine the reason for the stability; hence gain an insight to acid mine drainage abatement.

SUPPORTED BY Pennsylvania State Government

5.1045, EFFECTS OF IRRIGATION OF MUNCIPAL SEWAGE EFFLUENT ON SPOILS BANKS

W.E. SOPPER, Penn. State University, Inst. For Res. on Land & Water, *University Park, Pennsylvania* 16802

The purpose of the proposed project is to investigate the feasibility of ameliorating adverse strip mine spoil bank sites through irrigation with municipal sewage effluent. Benefits derived from such a method, if feasible, would be twofold (1) alleviation of stream pollution as a result of diversion of the effluent load from streams to land areas and (2) restoration of these disturbed land areas to useful productivity.

The specific objectives are: (1) to determine the degree of chemical renovation of municipal sewage effluent and sludge by spoils bank material, (2) to determine the extent of site amelioration as a result of irrigation of sewage effluent and mixtures of effluent and digested sludge on spoils banks material and (3) to determine the effectiveness of various proportions of sewage effluent and sludge and various amounts of the mixture on the revegetation of the spoils material.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

5.1046, MICROBIOLOGICAL CHARACTERIZATION OF ACTIVATED SLUDGE IN A WASTEWATER TREATMENT PLANT CHEMICALLY MODIFIED FOR PHOSPHORUS REMOVAL

R.F. UNZ, Penn. State University, Inst. For Res. on Land & Water, *University Park, Pennsylvania* 16802

Full scale combined chemical-biological wastewater treatment for simultaneous removal of organic matters and phosphorous is in the pioneer stage. There is little evidence to show that the biological solids are not qualitatively and/or quantitatively altered in microbial composition as a result of chemical treatment. There is no information on the bacteriological quality of the effluent from the combined treatment systems.

The objectives of this study are: 1. To obtain basic information on the microbial composition of activated sludges before and following chemical treatment of wastewaters for phosphorous removal. 2. Assuming variations in wastewater treatment efficiency result during chemical treatment, it is the intent to determine if the changes in treatment efficiency parallel changes in microbial composition of the activated sludge. 3. To consider reasons for microbial diversity in activated sludges if such seems to be related to chemical treatment of the wastewaters. 4. To supplement the data to be collected by personnel connected with the engineering aspects of a phosphorous removal project being conducted at this University's wastewater treatment plant and to contribute toward the final evaluation of that project as well as general design and operation of combined chemical-biological wastewater treatment schemes.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Pennsylvania State University

5.1047, GUAVA VARIETIES. SELECTION & PROPAGATION OF GUAVA VARIETIES & INVESTIG. OF COMMERCIAL & INDUST. POSSIBILITIES OF THE FRUIT (ABBREV)

W. PENNACK, Univ. of Puerto Rico, Agricultural Experiment Sta., *Mayaguez, Puerto Rico*

To determine the adaptability of selected guava varieties for production in the different regions of Puerto Rico.

Description of Work: Data will be assembled on selected guava clones. The selection to be based on desirable processing, table and orchard characteristics like fruit yield, size, soluble solids, acidity, and vitamin C content. The best selections will be asexually propagated for further observations and propagation.

Field experiments will be performed in different areas to study the performance of selected varieties as to yield and fruit quality.

Flowering period, fruit yield and fruit size as affected by irrigation at different intervals will be studied. Usefulness of fungicides for the control of Glomerella disease will be determined. Propagation by cuttings using different rooting media will be studied.

5. WATER QUALITY MANAGEMENT AND PROTECTION

SUPPORTED BY Puerto Rico Government

5.1048, SOCIO-ECONOMIC FACTORS RELATED TO THE INCIDENCE OF A WATER-BORNE DISEASE

G.C. UZDAVINI, Univ. of Puerto Rico, Water Resources Research Inst. , *Mayaguez, Puerto Rico*

This study is to determine primarily the impact of Gastroenteritis, an illness caused by the water-borne enterobacteriaceae on the social and economic life in a community within the municipality of San German, Puerto Rico. Two areas within the community, one a public housing scheme and a slum area will be used to accomplish the following goals: (a) To determine the economic and social factors which lead to unsanitary conditions which enable enterobacteriaceae to develop and multiply, thereby causing an increase in the water contamination even though facilities are available; (b) To determine what the needs are that would alleviate this and other situations; (c) To mobilize the forces in the community to bring about changes in the physical and social environments which will diminish the incidence of this water carried organism and thereby create an atmosphere more conducive to physical health; (d) To develop a framework and background for further research in the area of the effects of water upon physical and mental health.

To accomplish these goals, the relevant sociological instruments and consequent analysis will be implemented.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Puerto Rico

5.1049, DESIGN OF FACILITIES FOR ANIMAL WASTE DISPOSAL

D.J. VANREST, Univ. of Puerto Rico, Agricultural Experiment Sta. , *Mayaguez, Puerto Rico*

Objectives: (1) Development of design and management criteria for anaerobic digesters as a primary method of animal excrement stabilization in Puerto Rico. (2) Evaluate by means of pilot systems combinations of secondary methods of stabilization and utilization of the effluent from anaerobic primary systems.

Description of Work Proposed: A series of pilot plant digesters will be installed to determine optimum conditions for certain design parameters, viz, method of initiating fermentation; loading rates per cubic foot of digester volume and circulation rates of digesting material. Parallel trials on secondary systems will be made on the effluent from the primary system with aeration, settling and plant fish cultures.

SUPPORTED BY Puerto Rico Government

5.1050, CORRELATION OF STRUCTURE VS. ACTIVITY OF POLLUTANTS OF FRESH WATER

H.W. BOND, Univ. of Rhode Island, School of Pharmacy, *Kingston, Rhode Island* 02881

A series of nitroolefin, quaternary salt, and dithiocarbamate compunds will be synthetized and screened for potential molluscicidal activity against Astralorbis glabratus. In addition these compounds will be tested for activity against bacteria, fungi, and algae. The mechanism of the molluscicidal activity of the nitroolefins will be investigated in the Astralorbis glabratus through the use of tissue homogenates and subcellular particles. The data obtained from these studies will be correlated to molluscicidal activity for the purpose of establishing a rapid and reliable in vitro screening procedure.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Rhode Island

5.1051, INTERACTION OF ANIMAL VIRUSES WITH CLAY MINERALS

P.W. CHANG, Univ. of Rhode Island, School of Agriculture, *Kingston, Rhode Island* 02881

The objectives of this proposal are: (1) To compare the capacity of various types of natural minerals and clays to adsorb animal viruses under the effect of different pH levels and ionic strengths; (2) To determine the fate of viruses after their adsorption on minerals and clays.

This study should provide information regarding removal of animal viruses by natural clay minerals. Such findings should be applicable in water treatment plants to improve methods for more complete removal of viral pollutants. This study will also attempt to ascertain fate of viruses after their adsorption to clay. This will be investigated in three ways: (1) Dissociation of clay-virus complexes; (2) Assaying for infectious centers of clay-virus complexes; (3) Direct observation for viral antigen on clay by means of fluorescent antibody technique. Such basic knowledge will contribute greatly toward a better understanding and control of viral pollutants.

SUPPORTED BY University of Rhode Island

5.1052, MULTIPLICATION OF ENTERIC VIRUSES IN SHELLFISH

P.W. CHANG, Univ. of Rhode Island, School of Agriculture, *Kingston, Rhode Island* 02881

Shellfish have been incriminated repeatedly as reservoirs for virus pathogens. This is evidenced by numerous occurrences of infectious hepatitis outbreaks following ingestion of contaminated oysters and hard clams and also by isolation of enteric viruses in oysters obtained from estuarine environments polluted by raw sewage.

The proposed project attempts to answer whether multiplication of human enteric viruses occurs in shellfish. The methods outlined in this study are designed to circumvent the difficulties encountered by previous investigators in evaluating whether virus measured in shellfish tissue represents persisting input virus or virus formed de novo. These methods include the use of proflavine labelled virus, electron microscopy of infected tissue. The shellfish tissues will also be examined for viral receptors.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.1053, IRON AND MANGANESE REMOVAL FROM SMALL GOUND WATER SUPPLIES

F.J. DELUISE, Univ. of Rhode Island, School of Engineering, *Kingston, Rhode Island* 02881

This project will be concerned with the removal of iron and manganese from ground waters used for relatively small supplies, and for supplies which must have an iron and manganese content lower than normally acceptable. The primary areas to be investigated include chemical agents and combinations of these will be evaluated to determine the most efficient means of removing iron and manganese. It is anticipated that ultimately a complete process will be suggested for the satisfactory and efficient removal of iron and manganese from these small supplies

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Rhode Island

5.1054, STRUCTURAL CHEMISTRY OF YELLOW ORGANIC MATTER IN FRESH WATER

G.T. FELBECK, Univ. of Rhode Island, School of Agriculture, *Kingston, Rhode Island* 02881

The objectives of this study will be: 1. To examine the molecular structure of the yellow organic matter by a method of high pressure hydrogenolysis, 2. To determine the source of this material by examining similar material synthesized by representative aquatic and soil microfilm, and 3. To synthesize model organic compounds with structures similar or identical to those found in fresh water to verify structural data determined previously by analysis.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Rhode Island

5.1055, THE BIOASSAY OF WATER POLLUTANTS WITH CULTURED MAMMALIAN CELLS

H.W. FISHER, Univ. of Rhode Island, Graduate School, *Kingston, Rhode Island* 02881

The research plan proposes to utilize mammalian cells cultured in vitro for the quantitative determination of the titration end-point of toxicity for water pollutants. The quantitative methods would be plating efficiency and growth rate in the presence of selected model pollutants. Diffusion disc diameter methods for cyto-toxicity would also be investigated. The results with inorganic pollutants, herbicides, pesticides and detergents would be correlated with pratical conditions found in field locations.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Rhode Island

5.1056, CHEMICAL RESPONSES BY MARINE ORGANISMS TO STRESS

H.P. JEFFRIES, Univ. of Rhode Island, Graduate School, *Kingston, Rhode Island* 02881

The ocean is physically stable compared with land and freshwater environments, and the medium has intimate association with the life it bathes. Consequently marine organisms have developed less complex regulatory systems than their terrestrial and aquatic counterparts. But when the ocean does change -- by natural processes or as the result of pollution -- it follows that the biotic community will also change, along with the ecosystem's ability to process waste materials. Homeostatic control at the community level is, therefore, an essential element in understanding the sea's populations, especially in coastal waters where environmental oscillations are large.

The major goal of this investigation is to identify and measure quantitatively the ways marine communities respond to ecological stress. The internal responses are measured in terms of homeostasis; the external stresses result from temperature, salinity, competition, food and pollution.

The first phase of this investigation showed that the balances of free amino acids, fatty acids and blood constituents are sensitive indicators of environmental conditions. Relationships observed in nature between external stress and internal composition are now being analyzed in the laboratory. In addition, the genetic determinants of chemical specificity will be separated from environmental influences in copepods, mollusks and fishes.

When we know the minimum stress intensities and corresponding maximum internal tolerances within which normal community composition and function are maintained, we should be able to predict the fate of populations living under various conditions of water quality.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1057, THE INSECT ORDER PLECOPTERA AS A BIOLOGICAL INDEX OF FRESH WATER QUALITY IN RHODE ISLAND

T.W. KERR, Univ. of Rhode Island, School of Agriculture, *Kingston, Rhode Island* 02881

1. The insect order Plecoptera is an important element in the game fish food chain, in mosquito control, and its population density appears to be associated with the decomposition of certain types of organic matter. 2. A selected natural drainage system in Rhode Island will be studied for the purpose of determining the effect of industrial and sewage wastes, metal solutes, pH, water temperature, etc. on the population development of Plecoptera. 3. Eight sampling sites would be mapped in a stream where types of pollutants could be defined in four sites before and four sites after their discharge. 4. Sampling would be accomplished to quantify the various species of Plecoptera found. Concurrently, determination of the temperature, oxygen content, organic matter, free ions, pH, etc. of the water at each site would be taken. The 'quality' of the water would then be correlated with the number and species of Plecoptera present.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Rhode Island

5.1058, THE INSECT ORDER PLECOPTERA AS A BIOLOGICAL INDEX OF FRESH WATER QUALITY IN RHODE ISLAND

T.W. KERR, Univ. of Rhode Island, Agricultural Experiment Sta. , *Kingston, Rhode Island* 02881

Objective: To determine the degree of water 'pollution' on the presence of the insect order Plecoptera in a stream system in Rhode Island. he stream system will contain certain branches where type and degree of contaminants can be defined.

Procedure: Select and map 8 sampling sites in a stream system having several branches. The sites would be chosen at which water with defined type pollutants before (4) and after (4) discharge could be found. Sampling would be accomplished to quantify the species of Plecoptera present at each individual site. Concurrently, water samples

the percentage of organic matter, free ions, acids, etc. The 'quality' of the water including temperature/oxygen tension at each individual site would then be correlated with the number of species of Plecoptera nymphs present.

SUPPORTED BY Rhode Island State Government

5.1059, SENSITIVITY OF BENTHIC MICROFLORA TO POLLUTION GRADIENTS

N. MARSHALL, Univ. of Rhode Island, Graduate School, *Kingston, Rhode Island* 02881

Recent investigations show that the major share of the high productivity of shoal estuarine environments is due to the photosynthesis of the benthic microflora. This community, composed of one-celled forms, is probably quite vulnerable to pollution. We have developed a technique for assaying the productivity of this benthic community from the C-14 uptake, using small undisturbed samples. This program, based on such assays, has the following objectives:

(1) Continue to refine and verify the C-14 technique for assaying the productivity of the benthic microflora of undisturbed sediments.

(2) Establish with this technique the norms for three coastal areas that are free of pollution. These observations of norms are being conducted over a three-year period to establish satisfactory base lines. One site to be studied is adjacent to the Millstone Point Nuclear Power Plant and later will be affected by 10 degree F temp. increase and low-level radioactive input when the plant goes active (scheduled for 1969). The other two sites are nearby estuarine areas of Point Judith Pond and the Pettaquamscutt River.

(3) Investigate for a three-year period the effect of thermal change and domestic pollution on the productivity of the benthic microflora. This involves the Millstone site for thermal effects and the polluted Mystic River for effects of domestic pollution. The major microflora present and key ecological parameters are being determined for the observation sites.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1060, THE GAUZE PAD METHOD FOR THE ISOLATION OF VIRUSES FROM INLAND AND ESTUARINE WATERS

L.T. MILLER, Univ. of Rhode Island, School of Agriculture, *Kingston, Rhode Island* 02881

The bacterial flora of coastal and inland waters have been studied repeatedly, but information is very fragmentary concerning water pollution with human enteric viruses.

Phase 1. Evaluation and Development of Methodology. Under controlled laboratory conditions, water will be artificially polluted with known levels of enteric and other viruses. Experiments will be done to evaluate the adsorption capacity of various types of gauze pad as well as threads of synthetic fibers. Attempts will also be made to compare the elutability of virus from gauze pads of cotton and synthetic fibers in different buffers, namely phosphate, borate, tris, and others. Virus in these eluates will be concentrated by using the salts indicated above. A standard gauze pad technique will be developed for viral isolation in water and this will be used for the phase 2 study.

Phase 2. Field Investigation of Water Pollution. Samples will be collected periodically from selected areas in Rhode Island by using an appropriate standardized gauze pad technique developed in Phase 1. Attempts will be made to isolate their viral flora by inoculating the concentrates into a spectrum of cell cultures, suckling mice and avian embryos. Concommittantly, the waters for viral sampling will be tested for coliform MPN, E. Coli, and fecal streptococcal contents. The viral isolation results will be correlated with those of the bacterial indicator tests.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Rhode Island

5.1061, TURBULENT MIXING IN SURFACE AERATION

C.P. POON, Univ. of Rhode Island, School of Engineering, *Kingston, Rhode Island* 02881

Because of the low initial, operational and maintenance cost of mechanical surface aeration its use in stream aeration is considered economical. This work proposes to investigate the influence of turbulent mixing downstream from the aerator in aeration efficiency. Turbulent mixing entrains oxygen in an amount proportional to the intensity of turbulence and diffusion length. Fluorescent dye will be used in a tracer study with laboratory channel models to study the intensity of turbulence, eddy diffusivity and diffusion length. Important factors investigated will include (a) rotor submergence, (b) power input, (c) rate of stream flow and (d) refracted waves on the intensification of turbulent mixing.

SUPPORTED BY University of Rhode Island

5.1062, ANALYSIS OF TRACE ELEMENTS IN WATER

V.C. ROSE, Univ. of Rhode Island, School of Engineering, *Kingston, Rhode Island* 02881

Ion exchanger loaded filter paper techniques will be developed to rapidly concentrate trace metals in water samples. Analytical methods such as alpha, beta and gamma spectrometry, neutron activation and x-ray spectrography will be used for determining both radioactive and non-radioactive elements in the same sample.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Rhode Island

5.1063, COLLECTION AND ESTABLISHMENT IN CULTURE OF SPECIES AND STRAINS OF MARINE PHYTOPLANKTON ORGANISMS

T. SMAYDA, Univ. of Rhode Island, Graduate School, *Kingston, Rhode Island* 02881

The University of Rhode Island Graduate School of Oceanography shall supply a large number of species and strains of marine phytoplankton which should be at the disposal of the National Marine Water Quality Laboratory, at all times, so that various environmental, physiological, and toxicological tests can be accomplished. Cultures of the various species and strains shall also be made available to other FWPCA laboratories involved in pollution control activities for use in bioassays and other tests developed by NMWQL for the detection and evaluation of pollutants. The diversity of environmental requirements of phytoplankton necessitates the establishment of individual species and strains in culture.

Further, the contractor shall develop the mechanics of a system for obtaining these organisms so that the culture collection will become complete for the purpose at hand; shall develop an orderly arrangement for accession to the collection. The contractor shall also, scientifically identify each species and/or strain of phytoplankton by established procedures; utilize as the basis for the proposed collection, organisms already being maintained by the University Laboratory, NMWQL, and those available from academic institutions and research organizations. He must further provide the NMWQL with required data, and advise the NMWQL of the progress and status of the cultures and program as requested.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1064, BUOYANCY AND SINKING CHARACTERISTICS OF FRESHWATER PHYTOPLANKTON

T.J. SMAYDA, Univ. of Rhode Island, Graduate School, *Kingston, Rhode Island* 02881

The proposed research plans laboratory investigations of the sinking behavior of representative freshwater diatom and blue-green species occurring in the phytoplankton. It is directed towards understanding, predicting and controlling primary production, species periodicity and succession, algal blooms, and relevant lacustrine biogeochemical problems insofar as they are influenced by the sinking behavior of these plants. Following the establishment of the species into unialgal culture, the specific objectives employing several techniques are: 1. To determine the influence of cell size, cell age, cell shape, and colony size and mode of formation on limnetic phytoplankton sinking rates. 2. To determine the influnece of plant nutrients and inorganic and organic herbicides and inhibitors on sinking rates. 3. To determine the role of turbulence in the suspension of limnetic phytoplankters.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Rhode Island

5.1065, FLOCCULATION OF COLLOIDS WITH POLYELECTROLYTES IN AQUEOUS SALT SOLUTIONS

D.L. SUSSMAN, Univ. of Rhode Island, School of Engineering, *Kingston, Rhode Island* 02881

The aim of this project is to study the adsorption characteristics of polyelectrolytes in relation to the flocculation of colloidal and suspended matter in aqueous salt solutions, and to determine the factors that influence the adsorption equilibrium. The effects of the medium upon the polyelectrolytes will also have to be studied.

The study of the behavior of polyelectrolytes as flocculants in aqueous salt solutions would lead to the maximum effective utilization of the coagulation process in saline waters.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Rhode Island

5.1066, WATER QUALITY PROTECTION - SYNTHESIS OF POTENTIAL MOLLUSCICIDES

J.G. TURCOTTE, Univ. of Rhode Island, School of Pharmacy, *Kingston, Rhode Island* 02881

A number of hydroxy-L-proline derivatives having elements of structural similarity to the potent molluscicide, N-tritylmorpholine, will be synthesized and tested for potential molluscicidal activity against Australorbis glabratus, and intermediate host (pathogenic fresh water pollutant) of Schistosoma mansoni. The design of the derivatives features attempts to effect definite gradations in the water solubility and stability of the potential molluscicides. An attempt will be made, using sterochemical correlations, to determine whether or not the morpholine moiety of N-tritylmorpholine contributes significantly to the molluscicido-bioreceptor interaction in the snail (Australorbis glabratus).

SUPPORTED BY University of Rhode Island

5.1067, MODEL FOR DETERMINING THE MOST UNFAVORABLE CONDITIONS FOR AREA CLASSIFICATION

V.J. CABELLI, U.S. Dept. of Hlth. Ed. & Wel. , P.H.S. Marine Vir. Res. Ctr. , *Narraganset, Rhode Island*

Variable hydrographic, meteorological, and sanitary conditions modify the level of sanitary pollution reaching a shellfish growing area. To provide the required safety, the National Shellfish Sanitation Program requires that growing area classification be performed 'under the most unfavorable conditions (MUC)' that is, when conditions are most favorable for maximum pollution. Logistic factors associated with sampling and assay often limit the capabilities of States to determine the MUC. This project is intended to provide States with a 'modus operandi' consisting of, 1) a prediction based upon available information, 2) confirmation and, as required, modification of the prediction by a screening procedure using the ETCP method, and 3) actual sampling for classification using standard methods. Using Narragansett Bay, Rhode Island as a model area, the impact of day of week, time of day, and rainfall has been examined as a preliminary to this study. Rainfall, with its effect on runoff and sewage bypassing was found to be the major factor which must be considered. This project started in FY 1968; completion anticipated by FY 1969.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.1068, THE DEVELOPMENT OF OPERATIONAL SHELLFISH DEPURATION AND RELAYING SYSTEMS

V.J. CABELLI, U.S. Dept. of Hlth. Ed. & Wel. , P.H.S. Ne. Mar. Hlth. Sc. Lab. , *Narragansett, Rhode Island*

The feasibility of utilizing the normal feeding-cleansing mechanisms of molluscan shellfish for the removal of microbial pollutants (Depuration) is well established. However, in order to realize the full potential of the process in economically making a safe product available from that portion of the resource lost to pollution and as a second barrier to disease, the means must be found to 1) reduce the treatment period, 2) decrease the variability in animal response, 3) increase the upper limit of contamination in the animal which can be removed consistently, and 4) develop the economically more advantageous recirculating as opposed to flow-through systems.

Certain factors affecting contamination levels and depuration are being studied: 1) the initial level, 2) natural vs. artificial levels, 3) 'thermal shock,' which limits depuration of coliforms from quahaugs, and 4) chemical and physical stimuli for depuration. Completion is anticipated on the: 1) examination of uptake and elimination of Salmonella typhimurium by the quahaug, 2) model system for comparing indicator to pathogen uptake and elimination, and 3) development of operational recirculating depuration systems for the quahaug and softshell clam. The development and evaluation of 'two-stage' rafting- depuration system is underway from the depuration of grossly polluted quahaugs. Chemical studies continue on the mechanism and site of trace metal retention by shellfish towards development of: 1) relaying schedules for chemically-contaminated shellfish, and 2) operational depuration.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.1069, STUDY OF GROWING AREA STANDARD BY EXAMINING ENTEROPATHOGENS AND INDICATOR

V.J. CABELLI, U.S. Dept. of Hlth. Ed. & Wel. , P.H.S. Ne. Mar. Hlth. Sc. Lab. , *Narragansett, Rhode Island*

The microbiological standard for shellfish growing waters (median coliform MPN is less than 70/100ml)assumes that the probability of enteric infection from the consumption of shellfish taken from the area is negligible. Validity of correlation of the coliform indicator with outbreaks and sporadic cases of infectious hepatitis associated with the consumption of shellfish is being examined by determining the relationship of indicator levels to enteropathogenic viruses and bacteria in selected shellfish growing areas through 1) correlation of frequency of isolation of enteric viruses and Salmonella sp. to coliforn, fecal coliform and ET coliform levels; 2) longitudinal survey of estuaries and shellfish for presence of human enteric viruses; 3) comparative survival of coliforms, Salmonella species, and viruses in seawater; and 4) sanitary significance of members of the coliform group. Various enteric viruses were isolated from two species of shellfish and the overlying waters in a preliminary study conducted in the Pawcatuck River, Rhode Island. A rapid plating method for enumerating coliform capable of growth at an elevated temperature (ET coliform) has been developed and evaluated at three locations.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.1070, THE ECOLOGY OF CLOSTRIDIUM BOTULINUM TYPE E

V.J. CABELLI, U.S. Dept. of Hlth. Ed. & Wel. , P.H.S. Ne. Mar. Hlth. Sc. Lab. , *Narragansett, Rhode Island*

This project, whose major objective is a better understanding of the ecology of C. botulinum type E in the estuarine environment, includes studies on the biological control of toxin production by the organisms and genetic, serologic and physiologic studies on the organisms, particularly as they are significant to the taxonomic and ecologic relationship of C. botulinum to the so-called E-like organisms. This project was started in FY 1964 and it is anticipated it will be completed by June 1970.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.1071, STUDY ON METHODOLOGY FOR VIRAL EXAMINATION OF SEAWATER AND SHELLFISH

O.C. LIU, U.S. Dept. of Hlth. Ed. & Wel. , P.H.S. Ne. Mar. Hlth. Sc. Lab. , *Narragansett, Rhode Island*

Although epidemologic evidence indicates that the marine environment is polluted with human viral pathogens, no satisfactory methods are available to isolate the various types of enteroviruses in the marine waters and their fauna, especially shellfish which are consumed raw. At least eight procedures, described recently for isolation of low levels of virus from fresh waters, can be applied to examination of marine waters. These methods will be evaluated for their efficacy in recovery and enumeration of the virus in seawaters. Then the most simple and effective method will be standardized for widespread use to achieve this purpose. There is a paucity of information on methodology for viral examination of shellfish, except that described by Metcalf and Stiles (1965) and that used in this Laboratory. Four new approaches will be tried for examining very low viral contents in these animals; the best procedure will be standardized. Project started in FY 1969 and it is anticipated will be completed in FY 1972.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.1072, MARINE BIOTOXINS

B.H. PRINGLE, U.S. Dept. of Hlth. Ed. & Wel. , P.H.S. Ne. Mar. Hlth. Sc. Lab. , *Narragansett, Rhode Island*

Neither the number of known marine biotoxins nor the incidence of associated disease is great; however, with increased use of the marine environment as a source of food and recreation, the importance and number of these toxins as a health problem will increase. Study of Paralytic Shellfish Poison, a compound of both economic and scientific interest, is hampered by lack of a convenient and accurate method of analysis. Since shellfish apparently are not affected by PSP, although it is concentrated within them several thousandfold over maximum levels of the poison-producing organisms in the marine environment, we plan to introduce the poison directly into their circulatory systems to determine its overall effect. The relationship between effects of natural blooms of the dinoflagellates Gonyaulax catenella and G. tamarensis and the toxin (PSP) on the microflora of the water mass are unknown; it would be useful to know whether or not PSP has antimicrobial activity. Indeed, if the effect of PSP on a variety of microorganisms could be determined and its spectrum elucidated, it would be a significant contribution towards future ecological studies and it might provide an alternative assay method for PSP.

It is planned to attempt development of a suitable method for the quantification of PSP making use of chromatographic techniques. In addition, an investigation of the mechanics of uptake and the site of deposition of PSP in the mollusk will be made. Finally, a study of its biological effects other than its toxic properties will be initiated.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.1073, RELATIONSHIP OF THE SOURCE TO LEVELS OF TOXIC CHEMICALS IN SHELLFISH

B.H. PRINGLE, U.S. Dept. of Hlth. Ed. & Wel. , P.H.S. Ne. Mar. Hlth. Sc. Lab. , *Narragansett, Rhode Island*

Since 1964, we have been collecting and analyzing shellfish from the Atlantic Coast between Maine and North Carolina.. The analyses, except for special studies, have been confined to detecting heavy metals in commercial bivalve species; these shellfish selectively concentrate in their tissues chemicals from their environment. Much variation was discovered in the amounts and types of metals found in shellfish from different areas, however, little documented information was available for comparison with these differences. To bridge this gap, literature relevant to toxic chemical wastes produced along the coast will be reviewed, followed by contact with state agencies to obtain more detailed information. Such data, on the industrial complexes and their toxic chemical wastes, should provide an overview of the prevailing conditions to which shellfish are subjected and round-out information required for further development and review of toxic chemical standards for shellfish.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.1074, TOXIC AND OTHER CHEMICALS IN MARINE BIOTA

B.H. PRINGLE, U.S. Dept. of Hlth. Ed. & Wel. , P.H.S. Ne. Mar. Hlth. Sc. Lab. , *Narragansett, Rhode Island*

The mechanics of concentration of toxic and other chemical materials are under investigation and may be categorized as follows:

I. Uptake and concentration within the natural environment. II Determination of the uptake rates and concentration within a simulated natural environment. III Investigation of anatomical areas of storage. IV. Depletion rates in a simulated natural system.

Under the above categories our efforts are directed toward studies involving the uptake rates and concentration levels for selected trace metals under various conditions of salinity, temperature, and dissolved oxygen, which we might expect to be found under natural environmental conditions. Commensurate studies are being carried out within a simulated 'natural' environment using various concentrations of selected trace-metals. Anatomical areas of storage of trace-metals are being investigated for certain mollusks using a simulated 'natural' environmental system. In addition, depletion rates for certain of these materials are being determined in an environment free from pollution by these materials.

In addition to the above studies in the subject area the following related projects are presently under investigation. Instrumental methods for the quantitation of 'Dibrom,' 'Diquat' and 'Paraquat' are being developed or adapted for use with shellfish samples. Assay methods of fluorides in shellfish are being investigated. Methodology for the isolation and quantitation of Paralytic Shellfish Poison is being investigated.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.1075, GENERAL TECHNICAL ASSISTANCE

C.N. SHUSTER, U.S. Dept. of Hlth. Ed. & Wel. , P.H.S. Ne. Mar. Hlth. Sc. Lab. , *Narragansett, Rhode Island*

To support the goals of the National Shellfish Sanitation Program as updated in part by the 1968 Workshop by: 1) adapting, testing, and processing the research findings for ultimate program operations; 2) conducting field research studies; 3) assisting in the design of laboratory-based field surveys including direct service in sample collection and preparation for research; 4) providing design guidance for facility and equipment needs, and 5) consultation to Headquarters, Regions, States, etc. dealing with technical program operations. Based on need, objectives include pursuit of on-going Field Research and Development studies, initiation and expansion of some efforts in relatively new fields. Assistance in the areas of training, consultation on enforcement activities (P.L. 84-660), application of depuration, intramural field research, and laboratory appraisals will be given. This is a continuing project started in FY 1964 and will continue in accordance with the needs of the overall programs.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.1076, EFFECT OF THE EFFLUENT FROM AN ATOMIC POWER PLANT ON THE ADJACENT PORTION OF BARNEGAT BAY, NEW JERSEY

J.L. VERBER, U.S. Dept. of Hlth. Ed. & Wel. , P.H.S. Ne. Mar. Hlth. Sc. Lab. , *Narragansett, Rhode Island*

The purpose of the project is to investigate and monitor certain aspects of an estuarine environment before and after the activation of an atomic power plant.

Through survey work baseline information will be collected to determine the normal physical and biological regime of Barnegat Bay and adjacent water courses. The survey work will be quarterly operations over years to determine the annual and seasonal variations. Survey work will continue after the reactor becomes operational in order to determine the effects of thermal pollution on the previous ecological baseline of the Bay.

Studies will include monitoring of the shellfish resource, temperature variations, salinity, collection of shellfish meats for radioactive background data, tidal fluctuations, circulation patterns and gross plankton samples. Other studies will be made that are believed necessary due to changes in the environment or unusual circumstance.

Close cooperation will be maintained with other agencies maintaining operational programs in the area. Background data of pre- reactor conditions will be collected for analysis conditions.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.1077, A STUDY OF SUSPECTED LEAD POISONING OF SWANS AND GEESE

M. PERRY, State Div. of Conservation, *Providence, Rhode Island*

Objectives: 1. To determine if lead shot is present in sediments of Easton Pond. 2. To determine the concentration of lead in the liver, tibia, and blood of all swan. 3. To determine if acid-fast intranuclear inclusion bodies are present in kidney tissue of all swan. 4. To study the feeding behavior of swans and geese on and near Easton Pond.

Procedures: 1. Sediment samples will be taken at random throughout Easton Pond in Newport, R. I. and analysed for lead shot contents. 2. All dead swans and geese will be collected and necropsied. Gizzards will be examined for lead shot. Blood, liver and tibia samples will be taken and lead concentrations in parts per million will be determined by use of an Atomic Absorption Spectrophotometer. Technique to be used will be similar to that described in 'Analytical Methods for Atomic Absorption spectrophotometry,' Perkin-Elmer, Norwalk, Connecticut. 3. Kidney tissue from all dead swans and geese will be examined to determine if acid-fast intranuclear inclusion bodies are present (Lock, Bagley, Irby 1966. Bull. Wildlife Disease Assoc. 2:127-131). 4. A comparison of lead concentrations will be made between birds at Easton Pond and resident birds from another part of the state.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Rhode Island State Government

5.1078, STORM SEWER TREATMENT BY A SELF-CLEANING STRAINER, FILTER CONCEPT

S.S. BLECHARCZYK, Fram Corporation, *Providence - East Providence, Rhode Island* 02916

The purpose of this study is to evaluate the self-cleaning strainer, filter concept for effective pollution reduction of combined sewer overflows.

It is intended to: 1. Determine the rate and nature of pollution experienced at a typical combined sewer overflow. 2. Determine screen construction most effective, with and without coagulants. 3. Determine the effectiveness of various septa and diatomaceous earth materials in removing pollutants from the strainer effluent.

The variables involved in the filtration concept will be investigated by bench tests using small area test fixtures and actual storm sewer samples. The effectiveness of continuous back-washing on screen plugging and water content of the filtered solids will be studied.

A number of adsorbents and coagulants will be used in conjunction with the two devices.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1079, REARING AND SENSITIVITY STUDIES OF VARIOUS LIFE STAGES OF MARINE MACROINVERTEBRATES

G. MORRISON, U.S. Dept. of Interior, Natl. Marine Water Qual. Lab. , *Wakefield - Kingston, Rhode Island* 02881

The goal of this project is to determine the relative sensitivity of various stages of marine macroinvertebrates to specific materials and the evaluation of marine invertebrates as indicators of extreme levels of known toxicants over extended periods.

This work will eventually be incorporated in broader areas of research to determine the effects of these toxicants upon growth, reproduction, activity, metabolism, and the activity of hormones and enzymes.

The organisms studied to date are the first larval stages of Callinectes sapidus, Carcinus maenas, Uca pugilator (?), and Palaemonetes pugio and their reaction to various levels of copper.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1080, HISTOPATHOLOGIC EFFECTS OF POLLUTANTS ON CELLS AND TISSUES OF MARINE FISHES

P.P. YEVICH, U.S. Dept. of Interior, Natl. Marine Water Qual. Lab. , ***Wakefield - Kingston, Rhode Island*** 02881

Histopathologic studies will be conducted on various species of marine fishes after exposure to pollutants. Studies presently are being conducted on mummichogs being exposed to Cd and Pb.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1081, HISTOPATHOLOGIC EFFECTS OF POLLUTANTS ON CELLS AND TISSUES OF MARINE INVERTEBRATES

P.P. YEVICH, U.S. Dept. of Interior, Natl. Marine Water Qual. Lab. , ***Wakefield - Kingston, Rhode Island*** 02881

Histopathologic studies will be conducted on various species of marine invertebrates: quahogs, soft shell clams, oysters, lobsters, shrimp, blue crab, etc. after exposure to various pollutants. Studies are presently being conducted in cooperation with the Northeast Marine Health Sciences Laboratory on quahogs (Mercenaria mercenaria) which have been exposed to 0.05 and 0.025 ppm of Cu, 0.2 ppm of Zn, 0.2 and 0.1 ppm of Cd and 0.05 and 0.1 ppm of Cr.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1082, EFFECTS OF CRUDE OILS AND THEIR EMULSIONS TO MARINE ORGANISMS

R. EISLER, U.S. Dept. of Interior, Natl. Marine Water Qual. Lab. , ***West Kingston, Rhode Island*** 02892

Oil discharges at sea, especially accidental discharges by super- tankers, represent a potential threat to aquatic life. Laboratory bioassays on the acute toxicity of different grades of crude to various species of marine fishes and crustaceans are now in progress. The effect on toxicity of emulsifying or complexing the oil with various chemical agents is being investigated.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1083, PHARMACOLOGY OF METAL POISONING IN ESTUARINE FISHES

R. EISLER, U.S. Dept. of Interior, Natl. Marine Water Qual. Lab. , ***West Kingston, Rhode Island*** 02892

Pilot bioassays were conducted under laboratory conditons with mummichogs, Fundulus heteroclitus, against various metals abundant in solid wastes dumped off shore. Analyses by atomic absorption, and other methods, of mummichogs that died during exposure to high concentrations demonstrate measurable changes in elementary chemical composition. Tissues from fishes surviving sublethal exposures were also significantly different from controls in levels of one or more of the 25 metals measured The significance of these changes in terms of enviormental stress and metabolic pathways is being studied.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1084, COMPARATIVE TOXICITIES OF METALS TO ESTUARINE FISHES

R. EISLER, U.S. Dept. of Interior, Natl. Marine Water Qual. Lab. , ***West Kingston, Rhode Island*** 02892

Disposal of solid wastes at sea is being practiced by an increasing number of municipalities. Prelimianry analysis of incompletely-ashed incinerator wastes by atomic adsorption indicates that aluminum, iron, calcium, zinc, sodium,, potassium, and lead--in that order--are most abundant. Short-term bioassays with inorganic salts of these and other metals to the mummichog, Fundulus heteroclitus, are being conducted under controlled environmental conditions. Relationships between mortality, physical-chemical environment, and concentration of test metal in solution is being investigated.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1085, EFFECT OF NITRILOTRIACETIC ACID (NTA) UPON THE TOXICITY OF METALS TO SELECTED SPECIES OF ESTUARINE PHYTOPLANKTON

S.J. ERICKSON, U.S. Dept. of Interior, Natl. Marine Water Qual. Lab. , ***West Kingston, Rhode Island*** 02892

Laboratory studies will be conducted to determine the relationship of nitrilotriacetic acid (NTA), a metal chelator, to the toxicity of metals to selected species of estuarine phytoplankton. The metals employed in this study will be those which are known metabolic toxins and are of importance from the standpoint of estuarine pollution.

The toxicity of the various metals to six species of phytoplankton will be determined in the presence of several concentrations of NTA. In addition to growth rate, C14 labeled carbon dioxide will also be employed as a parameter for determining levels of metal toxicity.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1086, EFFECTS OF PETROLEUM AND PETROLEUM WASTES UPON IMPORTANT SPECIES OF ESTUARINE PHYTOPLANKTON AND ZOOPLANKTON

J.H. GENTILE, U.S. Dept. of Interior, Natl. Marine Water Qual. Lab. , ***West Kingston, Rhode Island*** 02892

The effects of petroleum and petroleum wastes upon important species of estuarine phytoplankton and zooplankton will be assessed. Assays on zooplankton will employ acute toxicity to various stages in the organisms' life history as the principal parameters. Assays on phytoplankton will involve the effects of pollutants on growth, photosynthesis, and respiration as well as mechanical effects such as cell lysis. Comparative toxicity of different types of petroleum products will be investigated.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1087, INTEGRATED FIELD AND LABORATORY SYSTEM FOR ASSAYING THE EFFECTS OF POLLUTANTS AND TOXICANTS UPON WATER QUALITY

J.H. GENTILE, U.S. Dept. of Interior, Natl. Marine Water Qual. Lab. , ***West Kingston, Rhode Island*** 02892

The purpose of this project is to investigate the effects of pollutants and toxicants on natural populations of marine phytoplankton as well as on axenic cultures of selected species comprising these populations. Assays will be performed in natural and defined seawaters in such combinations as to obtain a continuum of responses. Laboratory cultures will be designed to simulate field condtions. Measurement of photosynthesis and respiration rates using radioactive carbon will be the principal technique employed and will be correlated with long- term growth studies.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1088, DEVELOPMENT OF A METHOD FOR CHRONIC TOXICITY BIOASSAY USING MARINE PLANKTONIC ALGAE

C.S. HEGRE, U.S. Dept. of Interior, Natl. Marine Water Qual. Lab. , ***West Kingston, Rhode Island*** 02892

Objectives: To develop a method which will permit exposure of algal populations to constant low levels of test compounds, as well as monitoring of population dynamics or metabolic effects.

Procedures: 1. 2. Normal population dynamics and optimal medium exchange rates will be determined. 3. The utility of the apparatus will be tested by determining minimal requirements for a few known nutrients.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1089, STUDY OF NITROGEN METABOLISM IN MARINE ALGAE

C.S. HEGRE, U.S. Dept. of Interior, Natl. Marine Water Qual. Lab. , ***West Kingston, Rhode Island*** 02892

Objectives: To develop a method based on in vivo enzymatic activity which can be used as a bioassay parameter in determining the biological effects of potential pollutants.

Procedures: 1. An in vivo system for the assay of nitrite reductase activity in marine algae has been established. 2. Environmental factors which influence the expression of nitrite reductase activity will be investigated. 3. Cells preexposed to test compounds will be assayed for nitrite reductase activity. The results of such studies will be compared as indicators of biological effect with those of similar studies in which growth is measured.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1090, MEASUREMENT OF THE RATE OF CARBON DIOXIDE (C14) FIXATION INTO SUBCELLULAR FRACTIONS OF ALGAE

C.S. HEGRE, U.S. Dept. of Interior, Natl. Marine Water Qual. Lab., *West Kingston, Rhode Island* 02892

Objectives: To develop a rapid and sensitive method for detecting the metabolic effects of potential pollutants on cultures of marine algae.

Procedures: 1. Existing procedures for fractionating cells into classes of chemical constituents are being modified to permit processing of many small samples of algae. 2. Optimal labelling conditions and normal incorporation rates will be determined for each fraction. 3. Cultures preexposed to test substances will be allowed to fix Carbon- 14 labeled CO2. The cells will then be fractionated, and rates of synthesis of each fraction will then be determined from isotope incorporation data. Results will be correlated with those of similar studies using growth rate as the measure of biological effect.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1091, EFFECT OF METAL POISONING ON VARIOUS ENZYMES IN FISH

E. JACKIM, U.S. Dept. of Interior, Natl. Marine Water Qual. Lab., *West Kingston, Rhode Island* 02892

The present phase of the work is a study on the effects of various metals on the ATPase enzymes; namely the Na plus K dependent moiety (ouabain sensitive) and the Na plus K non-sensitive ATPase. ATPase was chosen because the metal requirements for these enzymes are very specific and because of previous evidence that they are poisoned by sulfhydrvl inhibitors. We believe that this enzyme might be involved in heavy metal toxicity and may be an indicator of chronic metal poisioning. The study is divided into two parts. The first was to observe the effects of adding various metal salts to partially purified enzyme preparations and determining the changes in activity. The second phase consists of exposing living killifish to heavy metals and determining any changes in the enzyme activity of several different tissues. The results of the first phase of the study indicate that the ouabain sensitive ATPase is very sensitive to some of the metals. One ten-thousandth M lead, mercury, cadmium and iron will produce a 90%-100% inhibition.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1092, HEMATOLOGICAL CHANGES IN F. HETEROCLITUS UPON EXPOSURE TO TOXIC METALS

E. JACKIM, U.S. Dept. of Interior, Natl. Marine Water Qual. Lab., *West Kingston, Rhode Island* 02892

Killifish are exposed to various toxic metals for 96-hr. and 30- days periods. The fish are killed and hematological tests conducted to observe and change in the differential blood count. Hematocrit and blood cell morphology are also compared to that of control fish. Normal seasonal, sex and size variations are also correlated to changes in the blood pricture. Cadmium and lead are now under investigation. Cadmium shows a marked eosionphilia while the effects of lead are more subtle. Cadium also appears to increase the hemoglobin and hematocrits in F. heteroclitus.

The blood morphology in other species of salt water fish is also being studied.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1093, USE OF MARINE PLANKTONIC ORGANISMS FOR EVALUATING THE QUALITY OF MARINE AND ESTUARINE WATERS

T.E. MALONEY, U.S. Dept. of Interior, Natl. Marine Water Qual. Lab., *West Kingston, Rhode Island* 02892

This project is concerned with the development of bioassay methods and techniques, employing various species of marine phytoplankton and zooplankton, for determining the toxicity and identity of pollutants in the marine environment and for determining and predicting the short- and long-term effects of lethal and sublethal concentrations of pollutants upon planktonic organisms and other organisms in the marine environment.

The test species will include those which are ecologically important and, in the case of zooplankton, their various life stages.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1094, DETERMINATION OF SELECTED ENVIRONMENTAL REQUIREMENTS OF IMPORTANT MARINE PHYTOPLANKTON SPECIES

J.C. PRAGER, U.S. Dept. of Interior, Natl. Marine Water Qual. Lab., *West Kingston, Rhode Island* 02892

Studies have been initited to determine minima, optima, and maxima of selected physical and chemical requirements of four ecologically and economically improtant species of unicellular marine algae. Requirements considered in this program are nitrogen, phosphorus, sulfur, and silicon; also temperature, light, major cations, and redox. Methods used on axenic cultures in synthetic seawater media are growth studies, radioisotopic tracer techniques, chemostatic culture and continuous culture techniques, and various physical mehtods of measuring environmental changes. Species studied are Skeletonema costatum, Olisthodiscus luteus, Nanochloris oculata, and Dunaliella tertiolecta.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1095, THE NORMAL ANATOMY AND HISTOLOGY OF SOME MARINE INVERTEBRATES

J.H. TUCKER, U.S. Dept. of Interior, Natl. Marine Water Qual. Lab., *West Kingston, Rhode Island* 02892

Initial literature studies of the anatomy and histology of some of the important marine invertebrates indicated that 'wide gaps' appear in the literature concerning the normal histology of some of these species. The purpose of this study is to fill in these 'gaps' and compile the information of a monograph.

The species under study at the present time are the quahog, Mercenaria mercenaria, and the soft shell clam, Mya arenaria. Other species to be studied are Homarus americanus, Mytilus edulis, Crassostrea virginica and other species which may be utilized in pollution studies.

Preparation of histological sections utilizing routine and special fixation and staining techniques are in progress and photomicrographic records of the information obtained are being compiled. Special techniques such as histochemistry and fluorescence microscopy are to be utilized.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1096, DEVELOPMENT OF CULTURE METHODS FOR ECOLOGICALLY IMPORTANT MARINE ZOOPLANKTON SPECIES

E.J. ZILLIOUX, U.S. Dept. of Interior, Natl. Marine Water Qual. Lab., *West Kingston, Rhode Island* 02892

Methods to culture large numbers of individuals of Acartia tonsa, A Clausi, Pseudodiaptomus coronatus, Tisbe furcata, Calanus sp., and Tigriopus californicus are being devised and tested in conjuction with another project concerned with enviornmental requirements of these species. Desiderata are the production of large numbers of individuals in a minimal volume of medium, sucessful completion of life cycles through several generations, elimination of undefined chemical compounds from the medium, simplicity of apparatus, definition of food materials, and ability to operate on a continuous basis.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1097, DETERMINATION OF SELECTED ENVIRONMENTAL REQUIREMENTS OF IMPORTANT SPECIES OF MARINE ZOOPLANKTON

E.J. ZILLIOUX, U.S. Dept. of Interior, Natl. Marine Water Qual. Lab. , *West Kingston, Rhode Island* 02892

Acartia tonsa, A. clausi, Pseudodiapatomus coronatus, Calanus sp., Tisbe furcata, and Tigropus californicus are undergoing experimentation to determine optimal conditons of temperature, salinity, oxygen saturation, and food materials for sucessful completion of their life cycles. Organisms are cultured and subcultured in the laboratory under small volume, static conditions. End points and condition of cultures are determined by microscopic examination of life cycle progress, in some experiments using time-lapse photography.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1098, RADIONUCLIDES IN THE SAVANNAH RIVER ESTUARY AND ADJACENT COASTAL WATERS

C.M. PATTERSON, U.S. Atomic Energy Commission, Savannah River Plant & Labs. , *Aiken, South Carolina*

Small amounts of radionuclides are released to the Savannah River by the Savannah River Plant 170 miles from the Atlantic Ocean. The distribution of radionuclides in the river's estuary and in adjacent coastal waters is being determined. Effects of water exchange between the estuary and ocean, sedimentation and other physical and chemical factors influencing dilution and distribution will be studied. The coastal waters are being analyzed for tritium, 90Sr and 137Cs. Sediments are being analyzed for 90Sr and 137Cs.

SUPPORTED BY U.S. Atomic Energy Commission

5.1099, RADIONUCLIDE MOVEMENT IN GROUNDWATER

C.M. PATTERSON, U.S. Atomic Energy Commission, Savannah River Plant & Labs. , *Aiken, South Carolina*

Large volumes of very low level radioactive wastes are discharged to earthen seepage basins. We are studying both the horizontal and vertical distribution of radionuclides in the groundwater between earth seepage basins and the nearest flowing stream. The flow path to the creek has been defined using the tritium in the waste as a tracer. Other than tritium only 90 Sr has migrated from the basins. Wells will be screened at various depths below the water table to determine the vertical distribution of radionuclides in the groundwater.

SUPPORTED BY U.S. Atomic Energy Commission

5.1100, IMPROVED DETECTION TECHNIQUES TO DETERMINE RADIONUCLIDES IN FRESH AND SEA WATER

C.M. PATTERSON, U.S. Atomic Energy Commission, Savannah River Plant & Labs. , *Aiken, South Carolina*

New sensitive radiochemical methods are being developed to qualitatively and quantitatively determine radionuclides in fresh and sea water. Trolled mixed resin ion exchange canisters have been successfully tested for rapid concentration of radionuclides in both fresh and saline water. Ammonium hexacyanocobalt ferrate, an inorganic ion exchanger, has been shown to be useful in the determination of radiocesium in water. A multiparameter programmed gamma analyzer, which will increase sensitivity by a factor of 100 will be constructed this year.

SUPPORTED BY U.S. Atomic Energy Commission

5.1101, CHARTING OF SUBTIDAL OYSTER BEDS AND EXPERIMENTAL TRANSPLANTING OF SEED OYSTERS FROM POLLUTED SEED OYSTER BEDS

G.R. LUNZ, State Div. of Comm. Fisheries, *Charleston, South Carolina* 29401

The South Carolina oyster industry is based almost entirely on intertidal oysters, yet subtidal beds do exist. Two such beds are known to produce more seed per unit of area than the famous James River, Virginia, seed beds. In the past, attempts to expand the growth of oysters subtidally have not been entirely successful. However, by locating areas with comparable environmental conditions to existing deep water beds, and by transplanting deep water seed to them, an attempt will be made to demonstrate a way to expand the industry.

Exploration for deep water growing sites in the more than 3200 miles of creeks and rivers within the State will begin as soon as the project can be activated. Several hundred bushels of seed oysters from the Wando and the Santee Rivers (existing deep water beds) will be moved to the new locations. Survival, growth, and quality of these transplanted oysters will be studied by regular sampling.

Continuing the program next fiscal year, larger amounts of oysters will be moved to test the possibility of introducing a system of oyster culture not now being practiced.

A two man team, yet to be employed, will conduct the survey. The entire project will be under the supervision of Bears Bluff Laboratories.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.
South Carolina State Government

5.1102, RESERVOIR WATER QUALITY PREDICTION BASED ON LIMNOLOGICAL PARAMETERS

A.R. ABERNATHY, Clemson University, School of Engineering, *Clemson, South Carolina* 29631

A restricted portion of Hartwell Reservoir will be studied by use of current limnological techniques to determine present water quality, primary productivity, and nutrient budget. A model will be proposed to describe the current conditions and predict ecological effects and changes in water quality resulting from a change in nutrinet budget.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
South Carolina State Government
Clemson University

5.1103, KINETICS OF BIOLOGICAL FILTERS

J.F. ANDREWS, Clemson University, School of Engineering, *Clemson, South Carolina* 29631

Since the trickling filter is an aerobic biological treatment process which depends upon the action of attached microorganisms for the removal of organic waste products, the overall process may be represented by the simplified reaction equation: ORGANISMS SUBSTRATE OXYGEN yields NEW CELLS METABOLIC WASTE PRODUCTS.

It is the objective of this research project to study the kinetics of biological filters by observing the influence of the three reactants on the rate of removal of organic products by attached microorganisms and use this data to evaluate a proposed mathematical model for trickling filters. In view of the fact that the microbial population of a trickling filter is responsible for the removal of organic waste products, it should be possible to express this removal in terms of microbial growth kinetics.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1104, WASTE DISPOSAL FROM FOOD PROCESSING PLANTS IN SOUTH CAROLINA

J.R. LAMBERT, Clemson University, Agricultural Experiment Sta. , *Clemson, South Carolina* 29631

The objective of this master project which is concerned with water resources is to determine the effectiveness of the soil mantle for purification of waste water from food processing plants. This will be done by studying the effect of the application of waste water on the hydrologic conductivity of the soil, and by studying the effects of various waste disposal application treatments on the quality of downstream flow. The interrelationships of engineering, agronomic, microbiological, meteorological, and climatic factors required for proper design and operation of an efficient and safe system for distributing waste on the surface of South Carolina soils will also be determined. Waster water from a pilot food processing plant will be applied at different application rates and intervals to lysimeters constructed of undisturbed soil with various vegetative covers and the quantity and quality of seepage will be measured. Lysimeters containing disturbed soil will be used to study the effects of soil properties, soil depth, and rate of application of the waste water on composition of the percolate from the soil and the effects of the waste on the physical and chemical properties of the soil.

SUPPORTED BY South Carolina State Government

5.1105, THE USE OF TAXES, SUBSIDIES, AND REGULATIONS TO CONTROL THE EFFLUENT OF THE TEXTILE INDUSTRY

H.H. MACAULAY, Clemson University, Graduate School, *Clemson, South Carolina* 29631

The purpose of the project will be to determine the differential effects of taxes, subsidies, and regulations on the use of water and the discharge of effluent by the textile industry. More specific objectives will be: 1. To estimate the economic values of nonmarket uses of water downstream from certain textile mills. 2. To determine the difference in economic results that stem from (a) regulations imposing higher stream standards, (b) a system of user charges or taxes, and (c) a system of subsidies. 3. To determine if a tax subsidy given at the local level (primarily by exemption from property taxes) differs in principle from a tax subsidy given at the national level (primarily by special deductions under the income tax). 4. To assess the difference in economic impact of higher stream standards on old mills and on new mills. 5. To estimate how the cost of cleaning up the effluent from the textile industry may affect the methods of processing textiles or lead to the development of new technology.

A theoretical model to provide for the optimum use of the resource will be constructed. An attempt will then be made to gather data which will make it possible to apply the model to the textile industry. Assumptions as to differences in taxes, subsidies, and regulations will be made to see how the use of water and the operation of the textile industry are changed by each of these conditions.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Clemson University

5.1106, THE REMOVAL OF IMPURITIES IN TRICKLING FILTER EFFLUENTS

W.M. MCLELLON, Clemson University, School of Engineering, *Clemson, South Carolina* 29631

Over the past ten years application of electrophoretic mobility measurements in control of water treatment processes has been investigated by Black and associates and Riddick, primarily, under various conditions using natural or synthetic waters. It is considered materially in improving efficiency of removal of impurities in both secondary and tertiary waste treatment.

It is planned, as a first step, to examine the colloidal properties of the particulates in a trickling filter effluent, using the effluent from Clemson University waste treatment plant, both before and after passage through the final clarifier. This plant discharges to a large impoundment which is used for water supply and recreation. Investigation of the chemical properties of the waste from the sampling points will be a necessary adjunct to the electrophoretic mobility measurements and microscopic examination of the particulates. Initial work will be extended to include treatment of the trickling filter effluent using coagulants, such as ferric sulfate, and further investigation of the colloidal properties, to obtain information on the conditions for optimum removal of impurities, along with the use of zeta potential as a control process in treatment.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Clemson University
South Carolina State Government

5.1107, INTERACTION OF PESTICIDE POLLUTANTS AND AQUATIC FOOD-CHAIN ORGANISMS

J.K. REED, Clemson University, Graduate School, *Clemson, South Carolina* 29631

This research project plans a field project to determine the distribution of DDT in one area of Lake Hartwell which is contaminated with DDT at a moderate level. The concentrations of DDT in water, plankton, fishes, benthos, and the substrate will be used to estimate the portion of DDT residing in each component of the environment. Samples of water and organisms from near the surface to near the bottom, plus bottom mud will be analyzed chemically for DDT content. The sampling will be distributed throughout a year.

A laboratory component of the study will be to assess the principal route of entry of DDT into an aquatic consumer organism (integument vs. food chain). Fish will be administered a dosage of DDT in food and an equivalent dosage in water, then by both routes at the same time. Chemical analysis by chromatography plus radiometric determination of labelled DDT will be used to indicate the importance of each route of entry, both separately and in combination.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Clemson University
South Carolina State Government

5.1108, HYDROLOGY OF THE SAVANNAH RIVER PLANT, SOUTH CAROLINA --BEDROCK WASTE STORAGE EXPLORATION - HYDROLOGY OF COASTAL PLAIN SEDIMENTS (ABBREV)

I.W. MARINE, U.S. Dept. of Interior, Water Resources Division, *Columbia, South Carolina*

Objectives are to define and delineate aquifers in the Coastal Plain sediments and within the first 1,000 feet of crystalline rock below the Coastal Plain sediments, to determine the hydrologic characteristics of the rock aquifers and Coastal Plain aquifers, and to evaluate the possibility of upward leakage of water within the sediments.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

5.1109, GROUND WATER CONTAMINATION RESULTING FROM WASTE DISPOSAL

J.R. ANDERSEN, South Dakota State University, School of Engineering, *Brookings, South Dakota* 57007

Representative waste disposal methods in South Dakota including land disposal of liquid and solid wastes will be investigated to determine: 1. A recommended procedure for selection of waste disposal sites in order to minimize ground water contamination problems. 2. The effects of waste disposal practices including: a. The nature and extent of ground water contamination. b. The effect of ground water contamination on proposed beneficial uses. c. The influence of such factors as climatic conditions, soil types and waste characteristics on the degree and extent of travel of pollutants.. 3. A means of combatting undesirable contamination of the ground water.

It is also proposed that the project will investigate the long term effects of solid waste landfill on ground water quality in an area where adequate background data have been collected to observe the initial influence.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
South Dakota State University

5.1110, ZOOPLANKTON STANDING CROPS IN A SOUTH DAKOTA PRAIRIE LAKE

R.L. APPLEGATE, South Dakota State University, School of Agriculture, *Brookings, South Dakota* 57007

Zooplankton composition and quantity in Lake Poinsett (3200 ha) South Dakota are described.

Population dynamics of major Cladocera are compared with dissolved organic carbon, sestonic carbon, and food habits of the largemouth buffalo, Ictiobus cyprinella.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
South Dakota State Government
South Dakota State University

5.1111, CHEMICAL BIOCIDES IN LAKES

Y.A. GREICHUS, South Dakota State University, Agricultural Experiment Sta., ***Brookings, South Dakota*** **57007**

Objectives: 1. To determine the levels of chemical biocides in the ecosystem of a prarie lake (Lake Poinsett). 2. To study the effects of these chemicals on the ecosystem of this lake.

Work Proposed: Plant and animal species of the food chain of the lake fish will be collected at the inlet and outlet areas, the littoral zone, the transition zone and the settling basin zone. The species will be identified and analyzed for pesticides. The fish, also, will be analyzed for pesticides.

SUPPORTED BY South Dakota State Government

5.1112, FABRICS AND WATER PROBLEMS

L.O. LUND, South Dakota State University, Agricultural Experiment Sta., ***Brookings, South Dakota*** **57007**

Effect of water of various degrees of hardness and mineral content on fabrics composed of cotton, chemical fibers and blends of fibers.

Effect of different methods of laundering used by a selected group of homemakers in water problem areas.

It is planned to work with extension personnel in determining where the serious laundering problems exist and in securing women who are interested in cooperating with the station workers. Some type of garment, such as a white slip, made of chemical and natural fibers will be selected by the station staff. These garments will be distributed to women in various counties to be worn and laundered along with their other apparel. The garments will be returned to the laboratory periodically for examination.

Laboratory work will parallel the wear study in determining methods of overcoming problems due to excessive mineral salts. Evaluation of fabrics will consist of visual observation, reflectometer readings for whiteness and microscopic inspection. When garments are withdrawn from wear further laboratory evaluation may include stiffness, residual strength, elongation, weight and thickness, dimensional stability and wrinkling.

SUPPORTED BY South Dakota State Government

5.1113, BACTERIOLOGICAL WATER QUALITY ANALYSES OF METHODS FOR DETECTING FECAL POLLUTION

P.R. MIDDAUGH, South Dakota State University, School of Agriculture, ***Brookings, South Dakota*** **57007**

The proposed research involves laboratory and field investigations to improve the specificity, speed and reliability of bacteriological methods for determining kinds and number of fecal bacteria in surface water resources. The main objective is to develop bacteriological methods to distinguish between human versus animal sources of pollution by fecal indicator and pathogenic bacteria.

Laboratory investigations: 1. Fecal bacteria isolated from water samples would be used to evaluate modified bacteriological methods designed to detect differences in kinds and numbers of coliform, fecal coliform and especially fecal streptococci of human versus animal sources. 2. Samples of polluted surface waters would be stored in controlled laboratory environments to determine the relative rates of die-off coliform, fecal coliform, fecal streptococci and fecal pathogens e. g., salmonellae.

Field investigations would employ the bacteriological methods to determine the ratio of numbers of fecal coliforms and fecal streptococci in the same sample of selected stream and lake waters. This ratio has been reported to distinguish between human and animal fecal bacteria.

Laboratory and field data would be correlated for practical application in attempts to trace sources of fecal bacterial pollution of surface water resources and to attempt to distinguish between human and animal wastes with emphasis on farm animal wastes.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
South Dakota State University

5.1114, CHEMICAL, PHYSICAL, AND BIOLOGICAL DYNAMICS OF NORTHERN PRAIRIE LAKES

J.G. NICKUM, South Dakota State University, School of Agriculture, ***Brookings, South Dakota*** **57007**

The research plan proposes to make it possible to describe the chemical, physical, and biological dynamics of heretofore unstudied lakes. This will provide information concerning the relationship between land use and water quality of lakes.

The project will study the present, the seasonal variation, and the possible year to year variation of water quality. This will be accomplished by biweekly sampling during June, July, and August, and monthly throughout the remainder of the year. In addition, samples of water flowing into the lakes will be taken whenever rainfall is sufficient to cause a runoff into each lake.

The chemical content of the water will receive special attention in that the levels of various chemical biocides in the ecosystem will be determined. Pesticide residues will include endrin, dieldrin, aldrin, heptachlor, heptachlor epoxide, DDT, DDD, DDE, lindane, toxaphene, and the chlorophenoxy compounds. Pesticide residues will be extracted from five types of materials including water, mud, plant material, small aquatic animals and fish.

The field data will be used to provide information concerning the relationship between land use and the dynamics of a lake.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
South Dakota State University

5.1115, INSECTICIDE RESIDUES ON ALFALFA

R.J. WALSTROM, South Dakota State University, Agricultural Experiment Sta., ***Brookings, South Dakota*** **57007**

Objectives: 1. Determine the fundamental physical, biochemical, and biological factors influencing occurrence, magnitude, interaction, and persistence of insecticidal chemical residues in soils and raw agricultural commodities.

2. Identify and evaluate fundamental factors influencing the magnitude and mechanism of air and water pollution by insecticidal chemical residues.

3. Develop basic studies related to the metabolism and detoxication of insecticidal chemical residues in animals, plants, soils and water.

4. Identify and evaluate the effects of residues of insecticidal chemicals on ecosystems with special emphasis on fish and wildlife.

5. Explore the reciprocal influences of residues of insecticidal chemicals on soil microflora, microfauna, and non-insect fauna.

6. Seek methods of removing or reducing residues of insecticidal chemicals from the environment.

7. Develop and improve analytical techniques essential to the pursuit of this research.

SUPPORTED BY U.S. Dept. of Agriculture
South Dakota State Government

5.1116, A STUDY TO EVALUATE THE EFFECT OF SILT AND SILT REMOVAL IN A NORTHERN PRAIRIE LAKE

C.K. BRASHIER, General Beadle State College, Undergraduate School, ***Madison, South Dakota*** **57042**

The objective of this project is to determine the amount of lake eutrophication due to siltation. A study of variations of mineral quality of lake water due to siltation from various water sheds will be made. Eutrophication elements (and biota) of silted late will be compared with those of relatively unsilted, but domestically polluted lake.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
General Beadle State College

5.1117, EFFECTS OF THE CHLORINATED HYDROCARBONS, ALDRIN AND DIELDRIN, ON FRESHWATER SEED SHRIMP (OSTRACODA)

J.C. SCHMULBACH, Univ. of South Dakota, Graduate School, *Vermillion, South Dakota* 57069

The proposed research involves laboratory investigations directed toward determining the acute and chronic effects, the degree of accumulation, and the site of accumulation of two widely-used chlorinated hydrocarbon insecticides, aldrin and dieldrin, on freshwater seed shrimp, primarily Chlamydotheca arcuata (Sars).

Laboratory investigations will include the following procedures:

1) Median tolerance limits will be determined for both insecticides on seed shrimp using a constant-flow, serial-dilution apparatus.

2) Chronic poisoning and the question of acquired resistance and/or induced sensitivity will be studied by long-term exposure to sub-lethal insecticide doses.

3) Exposure to C14 labeled aldrin and dieldrin followed by tissue extraction and radiological analyses will indicate the degree of gross insecticidal accumulation and tissue concentration. Gas chromatography will be employed to confirm these analyses.

4) Organisms subjected to lethal doses of the radioactive toxicants will be fixed, embedded, serially sectioned and subjected to autoradiographic analysis to reveal the anatomical localization of insecticide.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of South Dakota

5.1118, EFFECTS OF DEVELOPMENT ON WATER QUALITY

M.A. CHURCHILL, U.S. Tennessee Valley Auth. , *Knoxville, Tennessee*

Research will be conducted in an effort to determine the physical, chemical, and biological effects of various land uses on the quality of the through-flowing streams. Some types of coliforms normally live in the soil and on vegetation. These coliforms are not really indicative of pollution although they are occasionally interpreted as such. Research will be conducted on controlled land uses to determine the contribution of fecal and non-fecal coliforms from various types of soils and types of land cover. As an aid in assessing the extent of eutrophication, an evaluation will be made of nutrient contributions to streams and reservoirs from land areas having various forms of vegetal cover. Research will be conducted on controlled agricultural areas to determine what percentages of various insecticides used are washed off the land by rainfall to enter the receiving streams.

SUPPORTED BY U.S Tennessee Valley Auth.

5.1119, FACTORS INFLUENCING THE PRODUCTION OF PLANKTONIC AND BENTHIC PLANTS

M.A. CHURCHILL, U.S. Tennessee Valley Auth. , *Knoxville, Tennessee*

The role of factors that control rates of growth and total standing crop of both planktonic and benthic plants will be studied in streams and reservoirs. These studies will evaluate effects of the following factors in growth rates under field and, in some cases, laboratory conditions: (a) various nutrient levels; (b) interaction of communities due to excretion of extracellular metabolites or competition for nutrients; (c) the source of nutrients in streams and reservoirs whether from land areas having various forms of vegetal cover, or from waste discharges; (d) substrate types; (e) light penetration; (f) reservoir operation and hydraulic flow characteristics; and (g) other physical and chemical characteristics of the flowing or impounded waters. A prediction equation that will include and define the relative importance of the significant factors will be developed, based on a multivariate analysis of the data.

SUPPORTED BY U.S. Tennessee Valley Auth.

5.1120, TEMPERATURE DISTRIBUTION IN THE VICINITY OF WASTE HEAT DISCHARGES

M.A. CHURCHILL, U.S. Tennessee Valley Auth. , *Knoxville, Tennessee*

Research will provide means for predicting temporal and spatial distribution of excess heat in streams receiving condenser cooling water from steam-electric generating plants. This involves development of correlations for describing and predicting cooling rates based on meteorological data. The study also includes the development of mathematical models which account for the combined effects of cooling and mixing in rivers and reservoirs. There is particular interest in situations where the warm water, due to its lower density, stratifies in the surface layers of the receiving stream or reservoir and there loses much of its excess heat to the atmosphere before mixing takes place. Extensive data have been collected for such a thermally stratified river. Heat is distributed across the river immediately below the discharge allowing the situation to be analyzed as two dimensional.

Several more complex situations will provide data for the evaluation of temperature distribution in three dimensions. This situation occurs when discharge is into a reservoir or larger river. Data obtained below existing power plants will be used in developing and verifying the prediction methods.

SUPPORTED BY U.S. Tennessee Valley Auth.

5.1121, EFFECTS OF TEMPERATURE ON AQUATIC LIFE

M.A. CHURCHILL, U.S. Tennessee Valley Auth. , *Knoxville, Tennessee*

Research is being conducted to provide sound technical bases for development of realistic temperature control criteria for maintenance and propagation of aquatic life. The effects of temperature on the quality and quantity of economically important species and their supporting food chain will be studied. Laboratory studies have been initiated to determine lethal temperatures for nine species of locally important fish and several fish-food organisms. It is planned to construct eight large channels simulating natural waterways. In these channels, normal biotic situations will prevail except for water temperatures. Heated water will be obtained from the condenser discharge of a large steam-electric power plant and mixed with unheated lake water to maintain desired temperatures in the channels. Two channels will be used for controls.

SUPPORTED BY U.S. Tennessee Valley Auth.

5.1122, EFFECTS OF IMPOUNDMENT ON WATER QUALITY

M.A. CHURCHILL, U.S. Tennessee Valley Auth. , *Knoxville, Tennessee*

Research is being conducted to develop engineering methods which can be used in planning, designing, and operating river and reservoir water control structures associated with multipurpose water resource projects for management of water quality as well as water quantity. Specifically, the water quality management problem consists of developing methods for predicting the quality of the water to be released through low-level outlets of proposed and existing impoundments and determining the feasibility of modifying the design and operation of water control structures to improve the quality of water discharged. Data are being collected and analyzed to determine the physical, biological, and chemical variables that cause the low dissolved oxygen concentrations and other undesirable water quality characteristics.

The Engineering Laboratory is engaged in a program directed toward developing methods of predicting water temperatures and flow patterns upstream from, within, and downstream from existing and proposed reservoirs for a given reservoir inflow-outflow program.

SUPPORTED BY U.S. Tennessee Valley Auth.

5.1123, WATER QUALITY CONTROL

R.A. ELDER, U.S. Tennessee Valley Auth., *Knoxville, Tennessee*

TVA is conducting research to develop engineering methods which can be used in the planning, design, and operation of river and reservoir water control structures associated with multipurpose water resource projects for management of water quality as well as water quantity. Specifically, the water quality management problem consists of developing methods of predicting water temperatures, dissolved oxygen concentrations, and flow patterns upstream from, within, and downstream from existing and proposed reservoirs for a given reservoir inflow-outflow program, including the effects of locating thermal or other industrial plants upstream from, on, or downstream from the reservoir. The ultimate goal of this research is to provide information needed to operate river and reservoir systems so as to make the best possible use of the water from the standpoints of quality and quantity.

The Engineering Laboratory is presently engaged in a broad program of water resource structure studies aimed at solving some of these problems. During 1965, studies were conducted of the thermo hydrodynamics of the flows through many of TVA's existing reservoirs from which a procedure was developed for making fairly accurate predictions of the mean water temperature of the reservoir outflow. During 1966, the reservoir studies were expanded in an effort to combine the TVA procedure with a mathematical model of reservoir stratification based on vertical eddy diffusivity which was developed independently by one of the Laboratory's consultants.

The combined model was programmed for solution by digital computer and is being checked. Important adjuncts to these basic studies are comprehensive field studies which are undertaken to verify the developed methods. To obtain simultaneous data on the many important factors which influence the temperature and certain other water quality characteristics of the outflow from a stratified reservoir, an intensive one-year study was made at TVA's 29-mile-long, 450-foot deep Fontana Reservoir in 1966.

SUPPORTED BY U.S. Tennessee Valley Auth.

5.1124, COAL STRIP MINE WATERSHED DEMONSTRATION--JACKSON COUNTY, ALABAMA

K.J. SEIGWORTH, U.S. Tennessee Valley Auth., *Knoxville, Tennessee*

The demonstration-research watershed was established in June 1968 to determine how area coal strip-mining and subsequent reclamation practices will affect the water resource and aquatic life of a small 136-acre watershed in northeast Alabama. Farco Mining Company is cooperating in the study.

Hydrologic observations include precipitation, streamflow, water temperature, and sediment. Samples for complete water-quality are being secured. In addition, ecological studies of aquatic life in and adjacent to the stream are being conducted.

The project will be conducted in three phases: (1) a calibration period of approximately two years, (2) an action phase during which about 50 percent of the watershed will be mined, and (3) a recovery period following reclamation work on the stripped areas. Current reclamation provisions included in TVA coal contracts will be reviewed in the light of data obtained from the project.

SUPPORTED BY U.S. Tennessee Valley Auth.

5.1125, MOVEMENT AND PERSISTENCE OF HERBICIDES IN THE SOIL

E. ANDREWS, Univ. of Tennessee, Agricultural Experiment Sta., *Knoxville, Tennessee* 37916

Objectives: To determine the effects of climatic and edaphic factors on movement, persistence and toxicity of herbicides in the soil.

Procedures: For a more detailed explanation, see S-18 (Revised) dated July 1965. Soil columns representing several soil types will be constructed in the laboratory. These columns will be treated with herbicides and then varying amounts of simulated rainfall applied. Bioassays will be conducted to determine the depth to which the herbicides are leached in phytotoxic concentrations. Similar studies will also be conducted under field conditions.

To establish the pattern of herbicide dissipation in the soil under field conditions, field plots will be treated at recommended and higher rates. Plots will be sampled and bioassays conducted. These treatments and samplings will be conducted over a period of several years.

SUPPORTED BY U.S. Dept. of Agriculture
Tennessee State Government

5.1126, SEASONAL AND DIURNAL ASPECTS OF ZOOPLANKTON MICRODISTRIBUTION AND VERTICAL MIGRATION IN RELATION TO WATER POLLUTION

D.L. BUNTING, Univ. of Tennessee, Water Resources Research Ctr., *Knoxville, Tennessee* 37916

The proposed research involves the study of microdistribution and vertical migration patterns of freshwater zooplankton populations in relation to physical and chemical environmental factors. Seasonal and diurnal changes in distribution will be analyzed to determine the effects of various environmental parameters associated with pollution.

Collection of data: (1) Diurnal studies based on six-hour sampling intervals, will be made throughout the year with special emphasis on the following periods; the onset of stratification, summer stagnation, fall overturn, winter isothermy, and spring overturn. (2) Weekly plankton and environmental determinations will be made to formulate a continuous picture of the changing conditions of the habitat. (3) Physical and chemical determinations will include light penetration, turbidity, temperature, oxygen, pH, alkalinity, carbon dioxide, conductivity, and total dissolved solids.

Analysis of data: Numerical plankton data will be subjected to correlation and multivariate analysis.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Tennessee

5.1127, EFFECTS OF WATER POLLUTION ON ZOOPLANKTON

D.L. BUNTING, Univ. of Tennessee, Graduate School, *Knoxville, Tennessee* 37916

Because of the lack of information dealing with the tolerances and reproductive rates of zooplankton species in polluted waters, it is planned to 1) provide estimates of the median tolerance limits of planktonic rotifers, cladocerans, and copepods to insecticides and toxic materials found in domestic and industrial wastes, 2) to measure the effect of sublethal concentrations of toxic wastes on the reproductive rates of natural and laboratory populations of planktonic rotifers, cladocerans, and copepods, and 3) to determine the growth patterns of several important planktonic rotifers, so that immature specimens may be segregated from adults in the egg/female/day estimates of reproduction. It is expected that the median tolerance limits based on long term studies will contribute to the study of water quality criteria. And that the knowledge of tolerances and reproductive rates along with critical study of standing crops will further the understanding of changes in community structure brought about by the addition of toxic materials to natural water.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1128, AN INVESTIGATION OF THE EFFECT OF CONTROLLED RELEASES ON THE PHYSICAL, CHEMICAL AND BACTERIOLOGICAL CHARACTERISTICS OF FORT LOUDOUN RESERVOIR

F.C. LARSON, Univ. of Tennessee, School of Engineering, *Knoxville, Tennessee* 37916

Stratification occurs in many streams and impoundments. In this study, it is desired to determine whether large, sudden releases from upstream impoundments will affect stratification in a large downstream reservoir. Inasmuch as it is difficult to duplicate the prototype in the laboratory, all data will be collected from the prototype, (This becomes possible because all the impoundments are a part of the TVA system.)

It is proposed to collect all basic data (D.O., B.O.D., temperature, pH, conductivity, turbidity, color, suspended solids, and coliform count) before, during, and after the controlled releases. The data so collected is to be used to develop formulations for stratification prediction.

In addition to the stratification study, base line data on phosphates and the nitrogens (ammonia, nitrite, nitrate) are being secured from the reservoir.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Tennessee

5.1129, CHANGES IN WATER QUALITY PARAMETERS OF RESERVOIRS DURING REGULATED FLOW CONDITIONS

F.C. LARSON, Univ. of Tennessee, School of Engineering, *Knoxville, Tennessee* 37916

Weekly sampling and testing is to be done at ten stations in Fort Loudoun Reservoir, Tennessee (a T.V.A. impoundment). The following tests will be made on all samples: The coliform count (membrane filter technique), pH, conductivity, dissolved oxygen, biochemical oxygen demand, apparent and centrifuged color, suspended solids, chlorides, iron, manganese, phosphates, ammonia N, nitrite N, nitrate N, and organic N. A portable continuous recording monitoring system will also be used in this investigation.

Inasmuch as the total organic loading on the reservoir will be greatly reduced this year, changes in water quality can be recorded and compared with previous results.

Additional information on iron and manganese build-up and eutrophication in a river-lake regime will be obtained and studied.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Tennessee

5.1130, TURBULENT MIXING IN SUBMERGED FLUID JETS

F.N. PEEBLES, Univ. of Tennessee, School of Engineering, *Knoxville, Tennessee* 37916

This project is concerned with turbulent mixing mechanisms which result as a stream of water bearing soluble or thermal pollutants is discharged into a second stream. The research is directed to provide fundamental information useful for engineering predictions of the pollutant concentration in the vicinity of the stream junction. Such information will be directly applicable to devising solutions to problems of thermal pollution which now exist in the streams and lakes in the Southeastern United States.

The research has involved simulation of water flows by investigating the turbulent mixing of a high velocity air jet with ambient air. Earlier experiments were performed to measure attenuation of the velocity, temperature, and concentration excess of the inlet jet. The current phase of the research involves investigation of the local turbulence in the submerged jet flows. A parallel investigation of the turbulence in the boundary layer of a pipe entrance region is being conducted to aid in the analysis of the more complicated jet mixing flow.

During the past year the investigation of the turbulent flow in the entrance region of a pipe was essentially completed, the experimental methods for turbulence measurements in the wall-jet wind tunnel were worked out, and modifications of the constant temperature hot wire anemometer to permit measurements in the large-turbulence flow field were completed.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Tennessee

5.1131, LAND FORMING FOR DRAINAGE AND FURROW IRRIGATION

J.I. SEWELL, Univ. of Tennessee, Agricultural Experiment Sta. , *Knoxville, Tennessee* 37916

1. To make cost analyses of land forming operations, drainage ditch layouts, and pumping plant installations. 2. To determine maintenance requirements, operation costs, and longevity of the drainage system. 3. To determine furrow irrigation efficiency and effect on crop yields.

During the Fall of 1962, the land forming and ditching operations will be carried out at the West Tennessee Experiment Station according to the plans developed in cooperation with the Soil Conservation Service. The amount of sediment removed and the change in cross-section of the ditches will be determined annually. An attempt will be made to relate sedimentation to the climatological data available at the station. Comparisons will be made between the yields and crop quality from irrigated and unirrigated treatments.

To make accurate cost analyses, records will be kept of manhours for labor and supervision, materials used, kind of machinery and equipment used and days of use, amount of soil moved and distance moved, depths of cuts and fills, and any other data needed for computing costs.

SUPPORTED BY Tennessee State Government

5.1132, EFFECT OF POLLUTING AGENTS ON SURVIVAL OF INDICATOR ORGANISMS

J.D. WOMACK, Univ. of Tennessee, School of Engineering, *Knoxville, Tennessee* 37916

The Distribution and survival of enteric pathogens, especially Salmonella and Shigella species, in Fort Loudoun Lake, TVA, is being investigated. This study is intended to correlate with previous work on survival of indicator organisms in the same environment. Incidental occurrence versus time will be studied. Dye tracer techniques will be used to establish time of flow. Diffusion cell techniques will be used in the lake to confine and control pathogenic cultures and laboratory survival studies may also be needed.

Bacterial indicators will continue to be studied and correlated with zooplankton density and distribution in a joint study with the Zoology Department. The Cladocera, Daphnia retrocurva and D. parvula will be correlated with bacterial indicators and physical and chemical parameters in Fort Loudoun Lake. It is intended to show relationships between these organisms and the changes in water quality effected by self-purification in the lake.

The effects of Nitrogen nutrient levels on growth and persistence of Enterococci will be studied jointly with the Microbiology Department. Variations in enterococcus concentrations in a small unpolluted lake will be correlated with variations in nitrogen nutrient levels occurring seasonally. Laboratory growth studies will also be performed.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Tennessee

5.1133, SURVIVAL OF INDICATOR ORGANISMS AND ENTERIC BACTERIA IN WATER

J.D. WOMACK, Univ. of Tennessee, School of Engineering, *Knoxville, Tennessee* 37916

The proposed work involves a study of Indicator organisms and enteric bacteria in three areas. The survival of Coliform bacteria and fecal Streptococci will be compared with other organisms found in the intestinal tract of man and in contaminated waters. Especial attention will be given to the enteric pathogens in the Salmonella group responsible for food intoxication. The effects of the Employment of a new secondary treatment plant by the city of Knoxville, Tennessee on the survival and persistence of indicator organisms in Fort Loudoun Lake will be investigated. Also to be examined in this project is the effect of Nitrogen nutrient levels on the growth and persistence of Fecal Streptococci in Lake water.

Field and laboratory studies will be conducted to measure the numbers of indicator organisms surviving in the lake. Time of flow will be determined with dye tracer techniques. Diffusion cell techniques will be employed to reveal the survival characteristics of enteric pathogens and naturally occurring pathogens will be investigated.

Data already in hand on the 'before' characteristics of Fort Loudoun Lake will be correlated with new information on Survival of indicator organisms after the new secondary plant is brought on the line. This data will be taken from samples taken from the lake on a time-of-flow basis using dye tracer techniques.

The natural nitrogen nutrient level variations in a small lake will be related to the survival and growth of Fecal Streptococci. Laboratory studies under controlled conditions will also be performed.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Tennessee

5.1134, EFFECT OF INDUST WASTES OF MEMPHIS & SHELBY COUNTY ON PRIMARY PLANKTONIC PRODUCERS

E. DOODY, Christian Brothers College, Undergradute School, *Memphis, Tennessee* 38104

The study aims to find characteristics of the principal waterways draining the area in and around Memphis, Tennessee, into the Mississippi River. Physical and biological features will be investigated in relation to present potential pollutants along the course of such drainages. Planktonic species will be studied in their role as primary producers in an ecosystem. The first stage of investigation will be the periodic collection, identification, and evaluation of organisms and the chemical composition of the waters in which they were found. The second stage will involve the isolation and clonal growth in vitro of key species. The third stage will determine the susceptibility of the clonal forms to the effluents from industrial plants or to suspected pollutants from these industries.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Christain Brothers College
Siena College

5.1135, REFRACTORY ADSORPTION ON CHEMCOKE

G.T. FISHER, Vanderbilt University, School of Engineering, *Nashville, Tennessee* 37203

The adsorption properties of chemcoke, an apparent competitive material for activated carbon, will be examined for refractory materials.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1136, TURBULENT DIFFUSION AND REAERATION IN NATURAL RIVERS

P.A. KRENKEL, Vanderbilt University, School of Engineering, *Nashville, Tennessee* 37203

With the cooperation of the TWA and the Corps of Engineering in regulating flow through selected impoundments, field scale measurements of reaeration will be made using oxygen deficient hypolimnion waters. At the same time, vertical, surface, lateral and longitudinal mixing coefficients will be measured using previously developed techniques. Tracer methodology for the determination of mixing parameters under non-study state and stratified flow conditions recently developed theoretical mathematical models will be tested utilizing frequency response techniques.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Vanderbilt University

5.1137, CENTER FOR RESEARCH AND TRAINING IN HYDRAULIC AND HYDROLOGIC ASPECTS OF WATER POLLUTION CONTROL

P.A. KRENKEL, Vanderbilt University, School of Engineering, *Nashville, Tennessee* 37203

To formally establish a training and research center for the study of the hydraulic and Hydrologic Factors affecting water pollution control; to continue existing research endeavors in this area of study, and to instigate new investigations utilizing the Tennessee Valley Authority and the Corps of Engineers reservoirs as 'laboratories;' to establish an information retrieval center for the subject area that would be of world-wide value; to eventually construct a building solely for the purposes described herein; and to continue and expand the existing training program designed to produce engineers knowledgeable in hydraulics, hydrology, and water pollution control. The project will be coordinated by a joint committee, comprised of members of the Federal Water Pollution Control Administration and Vanderbilt University.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1138, NATIONAL SYMPOSIUM ON THERMAL POLLUTION

P.A. KRENKEL, Vanderbilt University, School of Engineering, *Nashville, Tennessee* 37203

A. Project Objectives: To illustrate the need for research in Thermal Pollution, to elucidate the problems involved and their magnitude, to satisfy the need for exchange and dissemination of information concerning the thermal pollution problems confronting industry, municipalities and regulatory agencies involved in water pollution control work and to present the present state of knowledge in this rapidly growing field.

B. Plan of Operation: Two symposia will be held; one in Portland, Oregon concerned with the biological and chemical aspects of thermal pollution; and the other at Vanderbilt University involving the engineering and economic aspects of thermal pollution. The meeting will be co-sponsored by Vanderbilt University and the Federal Water Pollution Control Administration and will utilize the most competent people available.

C. Need for Project: The United States has more than doubled its electrical power production every ten years since 1935 and the corresponding increasing quantity of heated water discharged to our receiving waters is expected to continue to more than proportionately increase. A definite need exists to increase public and technical awareness of the problems caused by thermal pollution and to stimulate research and adequate water quality management of water temperature.

D. Facilities Available: The staff and faculty of Vanderbilt University and the Federal Water Pollution Control Administration will cooperate in planning the conferences and making the necessary arrangements. In Portland, the Bonneville Power Administation Auditorium will be used for the meetings and the Sheraton Motor Inn for accomodations. The Nashville Meeting will utilize the facilities of Vanderbilt University.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1139, STATUS OF THERMAL POLLUTION AND RESEARCH NEEDS

F.L. PARKER, Vanderbilt University, School of Engineering, *Nashville, Tennessee* 37203

Specific Objectives: The specific objectives of this study are: 1. To compile an exhaustive bibliography on thermal pollution, including the effects of heat on chemical, biological and physical aspects of water quality, the effects of heat on waste assimilative capacity, alternative methods for the dissipation of excess heat from cooling waters, the hydrodynamics of heated water discharges, and the energy balance as related to the dissipation of heat from receiving waters. 2. After intensive review, to select the most meaningful and current references from the bibliography and subject these papers to critical review and summary. 3. To present a report derived from (2) which will contain the following items: a. Discussion of each topic in sufficient detain to give the reader insight into the current stage of development of that topic. b. Discussion of the major research needs in each problem area and an indication of the most fruitful approaches of these needs. c. Discussion of the existing and potential water quality problems due to heated discharges and their relationship to water pollution control requirements.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1140, DEWATERING AND DRYING OF SLUDGE ON POROUS MEDIA

K.B. SCHNELLE, Vanderbilt University, School of Engineering, *Nashville, Tennessee* 37203

The dewatering and drying of sewage sludge is most commonly carried out in porous supporting media such as sand over a soil in a drying bed. Dewatering takes place as the water in the sludge simultaneously filters down through the porous supporting media and evaporates from the surface of the bed into the atmosphere. As the dewatering takes place moisture gradients are established and in turn provide the driving force for the diffusion of the moisture to the surface of the bed and the subsequent further drying of the sludge. Sludge, being a porous collodial substance, often biologically unstable even if digested, forms a highly compressible structural lattice of low tensile strength as it dries. This weak lattice structure results in a decrease in permeability as well as surface cracking as the material dries.

The proposed research evolves around the determination of moisture gradients and transport rates within the supporting media, the sludge, and the air-vapor boundary layer in the atmosphere. Gamma ray spectroscopy will be used to ascertain the changes in moisture without disturbing the flow system. These measurements will be used to establish the dewatering and drying rate of sludge under various climatic, operating and design conditions.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1141, DETERMINATION OF HOWELL-BUNGER VALVE AERATION EFFICIENCY

R.A. ELDER, U.S. Tennessee Valley Auth. , Engineering Laboratory, *Norris, Tennessee* 37828

The purpose of this project is to determine the efficiency of Howell -Bunger valves for increasing the oxygen content of oxygen deficient waters discharged from reservoirs. To obtain this knowledge, the Howell -Bunger valves are tested at a site approximately 600 feet downstream from TVA's Nottely Dam powerhouse. Water is withdrawn from the turbine scroll case and flows through a 30-inch-diameter steel pipe to the test location. Tests to determine the aeration characteristics for two basic configurations have been completed, i.e. (1) a valve at the end of a pressure conduit discharging freely into the air, and (2) a valve at the end of a pressure conduit with the discharge contained by a structure. Tests on a third basic configuration, i.e., with a valve located in a discharge tunnel, will be performed during the summer of 1969.

The following report describes the results of the two basic configurations: 'Aeration Efficiency of Howell-Bunger Valves,' Laboratory Report No. 1, TVA Engineering Laboratory, Norris, Tennessee, July 1968.

SUPPORTED BY U.S. Tennessee Valley Auth.

5.1142, ENCAPSULATION AND SOLIDIFICATION OF INTERMEDIATE LEVEL RADIOACTIVE WASTES IN THERMOPLASTICS

R.E. BLANCO, U.S. Atomic Energy Commission, Oak Ridge National Lab. , *Oak Ridge, Tennessee*

Development studies will determine the kinds and quantities of waste that can be incorporated in various thermoplastics, the levels of radioactivity that can be tolerated and the engineering variables involved in operation of a mixer-evaporator for production of the plastic product. Thermoplastics appear to be a marked improvement over encapsulation in asphalt particularly with respect to fire and explosion potential. The program will include laboratory hot cell and engineering development studies. Leach rate will also be determined for the final product.

SUPPORTED BY U.S. Atomic Energy Commission

5.1143, APPLICATION OF HYPERFILTRATION WITH DYNAMICALLY-FORMED MEMBRANES TO TREATMENT OF MUNICIPAL SEWAGE EFFLUENTS

K. KRAUS, U.S. Atomic Energy Commission, Oak Ridge National Lab. , *Oak Ridge, Tennessee* (14-12-423)

Oak Ridge National Laboratory will investigate the application of hyperfiltration with dynamically-formed membranes to the treatment of municipal sewage. Primary and secondary effluents will be included in the study, but with special emphasis on activated sludge effluent. An assessment of both organic and inorganic rejection will be made. Various membrane support materials of various pore sizes will be evaluated and the necessity of using filter aids (with the larger pore sizes) and film-forming additives will be examined. Diatomaceous earth, polyelectrolytes, and the hydrous oxides of iron (III) and aluminum (III) would be the first choices if such substances are needed. Salts such as nitrate, ammonia, and phosphate will be monitored to investigate the question of specificity of salt rejection. The effects of pressure, temperature, and influent pH upon product quality and flux will be investigated. To extend the period of high flux, some studies of methods of preventing membrane-fouling via turbulence promoters or backwashing are also proposed.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1144, A STUDY OF HYDRODYNAMIC ASPECTS OF REVERSE OSMOSIS (HYPERFILTRATION)

D.G. THOMAS, U.S. Atomic Energy Commission, Oak Ridge National Lab. , *Oak Ridge, Tennessee*

Objectives - The objectives of this study will be to undertake a detailed analysis of three different present day technology reverse osmosis plant designs (plate and frame, spiral and tubular) to identify: (a) Critical hydrodynamic factors and their relative contribution to the total product water cost. (b) Optimum turbulence promoter designs and cell configuration geometries that will improve reverse osmosis process efficiency and reduce product water costs. (c) An experimental evaluation of concentration polarization in an idealized plate and frame geometry. The work shall include the following: (1) An analysis of empty channel hydrodynamics. (2) An evaluation of present turbulence promoter performance in turbulence promoter design. (3) An estimation of potential benefit from future improvements in turbulence promoter design. (4) An economic evaluation to identify the region of economic usefulness of turbulence promoters. (d) Modifications to existing designs which will improve the operational characteristics of the present designs.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

5.1145, NORTH FORK ALLUVIAL DECONTAMINATION PROJECT

A.P. HANCOCK, West Cen. Tex. Mun. Water Dst. , *Abilene, Texas* 79604

This project will demonstrate the abatement of surface water pollution caused by oil production brine seepage from shallow groundwater aquifers. The demonstration will be carried out at a site west of Albany, Texas, in one of the most heavily drilled oil and gas areas in the U.S.

Groundwater will be intercepted before reaching the stream (North Fork) by a series of shallow wells. Once removed from the shallow zone, this brine-contaminated water will be injected into deep subsurface geological formations for permanent disposal. Continuation of this corrective action combined with improved pollution control measures and natural recharge of the groundwater should eventually return the area to natural conditions.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Texas State Government

5.1146, TOXAPHENE FILTRATION PUBLICATION

J.C. BARRON, State Parks & Wildlife Dept. , *Austin, Texas*

PPS Objective: To publish the results of research work on filtering toxaphene with activated charcoal.

Procedure: A manuscript based on the results of research conducted under Job E-9, D-J Project F-9-R-13 has been prepared and awaits departmental approval. If approved, it will be presented to the Texas Journal of Science for publication.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Texas State Government

5.1147, FISH TOXICANT STUDIES

R.L. WHITE, State Parks & Wildlife Dept. , *Austin, Texas*

Objective: To test the effectiveness and desirability of anhydrous ammonia for the total elimination of fish populations.

Procedures: Anhydrous ammonia will be screened in literature, in the laboratory and in the field to determine its effectiveness as a fish toxicant. Application techniques, species selectiveness, duration of toxicity and overall effectiveness will be of prime concern in this study.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Texas State Government

5.1148, LIMNOLOGICAL INVESTIGATIONS OF TEXAS IMPOUNDMENTS FOR WATER QUALITY MANAGEMENT PURPOSES

E.G. FRUH, Univ. of Texas, School of Engineering, *Austin, Texas* 78712

The seasonal change in water quality parameters such as dissolved oxygen, pH, precipitates, nutrients, and microorganisms will be measured in seven sub-tropical impoundments within a 150 mile reach of the Lower Colorado near Austin. Field surveys will be conducted below the impoundments to determine the effect of releases on the water quality of the downstream impoundment. The data will serve as a model for future river systems which have been transformed from a free-flowing river to a series of slack-water pools with intermittent river reaches.

In the last year of the project, major emphasis will be placed on determining what effect additions of different quality waters (through a diversion project or pollution) would have on the water quality of the impoundments. Various nutrient enrichment studies will be conducted under different temperature and light conditions. Carbon- 14 bioassay techniques will be utilized to determine limiting nutrient concentrations. Similar tests will be conducted using additions of river waters most likely to be diverted to the Texas Colorado River Basin in any future state water plan.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Texas

5.1149, ENZYMATIC TECHNIQUE FOR DETECTION OF SURPLUS PHOSPHORUS UPTAKE BY ACTIVATED SLUDGE

E.G. FRUH, Univ. of Texas, School of Engineering, *Austin, Texas* 78712

A. Project Objectives - The overall goal of this proposal is to distinguish the various mechanisms of phosphorus removal (physiochemical sorption, chemical precipitation, and 'luxury biological uptake') occurring in activated sludge systems.

B. Plan of Operation - An alkaline phosphatase test will be investigated to detect 'luxury phosphorus uptake' by activated sludge. 'Luxury uptake' can be distinguished because the enzyme is inhibited by orthophosphate. The test will be conducted under various environmental conditions so that phosphorus sorption and precipitation can be controlled.

Need for Grant - To alleviate nutrient enrichment of aquatic environments, phosphorus must be removed from wastewater effluents. To do this by a modified activated sludge system, the mechanism of phosphorus removal must be known.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1150, PHYSIOCHEMICAL RESPONSES OF RIVERS TO NATURAL AND MANMADE ENVIRONMENTAL CHANGES

E.F. GLOYNA, Univ. of Texas, School of Engineering, *Austin, Texas* 78712

The proposed research plan involves various interaction studies using closed ecosystems and a 'Model River.' The Objective is to evaluate the transport mechanisms which are operative in the waterway. Specifically, it is desired to develop a better understanding of the cycling effects of nutrients and conservative materials under various environmental conditions and to incorporate these uptake, release, and cycling effects into the total transport model. To accomplish this it is necessary to develop better approximations of the physiochemical system of a fertile waterway.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Texas

5.1151, BACTERIDAL EFFECTS OF ALGAE ON ENTERIC ORGANISMS

E.F. GLOYNA, Univ. of Texas, School of Engineering, *Austin, Texas* 78712

The research will demonstrate the effectiveness or selectivity of certain algal cultures in reducing the viable numbers of bacteria which are common to waste-waters of domestic origin. The information obtained will demonstrate the effectiveness of waste stabilization ponds and receiving streams in reducing the numbers of enteric bacteria when ponds and streams contain large populations of algae. Through this research it is hoped that a means can be found to estimate the die-off and aftergrowth rates of enteric bacteria where certain algal forms predominate. The growing use of various types of waste stabilization ponds throughout the USA and particularly the lesser developed countries provides a strong justification for support. The results of the proposed research, in conjunction with the current process design studies and the 'Effect of Toxic Organics on Waste Stabilization' (WP-00688-02, February 1, 1965 - January 31, 1968), will provide an important insight to design practices as based on disease transmission and its control.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1152, CONFERENCE ON SANITARY ENGINEERING EDUCATION

W.J. KAUFMAN, Univ. of Texas, Amer. Assn. Prof. in San. Eng., *Austin, Texas* 78712

The broad objective of the Conference is to identify the role of the sanitary engineer in the fields of water and water pollution management, air pollution control, radiological health and the other areas that have traditionally been considered a part of sanitary engineering. The specific objectives focus on the graduate academic programs needed to provide adequately trained personnel, the scientific discipline content of these programs, and the mechanisms where by the profession may be assured of quality in the education of its members.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.1153, MIXING AND DISPERSION OF CONTAMINANTS IN RESERVOIRS

F.D. MASCH, Univ. of Texas, School of Engineering, *Austin, Texas* 78712

Field studies on the dispersion of a conservative tracer have been made in Lake Travis, Texas, a deep fresh water reservoir in which the predominant currents are generated by the wind. The purpose of the study was to examine the current velocity distribution with depth, the rate of dilution, and the dispersion coefficients for correlation with such parameters as the surface velocity and wave conditions. In all cases, time scales were limited to six hours and all tracer releases were made at the surface.

Results show that vertical and lateral diffusivities increase with the energy in the wave spectrum, but longitudinal diffusivity decreases. The dominant mechanism for dispersion appears to be the shear flow mixing resulting from the vertical distribution of velocity.

The peak concentration in a dispersing cloud was found to decrease with the -2.5 power of time. This rate appears to be independent of the ambient conditions and the geometric characteristics of the site.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1154, THE EFFECT OF PESTICIDES ON AN ECOSYSTEM

H.G. APPLEGATE, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

At Presidio, Texas, to follow changes in pesticide concentration in soil, water, bird, reptile, and animal tissue, human urine and vegetation for a 3 year period; to determine changes in water and soil biota as functions of the physical and chemical environments; to compare species and populations of native organisms living in an area heavily treated with pesticides with those from a similar area not treated with pesticides.

SUPPORTED BY Texas State Government

5.1155, THE MOLECULAR NATURE OF ORGANIC WASTE REMOVAL PATTERNS

W.B. DAVIS, Texas A & M University System, School of Engineering, *College Station*, *Texas* 77843

The objectives of this project shall be: (1) To investigate the behavior of organic compounds in activated sludge systems using gas chromatography of the aqueous solution phase as the analytical technique. (2) To investigate the use of gas chromatography in the characterization of natural waters with regard to identification of organic components.

In accordance with stated objectives, the behavior of representative organic chemicals will be investigated with regard to (a) rate and extent of removal from solution, (b) characterization of intermediate products in solution, (c) effects of molecular structure, and (d) interference effects in multicomponent systems. Gas chromatography will be supplemented by other instrumental techniques. All analytical data will be catloqued for reference value.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1156, MANAGEMENT OF INDUSTRIAL WASTE DISCHARGES IN COMPLEX ESTUARINE SYSTEMS

R.W. HANN, Texas A & M University System, School of Engineering, *College Station*, *Texas* 77843

This project is concerned with investigations of the quantity and quality parameters relevant to a consistent water quality management program for the Houston Ship Channel-Galveston Bay Estuary System. Included are data collection and evaluation on such parameters as salinity, diffusion patterns, water and industrial effluent quality, benthal deposits, and other pertinent variables.

Results of the data are to be translated into a management scheme which provides for achieving water quality standards in an orderly and efficient manner.

The final phases of the study are to be devoted to developing a three- dimensional dynamic model of the entire estuarine system for precise management of industrial waste discharge throughout the entire region.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Texas A. & M. University Research Fdn.

5.1157, ELECTROPHORETIC CLARIFICATION OF WATER

E.A. HILER, Texas A & M University System, School of Agriculture, *College Station*, *Texas* 77843

This research involves a study of the utilization of the electrophoretic method for pollutant removal from natural waters. Electrophoretic clarification is effected by removal of charged colloidal particles from water as the suspension is passed through a dc electric field.

The purpose of this research is to investigate the removal of colloidal clay, bacterial and pesticidal pollutants from water by the electrophoretic method. The objectives are as follows: (1) development of an optimal electrode arrangement based on results of theoretical and basic experimental research; (2) characterization of various contaminants present in typical natural waters; and (3) evaluation of the efficiency of removal of these pollutants by the electrophoretic method.

This study will provide a critical evaluation of the feasibility of the electrophoretic method of water clarification.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Texas A. & M. University System

5.1158, INTERMEDIATE PRODUCTS IN THE BACTERIAL DECOMPOSITION OF HEXADECANOL AND OCTADECANOL

W.D. LANGLEY, Texas A & M University System, School of Engineering, *College Station*, *Texas* 77843

Heterogeneous bacterial populations will be developed in simulated laboratory scale reservoir systems continually filmed with a hexadecanol-octadecanol mixture. Employing the instrumental analytical techniques of gas-liquid chromatography with the hydrogen flame ionization detector and total organic carbon analysis with infra-red detector, an attempt will be made to determine total organic balance in the solution phase of the system by identifying both qualitatively and quantitatively intermediate or end products present as a consequence of bacterial degradation of the monolayer. Oxygen utilization, pH, temperature, and total bacterial concentration will be monitored or controlled..

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Texas A. & M. University System

5.1159, METAL ION-CATALYZED OXIDATION OF PHENOLS AND AROMATIC AMINES

A.E. MARTELL, Texas A & M University System, Graduate School, *College Station*, *Texas* 77843

The purpose of this investigation is to study the kinetics and mechanisms of the oxidation of phenols and aromatic amines by molecular oxygen in the presence of manganese salts, and of other metal salts, as catalysts. Such reactions are of interest because of the use of permanganate, and because of the presence of compounds of other metals, in the purification of water containing phenols and aromatic amines derived from industrial contamination. Understanding of the reactions by which these substances are oxidized to innocuous compounds is expected to lead to improvements in methods of water purification.

The oxidation of phenols and aromatic amines will be studied with various oxidation states of manganese, and with the higher oxidation states of other metal ions such as iron, cobalt, and vanadium, as oxidizing agents. Similar reactions with molecular oxygen, in which the metal compounds have catalytic functions, will also be studied. Oxygen insertion reactions of the oxyanions of the metals will be investigated with isotopic 0-18 tracers. Special attention will be paid to oxygen-carrier systems in which the metal ions form complexes with molecular oxygen that are useful in the oxidation of organic compounds.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1160, THE INFLUENCE OF GRAZING MANAGEMENT SYSTEMS ON VEGETATION COMPOSITION AND LIVESTOCK REACTION

L.B. MERRILL, Texas A & M University System, Agricultural Experiment Sta., *College Station*, *Texas* 77843

Objectives: (1) Determination of desirable rates of stocking of range pastures. (2) Determination of desirable combinations of animals for proper utilization of range pastures. (3) Determination of desirability of deferred rotation grazing as compared with continuous grazing. (4) Determination of reaction of range vegetataion under various grazing uses.

Watershed studies in cooperation with ARS have shown great differences in water loss for pastures with different vegetative covers.

These results can be used by the action agencies to instigate soil and water conservation. The general public will be benefited in that the best systems of management also produce the greatest plant cover and will thus improve the vast natural watersheds and divert a maximum amount of rainfall to the underground water supply.

SUPPORTED BY Texas State Government

5.1161, LABORATORY STUDIES OF TOXIC DINOFLAGELLATES

S.M. RAY, Texas A & M University System, Graduate School, *College Station, Texas* 77843

Shellfish oysters, clams, and mussels are being subjected to laboratory cultures of Gulf of Mexico dinoflagellates (Gymnodinium breve and Gonyaulax monilata) which are toxic to marine fishes, to determine if these shellfish will produce toxic symptoms when eaten by mammals and birds. We have induced shellfish poisoning in chicks by feeding them oysters which had been subjected to G. breve cultures. The influence of variable culture conditions and media on the relative toxicity of G. breve and G. monilata cultures, and the influence of such factors on the stability of the toxin(s) in shellfish will be investigated. Furthermore, factors that might influence the feeding activity of shellfish subjected to cultures of these dinoflagellates will be considered. Pharmacological and toxicological studies will be conducted to determine the nature and mode of action of the toxins produced by these two dinoflagellates. The purpose of the proposed work is to gather information that will permit the evaluation of the Gulf of Mexico dinoflagellates as potential etiological agents for paralytic shellfish poisoning. Basic information will be obtained on dinoflagellate-mollusc relationships, and thus contribute to our knowledge of ecology and physiology of these two groups of organisms. Other species of Gonyaulax: G. acatenella, G. catenella G. tamarensis, G. polyedra, G. polygramma, G. sphaeroidea, G. spinifera, and G. washingtonensis, will also be studied. The proposed studies are a part of this laboratory's long-range research program in molluscan biology.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.1162, GROWTH HABITS, SPREAD AND HERBICIDAL RESPONSES OF TRUMPET CREEPER

H.E. REA, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

Objective: To determine the effects of climatic and edaphic factors on movement, persistence, and toxicity of herbicides in soil.

Procedures: The effect of incorporation, irrigation, rainfall and soil type on the phytoxicity, persistance and movement of 1, 1 dimethyl-3-(alpha, alpha)-trifluoro-m-tolyurea and (2,4 bis(isopropylamino)6-methylmercapto-s-triazine) will be determined. In field studies incorporation will vary from none to 4 inches deep prior to and at planting. Irrigation will vary from various amounts of sprinkling to flooding of flat and bedded land. Phytotoxicity will be determined under field conditions for cotton and crops that occur in common cropping sequences. Movement and degradation of herbicides in the soil will be determined by bioassay. Soil types will be clay, clay loam, loam, fine sandy loam and loamy sand. In conjunction with field studies, laboratory and greenhouse studies will be conducted to determine if the degree of soil moisture saturation affects herbicide toxicity. Studies will also be conducted to determine the effect of various amounts of simulated rainfall or irrigation on the leaching and persistence of the herbicide on the 5 soil types.

SUPPORTED BY U.S. Dept. of Agriculture
Texas State Government

5.1163, THE DISPOSITION OF PESTICIDES IN THE SOIL

G.W. THOMAS, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

Obj.: A. To determine the distribution of pesticides in selected soils and their drainage waters, using sites to which known amounts of pesticides have been applied. B. To determine the physical, chemical, and biological processes, and soil characteristics which are important in the disposition of pesticides in soils.

Description of work: Soils varying in physical, chemical and mineralogical properties will have pesticides of various types applied to them in laboratory columns. Movement of pesticides and movement of water will be compared. Prediction on the basis of pesticide and soil properties will be attempted.

Experimental plots in the field will be sampled to see how closely the behavior of pesticides predicted from laboratory experiments fits under field conditions.

SUPPORTED BY U.S. Dept. of Agriculture
Texas State Government

5.1164, STORM WATER TREATMENT FACILITIES

C.H. WILLAIMS, Dallas Water Works, *Dallas, Texas*

The proposed treatment facility is to serve a twofold need in that it will 1.) provide service to the City of Dallas in treating an overflow mixture of domestic wastewater and infiltration storm water; and, 2.) it will demonstrate the effectiveness of a new and improved method (ie, chemical treatment and clarification of this wastewater source). The City of Dallas suffers an ailment typical of many cities in that the majority of the separate sanitary sewers are subject to high infiltration quantities during storms. Current building code and design and inspection practices will ease the problem of overflows in future systems; however the existing sewers will not benefit and the problem of overflows will persist. The proposed facility will demonstrate an effective means to control this pollution source. The design of the proposed facility will also be applicable for overflow treatment from combined sewer systems which will expand its benefits as a demonstration facility. 3.) Since the proposed storm water treatment plant is convenient to the lime softening filter plant waste chemicals, it will provide a test of the effectiveness of using these chemicals for removal of phosphates and chemical precipitation of sewage sludge.

The project was approved May 22, 1968 with 665 days for design and construction after which there will be twelve (12) months for operation.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Dallas City Government - Texas

5.1165, A COMPLETE RECYCLE WASTE WATER TREATMENT PLANT

C.H. WILLIAMS, Dallas Water Works, *Dallas, Texas*

Some trickling-filter plants produce effluents having a quality below proposed standards. Many of these plants discharge effluent into streams, composed only of wastewater. Dallas and the Trinity River is an example of this regional problem.

The first objective of this project is to determine the best process to produce an effluent having the quality required for discharge into a river which, generally, has a flow made up of treated wastewater only. The second objective is to recycle some of the renovated wastewater, treated to raw water standards, into the city raw water supply, thus reducing the required quantity of the city water supply. The plan is to add the activated sludge process to the existing trickling filter. Coagulation-sedimentation and filtration will follow the biological treatment.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Dallas City Government - Texas

5.1166, ION SELECTIVE ELECTROCHEMICAL SENSORS

I. TRACHTENBERG, Texas Instruments Incorporated, *Dallas, Texas*

In this proposed research program we plan to demonstrate the feasibility of making ion selective electrochemical sensors for use in the continuous monitoring of saline and brackish water. These sensors hopefully will be inexpensive, chemically durable and highly ion selective. The ions of particular interest are Ca , Mg , Fe , Mn , Na , K and SO4--. Non-oxide glasses will be doped with varying concentrations of salts of the specific ion of interest or of salts which will selectively react with ions of interest. We plan also to study the homogeneity of the doping process as well as various electrode and membrane configurations. Activation of the various doped glasses will be carried out under a variety of controlled conditions. Finally we plan to evaluate the sensors' response to concentration changes and selectively to interference of other ions.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

5.1167, RAPID IDENTIFICATION OF MICROBIAL POPULATIONS IN WATER

R.K. GUTHRIE, North Texas State University, Graduate School, *Denton, Texas* 72603

This project will test the feasibility of using fluorescent antibody -membrane filter techniques for rapid identification of microorganisms in water supplies. Bacteria isolated from fresh water, reservoirs and streams, will be isolated and identified by conventional methods. Following identification, species specific and genera specific antisera will be produced in rabbits and conjugated with fluorescent dyes. These fluorescent antisera will then be used on non-fluorescent membrane filters for efficiency of identification by the methods of Danielsson.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
North Texas State University

5.1168, A STUDY OF THE METABOLISM OF THE AQUATIC ACTINOMYCETES

J.K. SILVEY, North Texas State University, Graduate School, *Denton, Texas* 72603

The aquatic actinomycetes have been shown to comprise a diverse serological group when compared with the terrestrial Streptomyces. Serological grouping is based on antigen-antibody precipitation tests in normal diffusion agar plates.

The spore stages of the aquatic serological group germinate under anaerobic conditions, and the primary mycelia adapt themselves to that environment for development. The terrestrial groups according to serological classification require oxygen for spore germination and primary mycelial development.

Studies on the water-mud interface in the bottom of reservoirs demonstrated the rapid development of the aquatic Streptomyces but an absence of terrestrial species. Odor compounds produced by the aquatic group appeared to be chemically different from those produced by the terrestrial forms. These findings are based on ecology, gas chromatography, and analytical chemical techniques.

The aquatic actinomycetes may become closely associated with certain species of blue-green algae. Cultures of the algae continue to liberate actinomycetic tastes and odors. The mechanism of the association is being investigated with the electron scope, with gas chromatographic techniques, and with chemical analyses.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1169, NATURALLY OCCURRING TASTES AND ODORS IN WATER SUPPLIES

J.K. SILVEY, North Texas State University, Graduate School, *Denton, Texas* 72603

The taste and odor compounds produced by the aquatic actinomycetes may be satisfactorily concentrated by employing freeze-stir techniques. Samples produced by this method may result in approximately 2,000 times the original concentration fo the organic components responsible for the tastes and odors. Low temperatures maintain the compounds in original chemical composition without altering the molecular structure. Gas chromatographic studies of the concentrates from laboratory-produced cultures indicate that six components are involved in the typical earthy, musty odors produced by these organisms. NMR investigations demonstrate that all compounds are neutral and polar. Studies on taste and odor components from the water supplies subjected to the same techniques demonstrate that the compounds available in raw water are chemically identical with those produced by laboratory techniques. With the above information available, the use of gas chromatography with the proper instrumentation now available to use the mass spectrometer should make identification of the compounds relatively assured.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1170, DISPERSAL OF VIABLE ALGAE AND PROTOZOA BY AQUATIC INSECTS

K.W. STEWART, North Texas State University, Graduate School, *Denton, Texas* 72603

Work on this proposed project is concerned primarily with determining the extent to which certain aquatic insects serve as passive transport vehicles for viable algae and protozoa. Aseptically collected insects are washed in sterile soil water extract or other desirable culture media. Washings are then cultured in a controlled environmental chamber and examined microscopically at one to two week intervals for detection of genera of algae and (or) protozoa. Similar cultures are made from contents of the fore, mid and hind guts of insects, dissected aseptically, to determine if algae and (or) protozoa can remain viable while passing through the alimentary tract.

Another phase of this study involves determination of the length of time commonly transported algae and protozoa can remain viable while attached or adhering to the external body of insects. This will be accomplished by artificially 'contaminating' sterile live specimens with pure cultures of algae and protozoa, and holding them with sterile clamps in a controlled environmental chamber. Interval washings of groups of specimens treated in this manner will yield the information desired.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1171, EFFECT OF ANTIBIOTICS ON FUNGUS PARASITES IN OYSTERS

S.M. RAY, Texas A & M University System, Marine Laboratory, *Galveston, Texas*

The main objective of the proposed research is to determine the efficiency of antibiotics and antibiotic-like synthetic compounds in controlling Dermocystidium marinum, an important fungus parasite of oysters. It is hoped that these studies will lead to a method for either inhibiting the development of or eliminating this disease-causing parasite from laboratory stocks of experimental oysters.

A secondary objective is to improve the culture method for detecting D. marinum in oyster tissue by using either more effective and/or less inhibitory antibacterial agents than those presently employed.

These studies should provide a better understanding of the life cycle of D. marinum and possibly provide additional basic information on fungal diseases in general.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.1172, PHOSPHORUS REMOVAL AND DISPOSAL FROM MUNICIPAL WASTEWATER

C.H. CONNELL, Univ. of Texas, School of Medicine, *Galveston, Texas*

The objective of this project is to demonstrate effectiveness, feasibility and costs of biological, chemical and physical processes for removal and disposal of phosphorus from Municipal Wastewater. The project was started in fiscal year 1968 and it is anticipated that it will be completed in fiscal year 1970.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
University of Texas

5.1173, STEROLS AND LIPIDS IN WATER POLLUTION

L.L. SMITH, Univ. of Texas, School of Medicine, *Galveston, Texas*

The presently proposed work considers the examination of natural waters for their lipid content, particularly their sterol content (including cholesterol and the fecal sterol coprosterol). It is hoped that a full knowledge of the sterol content of natural waters will permit the use of such analyses for sterols for recognition of pollution from domestic sewage, animal and plant wastes, etc. as these might be encountered in natural water supplies. Both animal and plant material contains sterols, and by detecting a given key sterol in excess in a water sample it should prove possible to identify the probable origin of the sterol. Furthermore, knowledge of the sterol content should offer a fundamental basis for our improved understanding of the means by which lipids and sterols are disposed of in natural waters. Water samples have been taken from open surf, quiet bay, running tidal, and domestic sewage treatment effluents and the sterols therein analyzed by chromatographic means. In open uncontaminated waters certain phytosterols have been found but no evidences of domestic sewage contamination were obtained. Domestic sewage does contain cholesterol and coprosterol, even in fully treated sewage. The fate of these sterols as they are diluted in water sources is under study.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1174, STUDY OF EFFECTS OF MILL WASTE WATER ON FISH LIFE

L.L. HISER, Southwest Research Institute, *Houston, Texas*

NO SUMMARY HAS BEEN PROVIDED TO THE SCIENCE INFORMATION EXCHANGE

SUPPORTED BY Southwest Research Institute

5.1175, STUDIES TO DEVELOP PROCESS DESIGNS FOR EFFLUENT QUALITY CONTROL

L.L. HISER, Southwest Research Institute, *Houston, Texas*

NO SUMMARY HAS BEEN PROVIDED TO THE SCIENCE INFORMATION EXCHANGE

SUPPORTED BY Southwest Research Institute

5.1176, USE OF TOTAL CARBON ANALYZER TO DEFINE MICROBIOLOGICAL PROCESSES

L.L. HISER, Southwest Research Institute, *Houston, Texas*

NO SUMMARY HAS BEEN PROVIDED TO THE SCIENCE INFORMATION EXCHANGE

SUPPORTED BY Southwest Research Institute

5.1177, DEVELOPMENT OF A WATER QUALITY CONTROL PROGRAM FOR THE SAN JACINTO RIVER BASIN

L.L. HISER, Southwest Research Institute, *Houston, Texas*

NO SUMMARY HAS BEEN PROVIDED TO THE SCIENCE INFORMATION EXCHANGE

SUPPORTED BY Texas State Government
Houston City Government - Texas

5.1178, MEASUREMENT OF AIR AND WATER QUALITY

H.C. MCKEE, Southwest Research Institute, *Houston, Texas*

NO SUMMARY HAS BEEN PROVIDED TO THE SCIENCE INFORMATION EXCHANGE

SUPPORTED BY Southwest Research Institute

5.1179, A COMPARISON OF THE GROWTH RATE OF BLUE CATFISH AND CHANNEL CATFISH FINGERLINGS FOR A PELLETED COMMERCIAL FEED

R.N. HAMBRIC, State Parks & Wildlife Dept. , *Houston, Texas* 77028

Interest in raising catfish commercially is expanding rapidly in the south. Most inquiries received by our Department concerns channel catfish but we also receive some questions relative to feeding blue catfish. Information concerning raising blue catfish is quite limited. This study is designed to compare the growth rate of the two species when fed the same type feed.

SUPPORTED BY Texas State Government

5.1180, ALTERNATE METHODS OF MOSQUITO CONTROL TO REDUCE CHEMICAL POLLUTION OF WATERS FOR RECHARGE OF THE OGALALLA FORMATION

E.W. HUDDLESTON, Texas Technological College, School of Agriculture, *Lubbock, Texas* 79409

The proposed research plan involves evaluation of alternate methods of mosquito control which will reduce the amount of organic pesticides applied to surface waters. The main objective is to evaluate the effects of mechanical and chemical weed control methods on oviposition, hatching, and larval development of those mosquitoes that breed in playa lakes.

Techniques will be developed to subdivide a playa lake bed into small experimental units permitting replication and statistical eval- uation of data. Information gained from small replicated plots will be used to design a practical, low-cost method of reducing mosquito populations to a level at which the amount of insecticides used in this region will be greatly reduced; thus, reducing the chemical pollution of waters used to recharge the aquifer, the Ogalalla formation.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Texas Technological College

5.1181, DEMONSTRATION OF INDUSTRIAL WATER RENOVATION PLANT AT ODESSA, TEXAS

T.O. MALLONEC, Water Renovation Plant, *Odessa, Texas* 79760

The project will involve a 15-month program to demonstrate on a suitable scale of operation, the feasibility of water renovation and reuse in a typical chemical-petrochemical complex.

The aim of the project is to demonstrate a method to handle easily and efficiently the pollution problems from a petrochemical complex and at the same time to provide an economic advantage of multiple reuse of input water, which will be of great value to a larger number of industrial complexes.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Odessa City Government - Texas

5.1182, EFFECTS OF RIVERS ON THE METABOLISM OF TEXAS BAYS

B.J. COPELAND, Univ. of Texas, Graduate School, *Port Aransas, Texas* 78373

The overall objective of the research proposal is to seek ways to distinguish the degree to which a body of water is polluted, ascertain the contribution of rivers to the bay, and to discover quantitative and qualitative differences between polluted and unpolluted coastal waters. Comparisons of concentrations of various nutrient compounds to primary productivity and various animal and plant assemblages will be made and the river's contribution to the bay will be evaluated.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1183, STABLE CARBON AND OXYGEN ISOTOPE RATIO VARIATIONS IN THE FLOW TO CARBON AND OXYGEN THROUGH NORMAL AND POLLUTED AQUATIC SYSTEMS

P.L. PARKER, Univ. of Texas, Graduate School, *Port Aransas, Texas* 78373

The main goal of the proposed research is to develop ways to use measured variations in stable carbon and oxygen isotope ratios to solve problems concerning the flow of these elements in aquatic systems. By investigating both normal and polluted systems a better understanding of both will result. Rivers, lakes and marine bays are aquatic systems which would be studied. However, single species of organisms, sewage systems and industrial plants also have a flow of carbon and oxygen and would be suitable for study.

In addition to the stable isotope studies the total amount of dissolved and particulate organic matter in area waters will be investigated. The organic geochemical studies which have been conducted here for the past three years will be continued.

SUPPORTED BY U.S. National Science Foundation

5.1184, AQUATIC PLANTS OF POLLUTED WATERS IN S. W. UNITED STATES

D.S. CORRELL, Texas Res. Foundation, *Renner, Texas*

The goal of this project is the production of a descriptive and illustrated manual of all the vascular plants of aquatic habitats, especially of polluted waters, found growing naturally in southwestern United States; namely, Oklahoma, Texas, New Mexico, Arizona, and the extreme southern parts of Utah and Nevada. Specifically, the product of this research will enable one to identify these plants in this part of the country and, hopefully, learn something about their role in the pollution or clarification of water. A map showing the distribution of each species, ecological and distributional data, and a discussion of methods of dissemination, reproduction and growth habit of each entity will also be included where possible. The work will be based upon field research and the study of herbarium specimens collected during the course of the work or that are available in various institutional herbaria.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1185, METHODS TO REDUCE WATER POLLUTION CAUSED BY STORM WATER SEWER LOADING BY USING FLUID FLOW FRICTION REDUCERS

H.R. CRAWFORD, Western Company, ***Richardson, Texas*** 75080

The research plan involves laboratory and field investigations directed at the use of high molecular weight polymers added to sanitary sewage with infiltrated ground water to demonstrate feasibility of reducing pipe friction loss with resulting increase in sewer flow rates.

Laboratory investigations shall consist of the following: 1. Small scale experiments on a water-polymer system to characterize friction reducing capabilities, storage life, toxicity, and effect as a coagulant. 2. Experiments to classify domestic sewage from chemical and physical properties. Field investigations shall consist of the following: 1. Testing on small scale models of a partial sewer system the friction reducing capability of selected polymers at varying sewage pipe depth and including surcharge. 2. Development of an injection device and method of injection of the polymer into the sewer pipe. 3. Determine the best location for injecting polymer into sewer pipe.

Laboratory and field data would be correlated for application in a full scale test of polymers added in a sanitary sewer infiltrated with ground water and in a waste water treatment plant.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1186, DEVELOPMENT AND DEMONSTRATION OF MATERIALS TO REDUCE OR ELIMINATE WATER INFILTRATION INTO SEWERAGE

H.R. CRAWFORD, Western Company, ***Richardson, Texas*** 75080

The research plan involves laboratory and large-scale investigations directed at the development of a chemical sealant to prevent ground water infiltrations into sanitary sewers and its feasibility in application.

Laboratory investigations shall consist of the following: 1. Small scale experiments to determine the most promising sealant formulations according to the following properties: a. Bonding ability b. Strength c. Variable cure time d. Ease of handling e. Stability f. Cost 2. The following parameters will be utilized in evaluating the sealant formulations: a. Tensile strength through the bond between cured sealant and the conduit. b. Flexural strength of cured sealant material. c. Environmental tests of cured sealant material.

The large-scale investigation shall consist of further screening of sealant formulations in a sewer line mock-up with a controlled environment. This will include an investigation and evaluation of existing equipment to apply the new sealant.

At the conclusion of the program recommendations will be made for a chemical sealant to prevent ground water infiltration and needed improvement and/or development for application of the sealant.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1187, MULTILAYER FILTRATION

K.J. IVES, Univ. College, ***London, United Kingdom***

The theory of the filtration of water or wastewater through deep granular beds indicates that an improvement in design can be obtained if the size of the granular media decreases in the direction of flow. This has been demonstrated experimentally for particulate suspension in water by filtering in an upflow direction through size-graded sand, or by downflow through three layers of coarse anthracite, medium size sand and fine garnet. The three-layer design is to be tested for the filtration of flocculent metal hydroxide suspensions, and compared with normal sand bed filtration. Various arrangements of grain sizes and layer thickness will be tried to determine an optimum design. This aspect will also be explored theoretically. Other media (e.g. magnetite, glass beads, crushed flint, plastics) will be examined to see if they are of any practical use, and to see if the three-layer concept can be extended to several layers.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1188, EUTROPHICATION OF SHELTERED BAYS IN A LARGE LAKE

W.T. HELM, Utah State University, Graduate School, ***Logan, Utah*** 84321

Bear Lake at the present time is a clear oligotrophic lake. With the recent increase in recreational use of the area, however, a number of boat harbors and breakwaters have been constructed. These structures have interrupted the normal shoreline currents. Along unprotected shores, the currents scour the bottom, limiting the amount and diversity of rooted vegetation and bottom organisms. Modification of this habitat by creating relatively quiet pockets protected from the wind driven water currents has encouraged the growth of a wide variety of organisms. The non-turbulent circulation pattern in these areas insures the rentention of at least part of any intruding nutrient-rich water. The reactions of the rooted vegetation, phytoplankton, zooplankton, and possibly fish to this altered environment will logically provide a preview of the changes to be expected throughout the lake if overall nutrient levels are allowed to increase.

The study will be initiated by locating a series of comparable bays. The water chemistry of these bays will be compared with each other and with the lake water. Complete records of chemical and physical conditions during the study will be kept. Biological sampling will determine the abundance and speciation of periphyton, plankton, bottom organisms, and rooted aquatic plants. Samples from the open lake and from non-enriched bays will be compared to those from enriched bays to determine changes caused by enrichment. In this fashion, both quantitative and qualitative changes can be measured and evaluated. This project was started in fiscal year 1968 and will continue through year 1970.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Utah State University

5.1189, SEQUENTIAL USE WITHIN A HYDROLOGIC COMPLEX

D.W. HENDRICKS, Utah State University, Utah Water Research Laboratory, ***Logan, Utah*** 84321

The project objective is to demonstrate the feasibility of developing and utilizing a unified hydrologic-quality simulation model, as a tool for the quality-quantity management of a hydrologic unit. The model development must be sufficiently general in approach that it may be adapted to other hydrologic entities. It is not only the model concept and approach per se that is of interest, but also delineation of necessary and sufficient inputs to make the model work. Such inputs include: (1) what amount of data is needed, in time and space, (2) how such data are utilized, and (3) what submodels are feasible (i.e., Streeter Phelps, statistical correlations, etc.). To a degree these inputs need to be delineated in the context of the specific purpose of the model, which is not to be ignored in the philosophy of development.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Utah State University

5.1190, BACTERIAL ADSORPTION ON SOILS

D.W. HENDRICKS, Utah State University, Utah Water Research Laboratory, ***Logan, Utah*** 84321

This work will focus upon the role of adsorption, as a mechanism in bacterial retention, in the flow of bacterial suspensions through soils. The project intends to be definitive in that all of the hypothesized factors that affect bacterial adsorption will be investigated. These factors include cell concentration temperature, chemical environment, and surface activity. By understanding and quantifying the fundamental removal mechanisms, predictions of bacterial movement through soils can be made. Other mechanisms of retention which will be investigated, but in a less exhaustive treatment, include sieving, gravitational sedimentation, and several other possibilities.

Such knowledge will allow rational assessments of the health hazards of groundwater recharge, shallow aquifer contamination, and proximity of septic tanks to wells.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Utah State University

5.1191, SORPTION KINETICS IN FLOW THROUGH GRANULAR PARTICLES

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This project proposes to focus specifically on delineating the sorption kinetics for a mobile dissolved chemical species interacting with a fixed phase, consisting of granular sorbent particles. The stress will be upon obtaining a generalized phenomenological description of the sorption kinetics--described in terms local solid and liquid phase sorbate concentrations, and which will reflect in the form of the rate law, the effects of temperature, competition for sorption sites by other species, nature of sorption site, and the nature of the rate limiting step in the reaction (i.e. solid or liquid phase diffusion). The results must be operational in terms of obtaining a solution for concentration profiles of sorbent in liquid and solid phases and the procedure for application must be based upon a limited amount of laboratory work--to be obtainable on a routine basis.

With the delineation on an operational basis of the above factors and methodology for describing sorption kinetics, one should be able to rationally assess concentration profiles in the liquid and solid phases. This should have application: (1) to investigative assessments and management of ground water contamination problems and (2) in optimizing the design and operation of ion-exchange and adsorption columns. The latter, of course, is becoming increasingly important as a step in tertiary treatment.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.1192, EFFECTS OF WATER TEMPERATURE UPON RESPIRATORY METABOLISM OF CUTTHROAT TROUT, SALMO CLARKI

R.H. KRAMER, Utah State University, State Coop. Wildlife Res. Unit, *Logan*, *Utah* 84321

This study is part of a long-range program at the Utah Cooperative Fishery Unit to determine water temperature requirements for respiratory metabolism of Utah fishes. The objectives of the present study are to describe standard metabolism, active metabolism, and scope for activity (all in terms of oxygen consumption rate) for cutthroat trout at 5, 10, 15, 20, and 25 C. The respirometer to determine active metabolic rate is a propeller-driven apparatus patterned after that used by Smit (1965, Can. J. Zool. 93: 623-633). The standard respirometer employs a heat-loss flowmeter like that used by Beamish and Mookherjii (1964, Can. J. Zool. 42:161-175) to obtain an index to spontaneous activity of the fish while in the respirometer. This index is plotted against simultaneous measurements of oxygen consumption and the regression line extrapolated to zero activity to obtain an estimated rate of standard metabolism. Scope for actigity is the arithmetic difference between the active and standard rates.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Utah State University

5.1193, THE EFFECTIVENESS OF WATERFOWL IN CARRYING PATHOGENIC MICRO-ORGANISMS

J.B. LOW, Utah State University, State Coop. Wildlife Res. Unit, *Logan*, *Utah* 84321

Waterfowl because of their migratory habits fly from one water source to another in their early or seasonal movements. These birds are potential carriers of disease producing micro-organisms because of the common practice of Utah towns and cities of disposing of their sewage into streams of water. These streams usually drain into lakes or marsh lands which are utilized by the watefowl for nesting, brood rearing, and other normal activities. There is a large accumulation of organic sewage in these areas and may be a source of pathogenic organisms. Because waterfowl are in contact with this raw sewage they will be investigated as to the role they may play in the dissemination of micro-organisms.

The work will be carried out under the following objectives: (1) To determine the incidence of indicators of pathogenic micro-organisms present on waterfowl in western marshlands. (2) To study the effectiveness of waterfowl to directly discriminate organisms by carring them on feet, feathers, and other body parts. (3) To determine the organisms available for transmission by waterfowl. (4) To determine the longivity of contamination of waterfowl by micro-organisms attached to feet, feathers and other parts of waterfowl.

SUPPORTED BY Utah State University

5.1194, FACTORS LIMITING WATERFOWL PRODUCTION ON THE SPRING-FED SALT MARSHES WEST OF THE GREAT SALT LAKE

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Current waterfowl productivity will be assertained for a typical spring-fed salt marsh and compared both quantitatively and qualitatively to available data from the Bear River Refuge on the hypothesis that a difference in waterfowl productivity exists between the two areas.

Disease and nutrition factors which alone or in combination might cause excessive brood mortality or cause lowered reproductive success through decreased vigor will be examined on the spring-fed marsh. Analyses of food plants and invertebrates to determine availablitiy, nutritional content, and levels of trace elements will be accomplished on the study area. Ducklings and adult ducks will be collected in the salt marsh and examined for abnormalities, and gullet-gizzard contents will be studied to determine food habits in this area. Periodic examinations will be made of the marshes to find sick or abnormally developing young ducks and geese. A sample of young mallard ducklings of various ages will be innoculated with varing doses of several endemic arboviruses in the laboratory to determine if these viruses can be lethal to ducklings. Serum samples from adult and young ducks from these marshes will be assayed to determine the incidence of natural exposure to arboviruses.

SUPPORTED BY Utah State University

5.1195, A STUDY OF THE BIOLOGICAL, CHEMICAL AND PHYSICAL NATURE OF WATER QUALITY FACTORS UNDER UTAH CONDITIONS

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The characteristics and relationships of water quality factors pertinent to short, snow-fed mountain streams feeding to desert floors will be studied. Consideration will be given to: 1) watershed contamination 2) irrigation return and 3) domestic and industrial pollution. The relationship of the contaminant to volume of flow, rate of degradation and subsequent incorporation into the aquatic biomass will the matter of primary concern. Contaminant cycling, sedimentation and physical change will also be studied. The system under study will lend itself to model construction in terms of the environmental, physical, chemical and biological effects on contaminants. The information for such a model will be obtained from field observations and from experiments conducted on excised portions of the environment.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Utah State University

5.1196, QUALITY OF IRRIGATION RETURN FLOW

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To conduct research on the problems that affect the quality of irrigation return flow. (1) Precipitation mechanisms in soils as they affect water quality. This phase will be concerned with the changes in the quality of water, as it moves through soils, as a result of precipitation of calcium carbonate. (2) To develop information for predicting the changes in the salinity content of soil and drainage water resulting in changes in the quality of irrigation water and in irrigation management.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1197, WATER QUALITY TELEMETRY

D.S. WOFFINDEN, Utah State University, Utah Water Research Laboratory, *Logan, Utah* 84321

The objectives of this project are to show the technical and economic feasibility of radio telemetering water quality data from remote sites to a central station.

The technical feasibility has been demonstrated during the last year. Continuing study of the system will investigate construction of an integrated system with maximum simplicity of operation and minimum cost. This investigation will include analysis of various water quality parameter sensors for direct use with the telemetry system. Stress will be placed on sensors requiring a minimum of maintenance and producing a maximum period of unattended operation.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Utah State University

5.1198, MINERAL RECOVERY FROM CONCENTRATED BRINES

J.M. GLASSETT, Brigham Young University, School of Engineering, *Provo, Utah* 84601

The separation and recovery of the principal inorganic salts from a simulated sea water brine, based on Great Salt Lake water, and from sea water brine will be investigated. In particular, a study will be made of a phase rule process for the separation of pure salts from the brines by two cooling steps alternated with two evaporation steps. Optimum conditions for the separation and recovery of minerals will be determined. Salts to be recovered are: sodium chloride, sodium sulfate, potassium chloride, and magnesium chloride. Particular emphasis will be placed upon the recovery of magnesium chloride and potassium chloride since these salts have greater commercial value than the sodium salts.

A goal of this research project is to define an economical mineral recovery process which may lower the cost of saline water conversion to fresh water.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

5.1199, POLLUTION AS A RESULT OF FISH CULTURAL ACTIVITIES

R.N. HINSHAW, State Div. of Fish & Game, *Salt Lake City, Utah* 84116

Fish hatchery effluents have not been evaluated as a source of pollution. However, with the large numbers of hatcheries in the Nation, this problem should not be overlooked any longer.

Three types of pollution are implicated in the waters contaminated by the effluent from fish hatcheries. The first of these are pathogens and parasites which effect is increased because of crowding in hatchery situations. A second category includes chemicals and drugs used for prophylatcic and therapeutic treatment of fish. A third section, with which this research is concerned, is that pollution caused by wastes from fish metabolic processes, and unutilized feeds as well as algae and ditritus from pond and raceway cleaning.

The research proposed for this study will be confined to that pollution represented by the third category. It is proposed to sample and examine those parameters that will best determine the levels, periodicity and the effects that these pollutants might have on the receiving waters and those organisms living in the affected waters. This is the first step of many in assessing the pollution contributed by fish cultural activities and leading eventually to the total clean- up of said pollution.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1200, CHEMICAL QUALITY OF BRINES ASSOCIATED WITH DEEP SEDIMENTS BENEATH GREAT SALT LAKE

W.P. HEWITT, Univ. of Utah, State Geolog. & Min. Surv. , *Salt Lake City, Utah* 84112

Brine samples from a few judiciously placed deep holes, drilled to a depth of possibly 700 feet beneath the bottom of the Lake, are to be analyzed for their chemical quality. The object of this study is two-fold: first, to attempt to determine whether deep brines exist; second, to learn whether the heavy brines of the Lake proper are slowly sinking in the form of an inverted bubble.

SUPPORTED BY Utah State Government

5.1201, SALT DISTRIBUTION ALONG LAKE BOTTOM AND WITHIN DEEP SEDIMENTS BENEATH GREAT SALT LAKE

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Measurements are to be obtained of the areal extent and depth of the sodium chloride that is being deposited on the Lake's bottom. By means of a Sparker Survey it is hoped to outline buried beds of Glauber's salt that have been precipitated from Lake Bonneville during the Quaternary. This program will be undertaken, in whole or in part, during the fiscal year that starts July 1, 1965.

Status: Work to commence on thickness of sodium chloride in northern arm of Lake in mid August 1966. Sparker survey work deferred to 1969.

SUPPORTED BY Utah State Government

5.1202, MICROBIAL ECOLOGY OF LAKE CHAMPLAIN AS INFLUENCED BY PESTICIDES

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Project Objectives: 1. To obtain an ecological evaluation of the various types of microorganisms present in the waters of Lake Champlain. 2. To determine the influence of microorganisms on pesticides in an aquatic environment. 3. To determine the influence of pesticides on the number and distribution of microorganisms in an aquatic environment. Description of Work Proposed. The aquatic microbial ecology in areas adjacent the Vermont shoreline and relatively free of agricultural chemicals will be examined by standard microbiological procedures for culturing and enumerating microorganisms in natural environments. This will be correlated with basic limnological data such as dissolved oxygen, temperature, etc. obtained by other investigators who will employ the same sampling stations. Special emphasis will be placed upon those groups of bacteria that are active in organic matter decomposition such as nitrogen transformations. This laboratory has been active in studies with nitrogen transforming bacteria (3,5,6,7,8).

SUPPORTED BY U.S. Dept. of Agriculture
Vermont State Government

5.1203, LIMNOLOGICAL STUDIES OF LAKE CHAMPLAIN

M. POTASH, Univ. of Vermont, Agricultural Experiment Sta. , *Burlington, Vermont* 05401

Objectives: To carry out field studies on Lake Champlain to determine as far as possible, its physical, chemical, and biological characteristics; and to continue long-term studies to determine whether these characteristics are being altered in any harmful way, or in any region of the lake, by the addition of pollutants.

Procedure: Present studies of three bays will be enlarged to encompass the entire lake, although emphasis will be concentrated on the eastern or Vermont shore. An additional 16-foot boat is requested to permit greater lake coverage. Transects of the lake will be established at approximately 5-mile intervals along the 112 miles length of the lake. Individual stations will be established at quarter- mile intervals along each transect, with physical and chemical measurements being made at standard depth intervals for each station.

Temperature measurements will be made with an electronic thermometer in shallow waters, and with a bathythermograph at deeper stations. Light transparency will be measured with a Secchi disc through the use of drogues with current drags lowered to standard depths.

SUPPORTED BY U.S. Dept. of Agriculture
Vermont State Government

5.1204, ECONOMIC ANALYSIS OF RESOURCE POLLUTION BY PESTICIDES AND OTHER WASTE MATERIALS

J. BINIEK, U.S. Dept. of Agriculture, *Arlington, Virginia*

Objectives: To develop economic information and techniques of analysis to determine optimum compromises between production efficiency and adverse monetary and nonmonetary effects, which arise from deterioration of the quality of resources.

Approach: Formal and informal cooperative relations are established with other research and action agencies to the exchange of information and data. Multidareciplinary research and information is reviewed and analyzed to determine the severity of specific pollution problems. Conceptual and qualitative studies are undertaken to improve analytical techniques for appraisal of adverse impact situations. Alternative pollution control systems are analyzed with the intent of selecting an optimum control system for policy decisions.

SUPPORTED BY U.S. Dept. of Agriculture

5.1205, THE BEHAVIOR AND FATE OF DDT AND ZECTRAN IN A FOREST SOIL

E.G. DUNFORD, U.S. Dept. of Agriculture, Forest Service, *Arlington, Virginia* 22209

Object: To determine the movement, chemical change and resulting distribution pattern of DDT and Zectran applied to Douglas fir soils and the effects of environment, land and forest treatments on such reactions.

Plan of Work: During the first 2 years of the 3-year project, the investigators will concentrate on field observations, (1) measuring the relationships between the insecticides and the forest soil and environment, and (2) determining the effect of various land and forest treatments on the behavior of the two insecticides. All work, including analysis and interpretation, will be completed the third year.

SUPPORTED BY U.S. Dept. of Agriculture

5.1206, AN EVALUATION OF THE INSECTICIDE SEVIN AS A WATERSHED POLLUTANT

E.G. DUNFORD, U.S. Dept. of Agriculture, Forest Service, *Arlington, Virginia* 22209

Object: To provide information upon which to judge the potential of 'Sevin' as an environmental pollutant in forested areas.

Plan of Work: A study area has been established on the Shackham Brook Watershed in central New York. It encompasses a 'treatment' and 'control' subwatershed. The treatment area will receive an aerial application of Sevin; then samples of soil, water, and aquatic insects will be taken at frequent intervals to be tested for the presence and concentration of Sevin residues. Results will be evaluated.

SUPPORTED BY U.S. Dept. of Agriculture

5.1207, THE EFFECT OF DETERGENTS ON THE OXYGENATION OF WATER

J.A. CASKEY, Virginia Polytechnic Institute, Graduate School, *Blacksburg, Virginia* 24061

Although many studies have been made showing that surfactants can lower oxygenation rates the mechanism by which this occurs is not known. The purpose of this investigation is to study what part of the surfactant molecule is responsible for this interfacial resistance to oxygenation. To this end the effect of following parameters on the interfacial resistance will be studied: hydrophobic chain length, hydrophilic functional group, surface orientation and counter ion effect. Pure surfactants will be used so that the resistance can be related to the surface concentration by means of Gibbs' adsorption isotherm.

A quiescent liquid manometric gas absorption contactor will be used for the study. From this investigation it is hoped that it will be possible to specify what type of detergent is needed to increase the capacity of existing activated sludge units in municipal waste treatment facilities.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Virginia Polytechnic Institute

5.1208, THE DISPOSITION OF PESTICIDES IN THE SOIL

T.B. HUTCHESON, Virginia Polytechnic Institute, Agricultural Experiment Sta., *Blacksburg, Virginia* 24061

Objectives: (a) To determine the distribution of pesticides in selected soils and their drainage waters, using sites to which known amounts of pesticides have been applied. (b) To determine the physical, chemical, and biological processes, and soil characteristics which are important in the disposition of pesticides in soils.

Description of work: Field plots will be located to which known amounts of heptachlor have been added representing a wide range of soil physical, chemical, and mineralogical properties. 'Matching' soil sites will also be selected which have known histories of no heptachlor application. Soils from these pair sites will be brought into the laboratory and greenhouse where persistence, degradation rate, and the movement of heptachlor and subsequent contamination of crop plants will be correlated with basic soil properties. Physical and chemical mechanisms affecting sorption, degradation and persistence of heptachlor and diazinon and the resulting contamination of crop plants, soils and agricultural waters will be studied by correlation of basic soil properties with reaction rates and plant uptake following application of these chemicals to soils under greenhouse and/or field conditions.

SUPPORTED BY U.S. Dept. of Agriculture
Virginia State Government

5.1209, REMOVAL OF TRACE ORGANICS FROM WATER BY ADSORPTION ON COAL

P.H. KING, Virginia Polytechnic Institute, School of Engineering, *Blacksburg, Virginia* 24061

The proposed research involves laboratory investigations to determine the extent of adsorption of trace quantities of biochemically resistant organic materials on coal. Specific methods to be employed include both batch and fluidized column studies utilizing a variety of selected solutes with a wide range of physical and chemical properties. Data obtained will be analyzed to show the kinetics of the adsorption process. The distribution of organic material between the aqueous phase and the adsorbed portion will be described if possible by an appropriate adsorption isotherm. The extent of adsorption on coal will be compared with similar data for activated carbon.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Virginia Polytechnic Institute

5.1210, A COMPUTER PROGRAM FOR FORECASTING POLLUTION AND DISSOLVED OXYGEN IN STREAMS

R.G. KRUTCHKOFF, Virginia Polytechnic Institute, Graduate School, *Blacksburg, Virginia* 24061

In a recent research project 'A Stochastic Model for Pollution and Dissolved Oxygen in Streams', the principal investigator wrote a computer program which could predict the probability distribution of pollution and disolved oxygen in streams as a function of the initial pollution and the stream parameters. This program suffers from two inadequacies which makes its use limited in practice. 1. It does not allow for changes in stream parameters along the stretch due to differences in stream beds, stream widths or a stream junction. 2. It does not permit the inclusion of more than one major source of pollution.

The inadequacies can be eliminated. The theory worked out for the original project should be sufficient to allow the changes necessary to eliminate the inadequacies of the program. The principal investigator and one graduate student will rederive the original program including these new features.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Virginia Polytechnic Institute

5.1211, A STOCHASTIC MODEL FOR POLLUTION IN ESTUARIES

R.G. KRUTCHKOFF, Virginia Polytechnic Institute, Research Division, *Blacksburg, Virginia* 24061

The purpose of this investigation is to find a stochastic model for pollution and dissolved oxygen in estuaries. With this model it will be possible to predict the proportion of time that pollution will be above any given concentration or that dissolved oxygen will be below any given level. It is hoped that this information will result in better management of water resource systems and aid in forming more realistic restrictions on the use of estuaries for disposal of pollutants.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1212, TREATMENT OF DYEING BATH WASTE STREAMS BY FOAMING AND FLOTATION TECHNIQUE

D.L. MICHELSEN, Virginia Polytechnic Institute, School of Engineering, *Blacksburg, Virginia* 24061

The treatment of waste streams from dyeing operations is a problem in industrial waste treatment centering in the southeastern states. The proposed research plan will be the study of waste treatment and color removal of dispersed dye bath waste streams using foaming techniques. The initial stream to be studied will be a synthetic black or blue-black dispersed dye formulation including carrier approximating waste stream conditions from the dyeing of polyesters (Dacron) and triacetate rayon. The object of the work will be to study the removal of color, carrier (solvent), and perhaps dispersant surfactant using foam fractionation, adsorptive bubble fractionation and homogeneous ion flotation (complexing). Various parameters will be studied.

Depending on the outcome, the treatment of waste streams from other types of dyeing procedures may be tested using foaming techniques.

Some exploratory work on the removal of dissolved phenol and phenol derivatives from water may also be explored. This problem is pertinent to waste treatment because of toxicity and fish taste.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Virginia Polytechnic Institute

5.1213, MICROBIAL RELEASE OF SOLUBLE PHOSPHATE IN AN ACTIVATED SLUDGE ENVIRONMENT

C.W. RANDALL, Virginia Polytechnic Institute, School of Engineering, *Blacksburg, Virginia* 24061

The proposed research plan involves laboratory investigation directed at evaluating the factors which affect the microbial release of phosphate back to solution after uptake by an activated sludge system has occurred. The primary approach is to evaluate the effect of activated sludge process operational parameters such as dissolved oxygen and ORP levels, rate and duration of aeration, loading conditions, duration of anaerobiosis, etc., on release of soluble phosphate from the activated sludge microorganisms. A second area of investigation is the ability of various chemicals to stimulate or inhibit activated sludge phosphate release.

Parameter evaluation would employ the following methods. 1. Small scale batch-type experiments to study the effect of the various operational parameters individually. 2. Continuous flow experiments to further study the parameters and their combined effect, and to determine the feasibility of process modification.

Investigation of chemical effects will employ the following methods. 1. Batch-type experiments of individual chemical effects. 2. Warburg respirometer studies to determine lasting effects of chemical addition on sludge performance.

Data will be correlated for clarification of the basic mechanisms of soluble phosphate release from activated sludge microorganisms.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Virginia Polytechnic Institute

5.1214, CW-BW WATER DECONTAMINATION SET

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Objective: Technical Objective: Develop a method of destroying and/or removing chemical and biological agents in water to make it suitable for drinking purposes. Equipment and methods should be compatible with existing standard 600, 1500, and 3000 GPH field water purification units and utilize only items of equipment currently standard in military supply systems.

Approach: Conduct laboratory and field studies jointly with the chemical research and development laboratories relative to developing an effective procedure for decontaminating water containing chemical and biological agents.

Progress- Aug 66 Mar 68: A CW-BW water decontamination procedure was developed for removing these agents from water, as pretreatment with standard U.S. Army Erdlator-type water purification units. The procedure consists of a superhypochlorination to 100 PPM available chlorine followed by treatment with 600 PPM activated carbon. The procedure is used prior to, and in series with, the standard Erdlator units. The procedure completed ET/ST by TECOM and proved satisfactory in destroying GA, GB and BZ in water but failed under all conditions to meet the low drinking water levels of established MPCS for VX, L and HN-1. A check test is planned during the summer of calendar year 1968 to resolve the difficulties. Mixed agents will be used and also nerve gas GD, untried to date.

SUPPORTED BY U.S. Dept. of Defense - Army

5.1215, ION EXCHANGE UNIT, 3000 GPH

R.J. GAINEY, U.S. Army, Mobility Eqp. Res. & Dev. Ctr., *Fort Belvoir, Virginia* 22060

Technical Objective: This development will make available equipment for removal of dissolved radionuclides and other deleterious substances from water. Currently, there is no equipment available for removing soluble radioactive contaminants from water other than distillation, which is comparatively expensive. A secondary use will be to reduce the mineral content of some brackish water for drinking purposes or otherwise produce a high quality demineralized water supply.

Approach: After study of all available methods for removal of dissolved radionuclides from water, develop equipment with satisfactory military characteristics.

Progress: A truck mounted ion exchange unit was developed which had satisfactory operating characteristics but did not meet the transportability requirement. A transportable shelter mounted unit has been designed and a contract is being negotiated for a protopye test model.

SUPPORTED BY U.S. Dept. of Defense - Army

5.1216, SEEDING OF BRACKISH WATER

J.E. JONES, U.S. Army, Mobility Eqp. Res. & Dev. Ctr., *Fort Belvoir, Virginia* 22060

Technical Objective - An investigation to determine the techniques and processes feasible for the treatment of brackish waters having a high calcium sulfate content. No equipment is presently available for troop use which can be used to treat these waters. Sea water distillation equipment will become inoperative in a short period of time on such waters because of heavy deposits of sulfate scale in the evaporator.

Approach - The evaluation and the proving of factors found to be essential in the use of sulfate crystal nucleation technique to prevent calcium sulfate scale in evaporators of distillation equipment will be accomplished. Investigations and tests will be conducted to gain fundamental information relative to the behavior of calcium sulfate seed crystals in the applicable environments.

Progress - Jul 67 Jun 68. During the report period investigations were made into the configuration of thickening devices for the concentration and classification of the seed crystals for reuse and the probability of ingestion of steam bubbles into the recirculation pump. The present forced circulation horizontal tube test evaporator was evaluated for entrainment of steam bubbles into the suction of the recirculation pump. Steam bubbles that become ingested by the pump could cause erosion and premature pump failure. The evaporator was fitted with strategically located sight glasses and operated over its entire flow range to over eight feet per second under heating conditions. No bubbles could be seen ingested into the pump. A 200 GPH film spray horizontal tube evaporator belonging to the Office of Saline Water is to be modified for seeding techniques. This unit, which requires a relatively low brine recirculation rate compared with other evaporation methods, will be tested by MERDC at Roswell, N. M. The program has been delayed pending availability of the modified film spray evaporator for tests in Roswell.

SUPPORTED BY U.S. Dept. of Defense - Army

5.1217, DECONTAMINATION OF WATER CONTAINING CBR AND OTHER MATERIALS

D.C. LINDSTEN, U.S. Army, Engineer Research & Dev. Labs., *Fort Belvoir, Virginia* 22060

Technical Objective: Investigate reverse osmosis water purification process for decontaminating water containing CBR agents. Emphasize applicability of reverse osmosis for new proposed lightweight field water purification unit and squad type water purification requirements, with capability of removing CBR agents, turbidity, and excessive dissolved mineral matter.

Approach: Procure prototype reverse osmosis equipment. Conduct a laboratory inhouse study of equipment for removing simulated (non- pathogenic) microorganisms and selected radioisotopes from water. Cooperate with Edgewood Arsenal Research Laboratories (EARL) in study of reverse osmosis for removing chemical agents from water.

Progress: Jul 67 - Jun 68. Determine performance of the reverse osmosis (RO) water purification process for removing CBR agents from water. Establish joint investigation with Edgewood Arsenal studying RO for decontaminating water containing significant CW agents, with particular emphasis on V-agents, G-agents and incapacitants. Conduct laboratory studies in-house of RO for removing BW materials; including viruses, spores and cysts; and RW materials, including strontium 85, from water. Study potential water treatment methods of decontaminating water containing newly developed CW agents. Participate with Edgewood Arsenal in evaluation

SUPPORTED BY U.S. Dept. of Defense - Army

5.1218, COAGULANT DOSAGE TEST KIT

M. PRESSMAN, U.S. Army, Mobility Eqp. Res. & Dev. Ctr., *Fort Belvoir, Virginia* 22060

Objective: Develop a simple apparatus and procedure for determining optimum coagulant dosages in field water coagulation practice. It is anticipated that the use of the proposed kit will reduce operator reliance on visual observation and result in significant logistical advantages through more economical and efficient use of coagulation chemicals and improved water filtrability.

Approach: Construct experimental kits. Conduct field jar tests with these kits and compare dosages determined as optimum by kit test with the dosage required to give the best coagulation in the operation of standard field water purification units. Modify the field test kits and/or procedures, as required, to produce better correlation between dosages determined on optimum equipment operation and experimental procedures. Study coagulant dispensing techniques. Construct and evaluate model kits by assignment to personnel operating standard water purification equipment.

Progress: (July 67 - June 68) Several variations of test kit components and operating procedures were studied. Simple procedures for adding the ferric chloride and limestone coagulants and mixing were developed to give consistent results correlating to within 10 ppm of the optimum dosages of coagulants as determined through independent experimental procedures and equipment operation. The present kit consists of four (4) 8-ounce screw cap coagulation bottles marked at the 200 ml level in a plastic frame, an 8-ounce bottle of powdered limestone, a small (0.05 gram) scoop, a 2-ounce dropper bottle of ferric chloride solution (40 MG/ML), and a carrying case. Sketches of the kit have been prepared for in-house fabrication of a prototype unit.

SUPPORTED BY U.S. Dept. of Defense - Army

5.1219, WATER SUPPLY TECHNOLOGY - WATER QUALITY MANAGEMENT AND PROTECTION

R.P. SCHMITT, U.S. Army, Mobility Eqp. Res. & Dev. Ctr., *Fort Belvoir, Virginia* 22060

The proposed work under this project is primarily designed to provide a technological base for: (1) simple but effective methods of detecting and utilizing ground water in the field, (2) improved water purification methods for producing water from the earth's sources that are difficult to treat because of unusual sanitary or chemical quality, (3) methods of decontaminating water containing CBR agents, (4) improved methods of removing excessive mineral matter from water and (5) a simple effective method of purifying waste waters in order to renovate them for reuse. Specific investigations under the project include a determination of : (1) the technical feasibility of new methods of ground water exploitation, including a lightweight drilling apparatus, (2) the effects of various hydrophilic colloids and other contaminants on the efficiency of polyelectrolytes in testing fresh non-potable raw water, (3) methods for destroying newly developed lethal and incapacitating type chemical agents in water, including superoxidation and carbon, polymeric and molecular sieve adsorption, (4) scale prevention in distillation by seed nucleation, (5) reverse osmosis for removing CBR agents, excessive mineral matter and other undesirable substances from water, (6) centrifugation for water clarification and (7) methods of renovating waste water for reuse, including mixed media filtration.

SUPPORTED BY U.S. Dept. of Defense - Army

5.1220, INVESTIGATION FOR CONTROL OF WATER POLLUTION FROM COMBINED SEWERS IN ROANOKE, VIRGINIA

J.M. STRICKLAND, Hayes Seay Mattern & Mattern, *Roanoke, Virginia* 24007

The project includes the gathering of field and statistical data necessary to assess sanitary sewer overflow problems and preparing data in a manner that will be useful to others involved in a sewer overflow problem. The Plan of Procedure includes: 1. Smoke testing about 25 percent of system. 2. Gaging all major streams and overflows. 3. Establish design input rate of runoff and/or overflow to control units by hydrograph prepared from data collected. 5. Establish water quality of sewer overflows to permit design of remedial measures. 6. Establish relationship between collection system and sewage treatment plant in terms of quantity and quality of flow resulting from individual storms. 7. Establishment of the feasibility of programming mathematical models for computer analyses of the system hydraulics under various frequency and storm durations. 8. Preparation of preliminary designs and specifications upon which to base choice of alternative solutions in regard to existing tehcnology and new technology. 9. Estimate of results from any proposed remedial measures.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1221, EFFECTS OF POLLUTANTS ON SUBMARINE PLANT SYNECOLOGY

M.A. DUBE, Western Washington State Coll., Graduate School, *Bellingham, Washington* 98225

The purpose of this study is to gain an understanding of the dynamics of subtidal marine plant communities which are exposed to industrial waste outfall as compared to the dynamics of communities located in waters carrying less industrial waste. When possible, the community dynamics will be studied in industrial areas before and after the developemnt of the industrial installation. Communities closer to the source of industrial waste will be contrasted with those farther away to determine basic differences in (a) plant community structure, (b) productivity of the plant community, (c) the reproductive output of the plants, and (d) plant successional pattern. For example, it may be found that a community which is affected by pollution is arrested in a condition resembling an early stage in the successional development of an undisturbed community.

An attempt will be made to interpret differences in community dynamics in terms of differences in environmental factors by comparing at each site (a) the degree of chemical enrichment and concentration of suspended particles in the water, (b) the degree of siltation of the plants and substrate, and (c) the role of primary consumers. Controlled experiments will be run when possible to determine the separate effects of these factors.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1222, ECONOMIC OPTIMIZATION OF SECONDARY TREATMENT AND DETERMINATION OF LOAD TO CONTROL BIOLOGICAL GROWTHS IN A STREAM

H. AMBERG, Crown Zellerbach Corporation, *Camas, Washington*

This project will seek to determine the costs of mechanically aerated lagoon treatment of pulp mill and paper mill wastes by examining in detail the comparison of retention time, aerated lagoon depth, basin configuration, recycle and parallel versus series operation of tow lagoons. Information will also be obtained concerning treatment achieved by multiple lower hp surface aerators compared to two high hp units. Further, the project will, by use of test streams, seek to determine the degree of treatment needed to prevent slime growth in the receiving stream.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Crown Zellerbach Corporation

5.1223, CLOSTRIDIUM OUTGROWTH AND TOXIN PRODUCTION DURING STORAGE OF SHELLFISH

T.H. ERICKSEN, U.S. Dept. of Hlth. Ed. & Wel. , Pac. Nw. Marine Hlth. Sc. Lab. , *Gig Harbor, Washington* 98335

Several experiments whereby Pacific oysters were fed Clostridium botulinum type E spores; shucked; stored at various temperatures and tested for toxin production have been completed. With completion of two or more experiments on effects of storage conditions on Cl. botulinum type E production in Pacific oysters, a report will be prepared for publication.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.1224, EVALUATION OF METHODS FOR QUANTITATION OF FECAL COLIFORM BACTERIA

T.H. ERICKSEN, U.S. Dept. of Hlth. Ed. & Wel. , Pac. Nw. Marine Hlth. Sc. Lab. , *Gig Harbor, Washington* 98335

Studies will be continued on the comparison of several methods for the testing of enumeration of fecal coliform organisms in the estuarine area. Among the methods that will be compared are: 24 hr. liquid method, membrane filter method and a plate count method.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.1225, EVALUATION OF METHODS FOR RECOVERY OF ENTEROBACTERIACEAE FROM MARINE SOURCES

J.C. HOFF, U.S. Dept. of Hlth. Ed. & Wel. , Pac. Nw. Marine Hlth. Sc. Lab. , *Gig Harbor, Washington* 98335

Comparisons of conventional enrichment and isolation media will be made for the detection of pathogenic enterobacteriaceae in estuarine water and shellfish samples. Where necessary, methodology will be improved to meet the unique requirements for the isolation and enumeration of these pathogenic organisms from the marine environment.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.1226, INCIDENCE OF PATHOGENIC ENTEROBACTERIACEAE AND ENTEROVIRUSES IN ESTUARINE AREAS

J.C. HOFF, U.S. Dept. of Hlth. Ed. & Wel. , Pac. Nw. Marine Hlth. Sc. Lab. , *Gig Harbor, Washington* 98335

Studies on the incidence of pathogenic bacteria and viruses in estuarine areas will be initiated. A sampler based on the gauze pad method will be used to concentrate the microorganisms present in the water. Several estuarine areas in Puget Sound, Washington, of varying known bacteriological quality will be studied.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.1227, ACCUMULATION AND ELIMINATION OF VIRUSES BY SHELLFISH

J.C. HOFF, U.S. Dept. of Hlth. Ed. & Wel. , Pac. Nw. Marine Hlth. Sc. Lab. , *Gig Harbor, Washington* 98335

Studies will be continued on the effects of the state of poliovirus on accumulation and elimination characteristics in West Coast species of shellfish. Feces from vaccinated individuals containing high levels of attenuated poliovirus will be examined by differential centrifugation to determine the nature of the association of the virus with fecal material. This natural virus reservoir will also be used in accumulation-elimination experiments using Olympia oysters (Ostrea lurida).

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.1228, DEVELOPMENT OF METHODOLOGY FOR ISOLATION OF VIRUSES FROM SEA WATER

W. JAKUBOWSKI, U.S. Dept. of Hlth. Ed. & Wel. , Pac. Nw. Marine Hlth. Sc. Lab. , *Gig Harbor, Washington* 98335

The efficiency of various types of particulate matter as adsorbing agents for the concentration of the virus particles present will be tested under laboratory conditions. The effects of various factors such as presence of dissolved organic matter, salinity and state of the virus on the efficiency of the process will be determined.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.1229, BACTERIAL DEPURATION OF WEST COAST SHELLFISH

G.J. VASCONCELOS, U.S. Dept. of Hlth. Ed. & Wel. , Pac. Nw. Marine Hlth. Sc. Lab. , *Gig Harbor, Washington* 98335

Studies will be continued on the influence of salinity and turbidity on the depuration of Manila clams (Tapes japonica). Studies will be initiated on effect of chemical and physical factors on the depuration of Pacific oysters (Crassostrea gigas). Pilot plant studies on depuration, utilizing the information gathered to date, will be initiated.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.1230, MASS MORTALITY OF PACIFIC OYSTERS ALONG THE WASHINGTON COAST

C. LINDSAY, State Dept. of Fisheries, *Olympia, Washington* (14-17-0001-1900)

The Department of Fisheries will conduct field and environmental studies on mass mortalities affecting Pacific Oysters as set forth in the following phases: Phase I. Monitoring of Mortality and Growth of Pacific Oyster Seed from 5 Source Areas. 1. Japan, Hokina (High mortality area). 2. Japan, Mongoku-ura (Low mortality area). 3. Washington, Dabob Bay. 4. Washington, Willapa Bay. 5. Canada, Pendrell Sound. Phase II. Float Studies, Eld Inlet. Mortality, growth, fatness, glycogen and histology of 1965 year class (planting) oysters from beds of LeRoy Patterson. Phase III. Transplant Study. Patterson 1965 year class (planting) oysters previously planted at Quilcene Bay, Eld Inlet (Matthews) and Eld Inlet (Brenners) will be transplanted from each station to the other two. Mortality, growth, fatness, glycogen and histology will be monitored. Phase IV. Mortality Monitoring. 1966 (planting) year class Patterson oysters at Case, Eld, and Totten Inlets and Oakland and Quilcene Bays. Phase V. Commercial Oyster-bed Mortality Monitoring. Northern, central, and southern Puget Sound, Grays Harbor, and Willapa Bay. Phase VI. Cultural Experiments to Circumvent Mortalities. 1967 Japanese year class seed planted and reared in Oakland Bay will be transplanted to North Bay. Commercial stocks (1967) reared in North Bay will be used for controls. Phase VII. Hydrographic Sampling. 1. Continuous recording of water temperature adjacent to oyster stocks at the sampling stations in Quilcene Bay, Eld Inlet (Matthews), and Eld Inlet (Brenners). 2. Eld Inlet. A. Center line of inlet. Vertical distribution of salinity, temperature, O2, chlorophyll and phosphate. B. Shallow oyster beds. Photosynthetic rate, chlorophyll, phytoplankton species, pH, temperature, salinity, O2, total and inorganic phosphates, nitrate, nitrite ammonia, soluble and particulate carbohydrates and organic nitrogen, lipids. 3. Quilcene Bay, Oakland Bay, Totten Inlet, and Case Inlet. Salinity, temperature, O2, chlorophyll, phytoplankton and phosphate. Phase VIII. Standardization of Data Collection Processing and Analysis.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

5.1231, PESTICIDE RESIDUE STUDY IN SPORT FISH WATERS

W. BRUNSON, State Dept. of Game, *Olympia*, *Washington*

Objective: To monitor levels of pesticide residues in hatchery and other game fish management waters and to evaluate the rate of the effect in fish mortalities.

Procedures: Hold live fish to determine effect of various concentration of pesticides. Determine stress by measuring amounts of 'stress hormones' cortisone and hydrocortisone released in the vascular system.

Establish sand-charcoal filters. The correct proportions of sand and charcoal and length of effective service will be determined by analyses of the effluent.

Conduct gas chromatographic, histopathological and chemical analysis on samples furnished and prepared by Mr. Wayne Brunson, Biologist II, Aquatic.

Prepare reports as well as preparing appropriate aspects of the project for publication in scientific journals.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Washington State Government

5.1232, ECOLOGY OF NEMATODES IN IRRIGATION WATER

L.R. FAULKNER, Washington State University, Irrigated Agr. Res. & Ex. Ctr., *Prosser*, *Washington* 99350

Investigations are proposed to ascertain the effects of various factors on longevity of nematodes in water and to evaluate nematode contaminated irrigation water as a source of infestations. Longevity of nematodes in water will be determined by suspending mesh cages containing monospecific populations in streams, canals, settling basins and lakes. Effects of temperature, pH, salinity, aeration and microbes will be determined by placing similar cages in controlled temperature baths equipped for water renewal and aeration. Survival will be ascertained by using vital stains and ability of nematodes to recolonize.

Effects of contaminated water on introduction of nematodes into non-infested soils will be studied in fumigated soil beds. The beds will be planted to selected indicator hosts and irrigated with canal or well water. Records will be kept on numbers and kinds of nematodes introduced with water, seasonal population trends, and time required for appearance of economic infestations.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Washington State University

5.1233, STUDIES ON APPLICATION OF RADIOISOTOPE TECHNIQUES IN STREAM POLLUTION PROBLEMS IN THE PULP AND PAPER INDUSTRY

R.M. CHATTERS, Washington State University, School of Engineering, *Pullman*, *Washington* 99163 (AT(45-1)1951)

Previous research has shown that paper pulp can be successfully tagged with iridium. Iridium is ideal since it is not normally present in pulp and paper mill systems and it can be activated to produce iridium-192 as a tracer with an appropriate half-life for the application. Current effort is directed toward in-mill research on those problems which the Northwest Pulp and Paper Association deem to be most urgent to reduce the amount of waste material which enters the public waterways. The work encompasses the spectrum from laboratory through actual testing in the plant systems. In addition, attempts will be made to trace additives such as filler clays, TiO2, alum, and sizing agents using the technique of activation analysis.

SUPPORTED BY U.S. Atomic Energy Commission

5.1234, THE PREDICTION OF WATER QUALITY ASPECTS OF THE WENATCHEE RIVER

H.D. COPP, Washington State University, School of Engineering, *Pullman*, *Washington* 99163

A pumped-storage hydroelectric power development has been proposed by the Sponsor on the Wenatchee River, a mountain stream in north central Washington State. Since this river is an important fish spawning stream, tributary to the Columbia River, and since recreation activity is increasing in the watershed, influences of the proposed power project on existing water quality need to be predicted.

Simulation techniques by digital computer are being developed for prediction purposes. Weather phenomena, system hydrology, heat transfer, principles and mixing processes have been programmed for both reservoir and stream waters to compute temperatures and oxygen and nitrogen contents in these waters. A program is operable and is quite general, i.e., it is not tied to the system under consideration. At present, July 1967, program optimization, process simulation mechanics, and logic continuity are under critical review.

SUPPORTED BY Chelan County Government - Washington

5.1235, ADVANCE WARNING OF GROUND-WATER POLLUTION HAZARDS, WITH SPECIAL REFERENCE TO AQUIFERS IN GLACIAL OUTWASH

J.W. CROSBY, Washington State University, Graduate School, *Pullman*, *Washington* 99163

It is proposed to study methods of providing advance warnings of pollution build-up so that public health hazards can be avoided. The research is to be done on the Spokane Valley aquifer where conditions now exist which are conducive to contamination of the Spokane water supply. Geoelectrical methods, utilizing both standard and specially designed probes, will be investigated and comparison drawn between electrical properties of the groundwater and water quality analyses. The desirable end result of the project would be to establish rapid, routine methods of identifying polluted zones in stratified groundwaters.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Washington State University

5.1236, ECOLOGY OF SELECTED AQUATIC BACTERIA IN THE SNAKE RIVER

C.H. DRAKE, Washington State University, Graduate School, *Pullman*, *Washington* 99163

This study is an investigation of several selected groups of aquatic bacteria occurring in natural waters. Their fluctuations in numbers will be followed over a considerable period of time to see the effect of season, temperature and other variables. There is an excellent opportunity to follow changes in the Snake River since at one point it has received almost no pollution in a distance of almost 200 miles. Then, it shortly receives the sewage of two cities and considerable sulfite waste liquor from a paper pulp plant. Cultural studies as well as observations on periphytic bacteria will be made above and below these points to see the effect these additions have on the normal bacterial flora, particularly in regard to certain sulfur bacteria. Other natural aquatic bacteria will also be studied to see how they are affected by these changes in ecology. This will supply basic data on the steam before its ecology is drastically changed by the imminent construction of a dam near here.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Washington State University

5.1237, OCCURRENCE OF PESTICIDES IN AQUATIC ENVIRONMENTS

E. HINDIN, Washington State University, School of Engineering, *Pullman, Washington* 99163

The method of transport to and the occurrence of pesticides in the aquatic environment is of extreme interest today. The increased use of pesticides for achieving higher agricultural and silvacultural productivity has allowed a greater amount of pesticides to enter into the aquatic environment. Though these amounts are generally in sublethal dosages, their presence constitutes a potential hazard. Certain pesticides can be concentrated in tissues of most organisms, thus entering in the food cycle of organisms in the aquatic habitat.

The purpose of this study is two fold. One purpose is to study the distribution of a chlorinated organic and organic phosphorus insecticide on an agricultural plot receiving insecticide application. A distribution budget will be made from analysis of soil, plant, and insecticide removal by irrigation runoff water and loss to the atmosphere taken throughout the growing season. Particular attention will be paid to that amount being carried off by the irrigation runoff water. During the second year insecticides will not be applied. A distribution budget will be made of the insecticides present on the plot. Emphasis will be placed on the insecticides leaching off the field in the irrigation runoff water.

The second purpose of the study is to determine the seasonal variation in the pesticide content of a dimictic and of a polymictic reservoir. Comparison will be made of the pesticide content of the water at specific depths, i.e. Epilimnion, Metalimnion and Hypolimnion. The surface inflows and outflows to the reservoirs will be sampled to better assess the pesticide variation. Samples of aquatic organisms, i.e., plankton, benthos, fish and snails, will be taken to determine the concentration of pesticides in organisms inhabiting the reservoir. Comparisons will be made of the pesticide content of those organisms feeding at specific depths.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1238, CLAY MINERAL STABILITY AND WATER COMPOSITION

J.A. KITTRICK, Washington State University, School of Agriculture, *Pullman, Washington* 99163

It is anticipated that this project would contribute to a better understanding of how the relatively small group of minerals that dominate soils and sediments control and are in turn altered by, the composition of waters with which they are in contact. The specific aim of this project is to obtain standard free energy of formation values of several of these minerals by solubility measurements and to correlate these free energy values with what is known of mineral occurrence and water composition in soils and sediments.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1239, SOILS, PESTICIDES AND THE QUALITY OF WATER

C.D. MOODIE, Washington State University, Agricultural Experiment Sta., *Pullman, Washington* 99163

1. To establish whether movement through the soil constitutes a significant source of the pesticides found in surface and ground water. 2. To identify the properties of pesticides and of soils that control the extent of movement of pesticides in and through soils. 3. To ascertain the solubility characteristics of pesticides sorbed on soil particles and hence the effect of suspended soil on the concentrations of pesticides in water. 4. To ascertain the effects of management of pesticides and land on the transport, by all means, of pesticides to water supplies.

The mobility of pesticides in soils of different properties is to be determined by use of soil columns operated as miniature lysimeters. By appropriate arrangement, the lysimeter can represent various zones or combinations of zones within the root zone of plants. The transport from pesticide-treated to untreated soil layers or to ground water can be followed as affected by such variables as pesticide solubility, dispersability and formulation, soil texture and organic matter, irrigation regime and water quality. The desorption of pesticides from soil into water that may take place as pesticide-treated soil is eroded and suspended in runoff and stream waters. The significance of soil pesticide ratio, and soil properties (clay type, particle size, organic colloid, ion saturation, etc.) will be evaluated.

SUPPORTED BY U.S. Dept. of Agriculture
Washington State Government

5.1240, LAGOONS FOR DAIRY FARMS

J. ROBERTS, Washington State University, Agricultural Experiment Sta., *Pullman, Washington* 99163

This is a project between the Division of Industrial Research and the Agricultural Experiment Stations. The cooperators are the Sanitary Engineering Section of the Division of Industrial Research and the Departments of Agricultural Engineering and Dairy Science. Four lagoons will be constructed at the Knott Dairy Farm.

The objectives will be to study the bacteriological factors involved in the breakdown of cow manure and methods of speeding up the bacterial action and the management factors, including costs, labor, and water requirements so that design criteria may be developed and made available.

The study as designed will include a comparison of the effectiveness of the three-stage process with recirculation of two different wastes--municipal wastes, and dairy wastes consisting of excreta from dairy cows. Facilities have already been constructed and they are now in operation at the city disposal plant.

Four ponds will be constructed at the Knott Dairy Farm. Plans include placing a diversion box in the present sewer line so that all or any part of the discharge from the present line may be conveyed into the experimental lagoons. The amount of manure from the holding pends that is conveyed into the lagoons can be controlled by the amount of washing done to the feed yards.

SUPPORTED BY Washington State Government

5.1241, THE BIOLOGY AND CHEMISTRY OF SPHAEROTILUS

J.L. STOKES, Washington State University, Graduate School, *Pullman, Washington* 99163

The possibility of chemautotrophic growth of Sphaerotilus discophorus, based on oxidation of manganous and ferrous ions, will be explored. Also, the heterotrophic metabolism of Sphaerotilus will be investigated with respect to formation and utilization of poly-B- hydroxybutyrate, lysis and control mechanisms.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1242, FLUSHING OF SMALL SHALLOW LAKES

E.R. TINNEY, Washington State University, School of Engineering, *Pullman, Washington* 99163

In recent years the quality of lake waters has become increasingly important, first because of the growing demand for recreational uses and, second because the use of lakes and adjacent lands has accelerated their deterioration. Research studies too numerous to mention have dealt with the quality of lake waters but most of the previous work is related to eutrophication and the biological processes involved. In recent years some studies have been made on the currents in a lake which markedly affect the limnological behavior but these studies have, for the most part, dealt with mixing phenomena associated with wind and the density currents associated with solar heating and relatively cold inflows.

The question of how best to improve a small lake by enhancing natural flushing has received little attention. This proposal treats this particular problem with specific attention to the flushing of a small shallow lake. The primary objective of this study will be to clarify the flushing phenomena in small lakes, recognizing that mixing is also enhanced in natural water bodies by wind and solar heating. Hopefully the end result of this would be an explanation of flushing that would indicate how much and in what manner water should be introduced into a class of small lakes to achieve a prescribed flushing action.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1243, ALUMINA COLUMNS FOR THE SELECTIVE REMOVAL OF PHOSPHORUS FROM WASTEWATERS AND THE ULTIMATE DISPOSAL OF PHOSPHORUS AS CALCIUM PHOSPHATE

L.L. AMES, Battelle Memorial Institute, *Richland, Washington* 99352

The proposed study objectives are: (1) to evaluate operating parameters of alumina (boehmite) columns for the selective removal of phosphorus from secondary sewage effluents and other phosphorus - containing waste-waters; and (2) to study alumina regeneration and phosphorus recovery for production of a saleable calcium phosphate product. The research will include studies of (1) boehmite column operating parameters, (2) effect of sodium hydroxide on phosphorus elution from boehmite, (3) elution of phosphorus from sodium hydroxide solutions, and (5) weight loss of the boehmite column with cyclic use.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1244, MECHANISMS OF ENVIRONMENTAL EXPOSURE

J.F. HONSTEAD, Battelle Memorial Institute, *Richland, Washington* 99352

Effluents from Hanford production facilities transport a certain amount of radioactive material into the populated environment adjacent to the plant, principally by way of the Columbia River. Radionuclides from these effluents may provide a significant portion of the radiation exposure of certain population groups as the result of a variety of mechanisms which transfer them through food chains into man or into his immediate environment. To provide a continuing evaluation of such exposure to local population groups requires an appreciation of the amount and rate of transfer of radionuclides through the environs and statistically the dietary habits and activities of the people involved. This project investigates quantitatively such mechanisms. Means of investigation are statistical studies of whole-body counting data and dietary questionnaires, and associated population surveys. Controlled ingestion experiments utilizing locally-produced foods are also part of the investigation. Of particular interest is large-scale whole body counting experience with local school children. These measurements are accompanied by a dietary study.

SUPPORTED BY U.S. Atomic Energy Commission

5.1245, A THREE DIMENSIONAL STUDY OF PARAMETERS RELATED TO THE CURRENT DISTRIBUTION IN LAKE ROOSEVELT

R.T. JASKE, Battelle Memorial Institute, *Richland, Washington* 99352

The proposed research plan involves the measurement of flow jet currents within Lake Roosevelt during the stratified period in order to permit mathematical modeling of reservoir water quality, primarily temperature. The field data would be combined with four years of previously collected temperature data in order to develop additional assurance that jet currents and temperature profiles can be correlated. The resulting information would be used to develop equations of state and continuity for the reservoir hydraulic regime.

Field investigations would consist of: (1) A series of two dimensional flow profiles taken at from ten to fifteen stations selected axially to the current flow. (2) A concurrent set of temperature traverses and profiles taken simultaneously with the current measurements. (3) Aircraft surveys at intervals to map thermal gradients outside the scope of boat party surveys.

Laboratory investigations would include: (1) Statistical processing of collected data. (2) Operations research supporting development of input-output models of general application.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

5.1246, EFFECT OF REACTOR EFFLUENT ON QUALITY OF COLUMBIA RIVER WATER

R.T. JASKE, Battelle Memorial Institute, *Richland, Washington* 99352

Effluent cooling water from the Hanford production reactors has effects on the thermal and chemical characteristics, and radionuclides content of the Columbia River. Substantial quantities of the released effluents disperse throughout the mainstream and eventually interact to some extent with the environment. It is the purpose of this study to define the extent of this interaction by measurements of the appropriate upstream and downstream parameters for comparison and correlation. Included are the development of relatively sophisticated digital computer models which serve not only as analytical tools, but as a means of proving highly refined estimates of flow times, concentrations, and other time-dependent phenomena in the event of plant accident. Associated with this program are detailed investigations of dye and rare-earth tracer technologies, and the mechanisms associated with filter plant operation on radionuclide and inorganic ion concentration. This program includes the incidental analysis of the effects of upstream dam regulation (for the exportation of peaking power out of the region) on the temperature of the Columbia below the Hanford plant, as a result of the extreme variations in available dilution flow below Priest Rapids Dam.

SUPPORTED BY U.S. Atomic Energy Commission

5.1247, AMMONIA REMOVAL FROM AGRICULTURAL RUNOFF BY SELECTIVE ION EXCHANGE

B.W. MERCER, Battelle Memorial Institute, *Richland, Washington* 99352

The study is directed toward development and demonstration of a selective ion-exchange process for the removal of ammonia from wastewaters. Laboratory research involved the selection of a zeolite ion exchange material and acquisition of design data for a demonstration pilot plant. The study will result in the construction and demonstration of the process in a 100,000 gpd mobile pilot plant.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Battelle Memorial Institute

5.1248, RADIATION EFFECTS IN AQUATIC SYSTEMS

R.E. NAKATANI, Battelle Memorial Institute, *Richland, Washington* 99352 (AT(45-1)1830)

The effects of both internal and external radiation will be studied and the following kinds of investigation emphasized: (1) low level chronic radiation administered throughout the life span of aquatic organisms; (2) susceptibility of different life stages, (3) the competitive ability of irradiated populations, and (4) the combined effects of radiation regimes resulting from radioactive waste disposal in aquatic environments. Advantage will be taken of the numerous siblings available from fish, the relative ease of following embryonic development, the many meristic characters available as possible measures of radiation effects, and the relatively simpler system of fish compared to mammals. This project will contribute to basic radiation biology and, in addition, will provide data needed for improved prediction and understanding of the consequences of radiation exposure of the aquatic environment due to waste disposal of radioactive materials.

SUPPORTED BY U.S. Atomic Energy Commission

5.1249, COLUMBIA RIVER SEDIMENT STUDIES

J. NIELSEN, Battelle Memorial Institute, *Richland, Washington* 99352

PNL provides analytical services for the Columbia River and estuary studies being conducted by the USGS for the AEC, aids in the evaluation of the fate of the radionuclides, especially in the area of effect of retention by sediments, and conducts geochemical studies involving mechanisms of radioactivity uptake by the sediments.

SUPPORTED BY U.S. Atomic Energy Commission

5.1250, TREATMENT AND DISPOSAL OF CONDENSATE WASTES FROM HIGH LEVEL WASTE SOLIDIFICATION PROCESSES

A. PLATT, Battelle Memorial Institute, *Richland, Washington* 99352

A number of low and intermediate level waste side streams result from processes now being developed for the solidification of power reactor fuel reprocessing wastes. These side streams are characterized by low volume, high acid or salt content, and significant levels of radioisotopes, particularly those which exhibit high vapor pressures at the elevated temperatures involved in solidification. This program involves development of techniques for treatment and disposal of these waste side streams.

A number of concepts including precipitation, fractional distillation, scavenging, and crystallization have been evaluated, present emphasis is being placed on sulfate distillation and incorporation of residue in asphalt. Studies will be extended to actual waste streams when they become available in the near future from a current demonstration of waste solidification. The program was initiated in FY'66 and is expected to be completed in FY'69.

SUPPORTED BY U.S. Atomic Energy Commission

5.1251, THERMAL EFFECTS ON MARINE AND ESTUARINE SHELLFISH

W.L. TEMPLETON, Battelle Memorial Institute, *Richland, Washington* 99352

Studies to determine the lethal temperatures, times to death at lethal temperatures, effects of sublethal temperatures on growth for various life stages of shellfish.

SUPPORTED BY No Formal Support Reported

5.1252, PRECIPITATION SCAVENGING

M.A. WOLF, Battelle Memorial Institute, *Richland, Washington* 99352 (AT(45-1)1830)

The studies are designed to determine the history and behavior of radioactive and other pollutants scavenged from the atmosphere and deposited on the earth by precipitation. Studies include transport to the scavenging site and below-cloud scavenging by precipitation.

This study is aimed at clarification of selected phases of the scavening process, the measurement of parameters needed for quantitative prediction of scavenging, and the adaptation or introduction of theories, thus providing information needed in reactor siting and hazards evaluation, and determining deposition of fallout from nuclear weapons or reactor accident.

SUPPORTED BY U.S. Atomic Energy Commission

5.1253, REDUCTION OF RADIOISOTOPES IN HANFORD REACTOR EFFLUENTS

R.G. GEIER, Douglas United Nuclear Inc., *Richland, Washington* 99352

The radionuclides in Hanford's reactor effluent are formed by neutron activation of salts not removed in the water pre-treatment process, salt additives, and corrosion products which adhere to the reactor coolant lines as a film long enough to become significantly activated.

This research includes both laboratory and in-reactor studies of the three methods of reducing effluent radioactivity: better methods of pre-treatment, reducing film adherence time, and effluent treatment.

SUPPORTED BY U.S. Atomic Energy Commission

5.1254, DUWAMISH RIVER-ELLIOTT BAY STORM WATER CONTROL SYSTEM

C.C. DONWORTH, Seattle City Government, *Seattle, Washington* 98104

This project will evaluate the effectiveness of using a computer for controlling regulator valves in order to maximuze utilization of the available capacity of the sewer interceptors for in-system storage and optimize treatment plant loading dependent on receiving water conditions. The major features of this project are: 1. Five (5) automated regulator stations; 2. One (1) electronic process control computer; 3. One (1) central control station; 4. Selected water quality monitoring equipment; 5. Necessary controls and wiring needed for automated centralized controlled combined waste water storage and regulation system. This project will also include the necessary evaluation required to meet the demonstration program objectives.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Seattle City Government - Washington

5.1255, ENHANCEMENT OF WATER QUALITY USING FOREST DERIVED COAGULATING SYSTEMS

G.G. ALLAN, Univ. of Washington, Graduate School, *Seattle, Washington* 98122

Waste phenolic material from forest-based industries which presently find their way into water resources will be characterized with respect to molecular weight and polarity.

Correlation of these parameters with their performance as coagulants for water quality improvement will be attempted.

The effect of additional variations in molecular size and polarity on the coagulation characteristics will be explored by chemical modifications, using aldehydes, halogenotriazines, aziridines, oxiranes and quaternary nitrogen and phosphorus derivatives to achieve intermolecular condensation and a reduction in anionic functionality.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Washington

5.1256, ANNUAL PHYTOPLANKTON PRODUCTION IN PUGET SOUND WATERS

G.C. ANDERSON, Univ. of Washington, Graduate School, *Seattle, Washington* 98122

Studies of phytoplankton production are being continued in Puget Sound. The investigation, since 1964, has provided quantitative information on annual phytoplankton production and mean standing crop in two areas of the Sound.

The research proposed herein is to elucidate the reasons for the very large blooms off Seattle when maximum values of 6-7 g C/square meter are photosynthesized per day. Weekly, daily and diurnal sampling will be carried out during periods of high phytoplankton production along with measurements of hydrographic conditions, light and nutrients. Particular attention will be given to the effect of stability, as affected by tides and winds, on the timing of phytoplankton blooms. Measurements will be made of the chemical composition of the crop as well as growth rates of dominant species.

Experimental work involving studies of phytoplankton blooms in enclosed columns of water in situ will be carried out. In this manner, the effects of advection will be eliminated. Culture studies will be conducted with some of the herbivorous copepods.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1257, NITRATE REMOVAL FROM ACTIVATED SLUDGE SYSTEMS

D.A. CARLSON, Univ. of Washington, School of Engineering, *Seattle, Washington* 98122

The proposed research plan is concerned with the biological removal of nitrates in used waters. The investigations would be based on operation, analyses and observation of a pilot plant denitrification unit recently constructed at Municipality of Metropolitan Seattle's West Point Waste Treatment Plant.

Field observations would study effects of season, waste concentration and composition, and nitrogen concentrations on nitrate removal efficiencies of the pilot plant.

The pilot plant is constructed so as to permit modification of operational conditions so that the results of the pilot plant study can be used to predict optimal design conditions for construction of full scale plants to remove nitrates by biological means.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Washington

5.1258, WASTE WATER ODOR REDUCTION MECHANISMS IN SOIL FILTERS

D.A. CARLSON, Univ. of Washington, School of Engineering, *Seattle, Washington* 98122

The purpose of this study will be to investigate the process involved in the removal of odorous compounds in soil filters. Previous work at the University of Washington indicates that the process of hydrogen sulfide degradation in soil filters is biological in nature, but further research is needed to establish the organisms responsible, to attempt pure culture studies with isolated colonies to verify column activity, and to establish optimum conditions for their growth and ability to degrade test compounds.

Other phases of the research will consider changes in soil properties during test gas application, accumulation of deposited products in the soil, gas pressure requirements under various gas flow conditions and development of optimum conditions for long period use of soil filters.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1259, CHEMICAL CHARACTERISTICS OF ORGANIC COLOR IN WATER

R.F. CHRISTMAN, Univ. of Washington, School of Engineering, *Seattle, Washington* 98122

In previous research (WP-00558) effort was directed toward the development of a satisfactory degraditon technique for studying the chemical nature of color molecules. Now that such a technique is available support is herein requested to extend this research in the following specific areas: (1) Determination of the uniformity of chemical structure among the color producing molecules in waters from a variety of sources and the dependence of chemical structure on various environmental paramenters. (2) Investigation of the mechanismm of coagulation of organic color by hydrolysis products of Al(III) and Fe(III).

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1260, DISTRIBUTION OF DEMERSAL FISHES IN INSHORE WATERS

T.S. ENGLISH, Univ. of Washington, Graduate School, *Seattle, Washington* 98122

This study will consider distribution of demersal fishes with area, season, depth, bottom sediments, hydrographic variables, and available food. Samples will be taken with small otter trawls (16 foot headrope) and beam trawls (3-meter beam). The distance trawls travel over the sea bottom will be measured with a pacer; a record of trawl depth with time will be taken with a bathykymograph; a fathometer record will be kept. Fishes will be examined by species, length, weight, age, sex, sexual maturity, and stomach contents.

Data will be programmed for computer analysis. Analysis of variance techniques will be used to study main effects, interactions, and components of variance. Determinations of experimental error will be used to specify the density of sampling required to obtain confidence limits of stated length. Biomass changes will be related to several variables; species associations, feeding habits, condition factors, and seasonal cycles will be examined. Growth and mortality rates of young ages classes can be estimated by progression with season of length-frequency modes.

Results of this study will be integrated with results from concurrent research of other workers on benthic invertebrates - bottom environment and plankton production - pelagic environment.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1261, VERIFICATION OF MODELS USED IN THE MANAGEMENT AND CONTROL OF WATER QUALITY

B.W. MAR, Univ. of Washington, School of Engineering, *Seattle, Washington* 98122

The proposed research involves the utilization of data and models resulting from the State of Washington Water Quality studies to develop a generalized model for intra-industry waste discharge, to verify existing water quality models, and to formulate and evaluate a water management policy based on discharge rights.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Washington

5.1262, STUDIES OF LOW MOLECULAR WEIGHT LIGNIN SULFONATES

J.L. MCCARTHY, Univ. of Washington, School of Engineering, *Seattle, Washington* 98122

Research on the preparation and characterization of lignin sulfonates of low molecular weight and/or fractions of same, is to be continued.

In very recent work, it has been found that better controlled Sephadex chromatographic column separations are obtained when the experiments are conducted using aqueous solutions of approximately constant ionic strengths, i.e., under 'swamping' conditions. Since earlier experiments have been conducted without this control, we now propose that further Sephadex separation studies be conducted under conditions of constant ionic strength.

We also have found very recently that lignin sulfonate molecular weight averages, and, indeed approximations to the distribution of molecular weights, can be estimated effectively by use of a short column sedimentation equilibria technique. We now propose to apply this to the separated lignin sulfonate fractions. Other techniques of physical and organic characterization of lignin sulfonate will also be applied.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1263, STEAM STRIPPING OF KRAFT PULP MILL EFFLUENT STREAMS

J.L. MCCARTHY, Univ. of Washington, School of Engineering, *Seattle, Washington* 98122

The broad objective of the presently proposed research is to improve the effectiveness and to extend knowledge concerning the possible industrial applications of the 'SEKOR' process which, in essence, comprises the counter-current steam stripping of Kraft pulp mill condensate streams in order to bring about the removal of steam- volatile organic compounds from the fluid and thereby provide relatively clean effluent water which can be reused in pulp mill process or else discharged without danger. The volatilized organic substances are condensed to yield water-immiscible 'SEKOR oils' which may find uses in commerce. Use of the process may also result in a substantial decrease in the odorous substances emitted into the atmosphere from Kraft pulp mills.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1264, INTERNAL CURRENTS RESULTING FROM INTERMEDIATE DENSITY INFLOWS INTO STRATIFIED RESERVOIRS

R.E. NECE, Univ. of Washington, School of Engineering, *Seattle, Washington* 98122

The objective of this laboratory study is to investigate one of the mechanisms by which reservoirs become stratified. To be studied are the current structure and longitudinal and vertical distribution within the reservoir of waters which are intermediate in temperature between the warmer surface waters which have been exposed to solar heating and the colder, denser waters at great depth; the water of intermediate density enters the sloping inlet (original river channel) at the upstream end of the reservoir.

Specific objectives are to study the effects on reservoir current and temperature distributions of such variables as: temperature, depth,and velocity of the inflow stream; slope of inlet channel; and initial temperature profile in the reservoir. Preliminary studies are to be made using simple laboratory apparatus in which the above variables may be varied systematically.

Results are to be compared with other solutions (analytical and experimental) previously found in studies of selective withdrawal from reservoirs; these conditions prevail 'downstream' from the region to be studied here, in which stratified flow becomes established.

5. WATER QUALITY MANAGEMENT AND PROTECTION

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Washington

5.1265, SALT WATER ENTRAINMENT FOR DILUTION IN SEWER OUTFALLS

R.E. NECE, Univ. of Washington, School of Engineering, *Seattle, Washington* 98122

This investigation is an experimental and analytical study of the mechanism of the entrainment of a fluid into a conduit passing through an infinite volume of this ambient fluid and through which flows a different fluid. The particular motivation is to obtain basic information which could be applied in the sanitary engineering design of sewer outfalls discharging into salt water. In this case, where density differentials exist, entrainment of salt water into the outfall prior to ultimate discharge would decrease the density differential between effluent and receiving water, thereby decreasing the amount of diffusion necessary to produce acceptable sewage concentrations at the water surface. Such entrainment could be accomplished by providing appropriate inlets through the wall at a reduced-pressure 'venturi' section in the outfall pipe.

This study is to treat a few relatively simple geometries in some detail. Attention is to be focused on those factors influencing entrainment rates, namely: density and pressure differentials between ambient and initial conduit fluids, velocity of approach in the conduit, and inlet geometry. Mixing patterns within the conduit are to be studied. It is planned to extend the tests to the case of an ambient fluid which is in motion.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1266, SYSTEM ANALYSIS OF EUTROPHICATION CONTROL BY FLUSHING

R.T. OGLESBY, Univ. of Washington, School of Engineering, *Seattle, Washington* 98122

This research project is designed as an intensive study of a highly eutrophic lake before and after additions of nutrient poor flushing water. System analysis techniques will be applied to this information, together with data obtained through laboratory and field experiments, to meet the following objectives: (1) establish knowledge and information concerning the functional performance and effectiveness of flushing as a means of eutrophication control; (2) define the engineering concepts, design procedures, and design criteria necessary for the general application of this method; and (3) further understanding of the relationship of primary production to the environment in which it occurs. A further objective is to promote significant improvements in the water quality of that portion of the lake under study most densely inhabited and most intensively used for recreation.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1267, BACTERIOLOGICAL AND ESTHETIC OF PLEASURE BOAT WASTE DISCHARGE ON SMALL HARBORS

R.W. SEABLOOM, Univ. of Washington, School of Engineering, *Seattle, Washington* 98122

The proposed research will involve field studies to determine and document the bacteriological pollution caused by the waste discharge from small pleasure craft in small harbors. Both fresh water and salt water harbors will be studied. The possible esthetic degradation of water quality will also be determined by visual surveillance of the water during periods of maximum boat activity. The bacteriological analysis will be initiated in the field and will be by the membrane filter technique.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Washington

5.1268, COLUMBIA RIVER STUDIES

A.H. SEYMORE, Univ. of Washington, Graduate School, *Seattle, Washington* 98122

Of the four studies greatest attention will be given to the effects of 65Zn, 51Cr, and 90Sr on oyster larvae. Oysters are brought to the spawning condition in the laboratory by manipulation of water temperature. Upon fertilization the eggs are placed into containers each with two liters of water of various radionuclide concentration. The experiment is terminated two days after fertilization at which time the oyster is in the straight-hinge larvae state. Later the larvae are classified as normal and abnormal and counted. Information from this experiment is related to waste disposal, oyster growing and to the controversy concerning the effects of radionuclides upon pelagic eggs and larvae of marine fishes. In other studies the geographical limit of distribution of Columbia River water along the Washington coast will be determined by monitoring 65Zn in mussels; a compilation of Hanford produced radionuclides in marine organisms will be prepared; and, the biological half-life of zinc in oysters will be determined by use of 65Zn and a small animal whole body counter. After feeding 65Zn to the oysters for a day or two only at the beginning of the experiment 65Zn measurements will be made periodically of individual oysters living in a natural environment except for the time they are transferred to and from laboratory for whole body counting.

Although the above studies are a new program, prior work does provide some pertinent information. Mussels along the outer Washington coast have been monitored for 65 Zn but now the sampling will be extended into the Straits of Juan de Fuca and Puget Sound. Much information from several sources is available on Hanford produced radionuclides in marine organisms. These data will be compiled and supplemented by a limited amount of new information. Also in the past the biological half-life of zinc in oysters has been determined by destructive sampling from lots of oysters transferred between 65Zn contaminated and non-contaminated waters, Willipa Bay and Puget Sound respectively. This time the loss of 65ZN in individual oysters will be followed as the oyster will not need to be sacrificed to make the 65Zn measurement.

SUPPORTED BY U.S. Atomic Energy Commission

5.1269, PESPONSES OF FISH TO ENVIRONMENTAL STRESSES

L.S. SMITH, Univ. of Washington, Graduate School, *Seattle, Washington* 98122

To correlate changes in blood circulation and excretion of fish with changes in environmental stress.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1270, BIOLOGICAL MODELS OF FRESHWATER COMMUNITIES

F.B. TAUB, Univ. of Washington, Graduate School, *Seattle, Washington* 98122

Ecosystems with defined species composition will be constructed as models of natural communities.

The interrelationships between species diversity (the experimental variable) and species abundance, population stability and productivity on the population and ecosystem level will be studied.

When suitable models are achieved, the ecosystems will serve as test systems for various environmental stresses including the addition of nutrients (metropolitan pollution) and introduction of competing species (pest introduction).

The long-term goal is a better understanding of the mechanics that regulate natural communities and their ability to adjust to disturbance.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1271, INFLUENCE OF INDUSTRIAL AND MUNICIPAL WASTES ON ESTUARINE AND OFF SHORE WATER QUALITY

J.F. SANTOS, U.S. Dept. of Interior, Geological Survey, *Tacoma, Washington*

This project is being carried on in cooperation with the Municipality of Metropolitan Seattle.

A major objective is to study the influence of industrial and municipal waste disposal on all phases of water quality, chemical, physical, ecological, and sanitary in fresh, brackish, and saline environments. Measurements made with multiple parameter water quality recorders at four sites on the Duamish River estuary are the basis for the attempted correlations. Parameters recorded include dissolved oxygen, specific conductance, water temperature, pH, turbidity and solar radiation index. Computer programs will be written to analyze these data and to detect significant relations.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Seattle City Government - Washington

5.1272, POLLUTION PREVENTION BY AERATION OF FRUIT PROCESSING WASTES

L. ESVELT*, Snokist Growers, *Yakima, Washington

The project involves a study of three methods of aerobic biological treatment of wastes from a fruit processing plant. The methods to be studied include a completely mixed aerated lagoon, a completely mixed activated sludge system, and a modified contact stabilization process. Oxygen transfer rates and utilization rates will be determined, and sludge dewatering studies will be made. A study of possible installation of solids removal equipment in the plant will be made as a possible method of reducing waste volumes and reducing of sugar leading into the carriage waters.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Snokist Growers

5.1273, LIMESTONE DRUM PRODUCTIVITY STUDY

R. MENENDEZ*, State Dept. of Nat. Resources, *Charleston, West Virginia

Limestone aggregate is being dissolved in revolving drums powered by stream flow (Zurbuch, 1963) and resultant effects on water chemistry and biology assessed. The project includes both lentic and lotic environments. A 4-drum treatment station is located on a poorly buffered acid stream (Otter Creek) and a 4-drum station located on the inflow of a 165-acre infertile lake (Sherwood Lake). The former has potential for a native brook trout (Salvelinus fontinalis) fishery; the later is primarily a largemouth bass (Micropterus salmoides) fishery.

The fish population study involves collection of data on the fish populations including species composition, production per unit area, food studies, and age and growth data. Collections are made with electrical shocking gear, netting, and chemical collection procedures. Data will be analysed to determine any change in growth and mortality rates, and increases in standing crop which may have occurred since the beginning of the project.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
West Virginia State Government

5.1274, LIMESTONE DRUM PRODUCTIVITY STUDY JOB NUMBER 3 - ECONOMIC EVALUATION

R. MENENDEZ*, State Div. of Game & Fish, *Charleston, West Virginia

Limestone aggregate is being dissolved in revolving drums powered by stream flow (Zurbuch, 1963) and resultant effects on water chemistry and biology assessed. The project includes both lentic and lotic environments. A 4-drum treatment station is located on a poorly buffered acid stream (Otter Creek) and a 4-drum station located on the inflow of a 165-acre infertile lake (Sherwood Lake). The former has potential for a native brook trout (Salvalinus fontinalis) fishery; the later is primarily a largemouth bass (Micropterus salmoides) fishery.

The economic evaluation phase of this study is directed toward analysis of treatment methods and benefits derived from an increase in sport fishing. Treatment will be evaluated as to cost of station installation, maintenance costs, and operational costs. These will be in turn evaluated on cost per unit of area and volume of flow or acid effectively treated. Fishery benefits will be computed through increased fish production provided and assigning values anglers would expend for such fishing.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
West Virginia State Government

5.1275, LIMESTONE DRUM PRODUCTIVITY STUDY JOB NUMBER 1 - LIMNOLOGICAL STUDY

R. MENENDEZ*, State Div. of Game & Fish, *Charleston, West Virginia

Limestone aggregate is being dissolved in revolving drums powered by stream flow (Zurbuch, 1963) and resultant effects on water chemistry and biology assessed. The project includes both lentic and lotic enviorments. A 4-drum treatment station is located on a poorly buffered acid stream (Otter Creek) and a 4-drum station located on the inflow of a 165-acre infertile lake (Sherwood Lake). The former has potential for a native brook trout (Salvelinus fontinalis) fishery; the later is primarily a largemouth bass (Micropterus salmoides) fishery.

The limnological phase of this project, presently in its foruth year, involves collection of data on stream and lake temperatures and chemistry, bottom fauna populations, lake water fluctuations, lake plankton and light penetration, and stream flow measurements. Data will be analysed for changes in water chemistry resulting from the dissolved limestone, and qualitative and quantitative changes in bottom fauna and lake plankton.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
West Virginia State Government

5.1276, TOLERANCE AND CYTOLOGICAL RESPONSE OF ALGAE TO MINE WATER

***H.D. BENNETT*, West Va. University, Graduate School, *Morgantown, West Virginia* 26506**

Field and laboratory studies are to be conducted to gain further information on the tolerance of algae to mine water and the cytologic effects of mine water on the algae. This is to obtain information on what specific factors of mine water affect the occurrence, establishment, and abundance of algae in mine water, and to determine adaptations of algae that permit or do not permit tolerance to pollution.

Studies are to be made with collections from natural habitats, from field cultures, and cultures in the laboratory. The study will make use of algae known to be tolerant, algae not known to be tolerant, acid mine water, non-acid mine water, and non-polluted water. Physical and chemical factors of the water to be determined will include the major contaminants known to be characteristic of mine water. The cytological characteristics will be studied with the aid of the bright field, phase, and the electron microscope.

The laboratory and field data will be processed to permit drawing of conclusions, based on this and related work, that will help clarify algae-mine water relationships, and to point toward continuing research needed.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
West Virginia University

5.1277, FISH ECOLOGY AND PHYSIOLOGY IN RELATION TO ACID MINE DRAINAGE

***A. BENSON*, West Va. University, Graduate School, *Morgantown, West Virginia* 26506**

The investigation seeks to relate water quality criteria to fish ecology in a mine acid polluted environment.

Study phases include: (1) seasonal relationship of fish distribution to changes in concentration of mine acid constituents; (2) distribution in environmentally graded habitats including tributary backwaters, sewage outfalls and river confluences of acid mine streams; (3) food availability and consumption; (4) evidence for ecological stress as indicated by species and age structure of populations, growth rate, condition factor, degree of reproductive success, and presence of developmental anomalies; (5) short term toxicity tests of acid mine water and chemical constituents of mine water. (6) Evidence for physiological stress in long term experiments based on sublethal concentrations of acid mine water constituents.

A principal objective is the development of ecological and physiological criteria as a basis for review and possible modification of water-quality standards for aquatic life in water subject to acid mine pollution.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
West Virginia University

5.1278, GROWTH OF THE BROWN BULLHEAD, ICTALURUS NEBULOSUS (LESUEUR), IN MINE ACID POLLUTED WATER

A. BENSON, West Va. University, Water Research Institute, *Morgantown, West Virginia* 26506

The study is an evaluation of the environmental effects of acid mine water on growth rates of the brown bullhead, Ictalurus nebulosus (Le Sueur). The investigation is based on evident tolerance of this species to acid conditions and its possible management potential in acid water.

The procedural research plan includes: (1) comparative sampling of brown bullhead populations in acid and non-acid bodies of water; (2) collecting data on environmental conditions; (3) determining growth rates; and (4) collecting supplemental data on food habits and on food availability.

The results are expected to be useful in management planning for sport fisheries, in establishing water-quality criteria, and in planning future research.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
West Virginia University

5.1279, CHEMICAL CHARACTERISTICS OF WATERS IN FLOODED BITUMINOUS-COAL MINESHAFTS

R.G. CORBETT, West Va. University, Graduate School, *Morgantown, West Virginia* 26506

We shall determine quantitatively the major chemical components of waters from various levels in flooded bituminous-coal mineshafts. We shall attempt to measure Eh and pH of samples without altering the values in the process of sampling. These data may aid in better understanding the mechanism of pyrite alteration in the mine environment.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
West Virginia University

5.1280, STUDIES ON AQUATIC STALKED BACTERIA

V.F. GERENCSER, West Va. University, School of Medicine, *Morgantown, West Virginia* 26506

Fresh surface waters will be examined for stalked bacteria which will be identified by their morphology. Correlations will then be made between these organisms and other microorganisms present in the water as well as with the physical and chemical properties of that water. Attempts will then be made to isolate the stalked bacteria in culture for further studies of their growth characteristics, cytology, and genetics.

In this way the ecological significance and taxonomic position of the aquatic stalked bacteria will be elucidated.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1281, PHYSIOLOGICAL EFFECTS OF SUBLETHAL LEVELS OF ACID WATER ON FISH

W.J. PEGG, West Va. University, Graduate School, *Morgantown, West Virginia* 26506

The project proposes to determine metabolic rates by indirect calorimetric methods; eg, measurement of oxygen consumption of sunfish and bullheads which have been subjected to different laboratory controlled aquatic environments. The environment will consist of acid waters with pH ranges about 6.0 to 3.0 and cold total acidities varying from 3 to 70 mg/l CaCO3. The environmental waters will be composed of combinations of acid coal mine drainage water and solutions of sulfuric acid diluted with natural river water and constituted river water. Calcium levels are to be varied in the test waters to determine whether or not increased levels of environmental calcium can reduce the effect of acid water. If oxygen consumption is a valid measure of energy utilization in fish, then increased metabolic rate under acid water conditions would indicate that the fish must expend energy to compensate for the stress induced by the environment.

This research proposes to add metabolic rate data relative to the acid environment typically found in the Monongahela River basin. It also proposes to evaluate the relative tolerances of native river fish to the acid environment. The study may also be considered as an effort to gain more appropriate water quality criteria applicable to the problems of reclamation and maintenance of a sport fishery in the Monongahela River basin.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
West Virginia University

5.1282, PHOSPHATE UPTAKE, STORAGE, AND RELEASE BY MICROORGANISMS IN WASTEWATER TREATMENT

W.A. SACK, West Va. University, School of Engineering, *Morgantown, West Virginia* 26506

The objective of this investigation is to understand and develop the capability of heterotrophic microorganisms to remove phosphate from wastewater. The first phase of the work will seek to determine how the uptake and turnover of phosphorus depend on the presence and level of a metabolizable substrate. Batch and continuous culture techniques will be used to simulate in a controlled manner the actual conditions of sludge contact with waste. The substrate-to-microorganism ratio will be varied over a wide range to observe the phosphate uptake per cell in growth situations. To closely follow the flow of phosphate, rigorous phosphate balances will be made on the cell mass and substrate. The second phase of the study will be an investigation of cellular storage of phosphate. Complex polyphosphates accumulate in a wide variety of organisms under certain conditions which limit their usual synthetic activities toward growth and division. In waste-treatment systems, carbon is the parameter limiting cellular growth. Observations therefore will be made for inorganic polyphosphate storage under carbon limiting conditions. The substrate limitation will be enforced on the culture under various patterns and cycles of loading.

Estimates of stored polyphosphates will be made by staining procedures and by chemical analyses. Chemically defined media will be used. Pure cultures and mixed cultures representative of those found in wastewater will be employed.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
West Virginia University

5.1283, BIOLOGICAL TREATMENT OF SPENT VEGETABLE TANNINS

W.A. SACK, West Va. University, School of Engineering, *Morgantown, West Virginia* 26506

The overall objective of the proposed study is to determine the feasibility of biological treatment of spent vegetable tannins and other color-producing substances in vegetable tan-house waste. Specific objectives are to: Study the kinetics of adsorption of the tannins on biological sludge; determine what part of the complex tannin extract is biodegradable by an adapted culture, and if degradation will proceed to a point of significant color reduction; study the effect of supplemental carbon sources on the extent and rate of oxidation; obtain data on sludge settlebility, required detention times, allowable waste strength, and sludge concentration that may be useful in design of an oxidation ditch for treatment of tannery waste. The investigation will be a bench-scale study using spent vegetable tans containing both condensed and hydrolyzable tannins. A mixed culture developed from a domestic-waste investigation is designed to supply basic information on the adsorption and biodegradation of tans that will be useful in design of a pilot or full-scale unit. The study is directed toward the oxidation-ditch method of treatment.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
West Virginia University

5.1284, ACID MINE DRAINAGE MICROBIOLOGICAL STUDIES

H.A. WILSON, West Va. University, School of Agriculture, *Morgantown, West Virginia* 26506

The proposed studies will be concerned with: 1. The isolation and identification of the heterotrophic acid tolerant bacteria in sewage polluted acid mine drainage streams. These isolates will be compared with those isolated in sewage polluted 'normal' (non-acid) streams; 2. the isolation of yeasts and true fungi from sewage polluted acid mine drainage streams. These also will be compared with isolates from non-acid streams; and to determine the role yeasts may play in sewage decomposition under the acid conditions; 3. to determine the amino acids and carbohydrates in sewage (by chromatography) and to compare their decomposition rates under 'normal' (non-acid) conditions with their decomposition rates in acid mine water environments.

Yeasts become the predominating microorganisms in sewage-acid mine water mixtures under laboratory conditions and these microorganisms also occur in streams with those characteristics. It is not known just what their role is. Two species of yeasts have been encountered in all of the work in our laboratories on studies of sewage decomposition in an acid mine water environment; however, little work was done to determine the role they played.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
West Virginia University

5.1285, EFFECT OF AN ACID-WATER ENVIRONMENT UPON THE SYNTHESIS OF GROWTH FACTORS BY BACTERIA

H.A. WILSON, West Va. University, School of Agriculture, *Morgantown, West Virginia* 26506

The research proposes to investigate whether an acidic environment resulting from acid mine drainage interferes with 'self sufficient' bacteria in synthesizing essential growth factors, such as vitamins. The project is a feasibility study to determine a possible design for additional research aimed at new methods of mine-drainage treatment. Bacterial isolates will be obtained from sewage-polluted acid mine drainage and from aerated sewage-acid mine drainage mixtures in the laboratory. 'Self sufficient' bacteria, those capable of synthesizing their own growth factors, will be inoculated into the synthetic medium. After determining reactions to various conditions, growth factors will be added to determine the effects on the isolates. The results will be used to determine additional research.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
West Virginia University

5.1286, THE MICROBIOLOGY OF FARM PONDS AND OTHER FRESH WATER SYSTEMS

H.A. WILSON, West Va. University, Agricultural Experiment Sta., *Morgantown, West Virginia* 26506

To study (1) qualitatively and quantitatively, wherever it seems desirable, the microbiological population of fresh water systems and the factors influencing this population; (2) whether certain special bacterial groups such as cellulose decomposers, nitrifiers, nitrogen fixers, etc., are present; (3) the effect that pesticide and herbicide residues have upon the microbial population of such waters and whether any members of the water microflora are capable of degrading either the active or inert constitudents of such materials; (4) the potential danger to livestock drinking from ponds and stagnant pools when heavy algal growths appear; (5) the probable pollution hazards to ponds and streams from garbage dumps, sanitary landfills and domestic sewage from private residences.

Standard microbiological procedures will be the general basis of study. Respirometer apparatus will be used to study the effects of pesticides. Phycological methods will be used to look for algae known to 'poison' water and standard methods of the American Public Health Association will be employed in the search for pollution hazards.

SUPPORTED BY U.S. Dept. of Agriculture
West Virginia State Government

5.1287, FLOOD RUNOFF REDUCTION AND WATER YIELD IMPROVEMENT

J.H. PATRIC, U.S. Dept. of Agriculture, *Parsons, West Virginia*

Object: To determine relationships between forest conditions and practices and the quantity, timing, and quality of streamflow from forested watersheds; and to improve watershed management in the northern Appalachian Mountains.

Plan of work: The project staff has already determined the effect of forest cutting on a series of experimental watersheds. They are continuing the studies to determine the duration of these effects and effect of subsequent cuttings on the same watersheds. Other studies involving partial watershed treatments and combinations are in process. They are also conducting basic studies on runoff and storage characteristics of the experimental watersheds, changes in microclimate resulting from watershed treatments, and the development of water yield prediction methods.

SUPPORTED BY U.S. Dept. of Agriculture

5.1288, IN-PLANT TREATMENT OF DILUTE WASTES OF THE PULPING INDUSTRY

A.J. WILEY, Pulp Manufacturers Res. League, *Appleton, Wisconsin* 54911

The purpose of the project will be to demonstrate field-scale, in-plant treatment of dilute pulping wastes utilizing a portable reverse osmosis unit. The in-plant treatment method will be developed to reduce hydraulic loadings on biological secondary treatment systems by concentrating the solids in the waste stream. Development and evaluation of reverse osmosis as a method of recovering clear water for reuse by the mill will be accomplished.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Pulp Manufacturers Research League, Inc.

5.1289, COMBINED INDUSTRIAL AND MUNICIPAL WASTE TREATMENT

D. MARTIN, Green Bay Met. Sewage Dist. , *Green Bay, Wisconsin*

The project will be a study, evaluation, and determination of the effectiveness, design, and operating parameters of four alternative biological treatment processes and modifications for treating combined municipal and industrial (primarily paper mill) waste waters. A pilot waste water treatment plant for each process will be determined. Each pilot plant will have a 1 to 10 gpm capacity for combined waste waters. After selecting the most promising process, an existing 60 gpm pilot plant will be modified to suit the selected process and will be operated for a year to demonstrate its performance and to generate performance data. The final objective is to evaluate the design, performance, and use of the systems and to generalize the results for applicability to other locations.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Green Bay City Government - Wisconsin

5.1290, NUTRITIONAL ECOLOGY AND COMMUNITY STRUCTURE OF THE PHYTOPLANKTON OF GREEN BAY

P.E. SAGER, Univ. of Wisconsin, Graduate School, *Green Bay, Wisconsin* 54302

The proposed research involves investigations on the relationship between phytoplankton community structure and nutrient availability. Previous studies have indicated an inverse relationship between species diversity and nutrient availability in the water. In this study, equal emphasis will be placed on the algal cell content of the important plant nutrients, nitrogen and phosphorous. Techniques to be utilized will determine the limiting or non-limiting nature of these nutrients in the algal material itself. The question to be answered is how is nutrient availability reflected in the structure of the community.

The phytoplankton community existing along the nutrient gradients in the Bay resulting from pollution inputs provides a large experimental system in which this question can be explored.

At selected sampling stations, seasonal estimates of community structure will be made from species-abundance enumerations and the subsequent calculation of a species diversity index. Pigment extraction will also be utilized for the estimation of community structure and standing crop. Several physico-chemical variables will be measured concurrently. The data will be examined in a framework which will lead to a better understanding of the factors that regulate structure and metabolism in the phytoplankton community in the face of an ecological disturbance (water pollution).

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Wisconsin

5.1291, SURVEY OF DDT AND DIELDRIN RESIDUES IN FISHES IN WISCONSIN WATERS

S.J. KLEINERT, State Dept. of Nat. Resources, *Madison, Wisconsin* 53701

Gas chromatographic analysis of 555 whole fish samples of 35 species of fish from 109 inland waters, the Mississippi River, and Wisconsin's coastal waters of Lakes Michigan and Superior, were made in 1965, 1966, and 1967, for the chlorinated hydrocarbon pesticides DDT and Dieldrin. The chief objective of the survey is to establish the residue levels of these pesticides in fish of a wide variety of waters of Wisconsin. Factors such as species differences in residues, geographical location, and pesticide usage are compared with the residue findings in the three year summary report being edited for publication in 1968.

SUPPORTED BY Wisconsin State Government

5.1292, DDT RESIDUE ACCUMULATION IN WISCONSIN FISH AND THE EFFECT ON REPRODUCTION

S.J. KLEINERT, State Dept. of Nat. Resources, *Madison, Wisconsin* 53701

In 1966 and 1967 studies were made of the survival of walleye eggs and fry of a variety of DDT residue levels. The 1967 studies were written into report from in 1968. This report is being edited for publication.

SUPPORTED BY Wisconsin State Government

5.1293, CHEMICAL TREATMENT OF NEBISH LAKE

J.J. KEMPINGER, State Div. of Conservation, *Madison, Wisconsin* 53701

Objective: To determine the standing crop and age and size composition of the fish population; to prepare for study of a two species fish population to be introduced.

Procedures: Fieldwork completed. Continue for data analyses and report preparation only.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Wisconsin State Government

5.1294, MANIPULATION OF RESERVOIR WATER FOR IMPROVED QUALITY AND FISH POPULATION RESPONSE

T.L. WIRTH, State Div. of Conservation, *Madison, Wisconsin* 53701

The number of small recreation reservoirs (50-200 acres) in Wisconsin's lakeless region is rapidly increasing. The formation of these impoundments alters the downstream channel while the fertility of the region causes the reservoirs to become highly eutrophic with limited aesthetic value due to aquatic nuisances. Recreational angling in the reservoirs appears to be depressed due mainly to intense algal growths and adverse aquatic environments (anerobic hypolimnion) which limit fish production in the steep-sided basins. Different management techniques are being applied to two in-line reservoirs. The downstream impoundment, which first filled in May 1967, is equipped with an outlet structure which continuously discharges hypolimnion water. The upstream impoundment discharges epilimnion water and is being continually mixed to prevent thermal stratification. Quantity and quality (temparature, pH, D. O., transparency, major nutrients, and elements) of the inflow, outflow, and impounded waters are being measured throughout the year. Fish production and harvest are measured through techniques of population estimates, growth rates, age distribution, and anglers' catch for comparison to previously measured levels. Invertebrate species composition and relative abundance are being measured in both of the impoundments and in the stream below the lower reservoir to ascertain changes brought about by manipulation. Aquatic vegetation changes are also being noted in the stream below.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Wisconsin State Government

5.1295, A STUDY OF LAND DISPOSAL OF SPENT SULFITE LIQUOR AT BADGER PAPER MILLS, INC., PESHTIGO, WISCONSIN

T.A. CALABRESA, State Div. of Env. Protection, *Madison, Wisconsin*

This cooperative project provides for the determination of the extent of movement of spent sulfite liquor both in depth and laterally from the ground surface disposal areas. This project hopefully will result in determinations of:

1. The influence that the bedrock configuration has on the subsurface movement of the waste sulfite liquor. 2. The effect limerock in the area has, if any, in neutralizing some of the acidity of the waste. 3. The potentiometric distribution of the sulfite liquor both vertically and horizontally in the surficial deposits above the limerock in the vicinity of the disposal sites. 4. The aquifer characteristics both in the unconsolidated and rock aquifers. 5. The quantity of the waste reaching the river. 6. Whether the Badger Paper Mills, Inc., shall abandon the present disposal method in favor of some other treatment method insofar as the Peshtigo River is concerned. 7. Whether such land disposal practice for this type or other strong industrial waste can be safely permitted under similar geological conditions.

SUPPORTED BY Wisconsin State Government
Badger Paper Mills, Inc.

5.1296, A COMPARISON OF TOTAL COLIFORM AND FECAL COLIFORM COUNTS IN STREAM POLLUTION SURVEYS

D.H. SCHUETTPELZ, State Div. of Resource Dev. , *Madison, Wisconsin*

The study consists of a literature review and limited field sampling to determine if the fecal coliform, rather than the total coliform count, would be a better indicator of bacterial contamination of surface waters. This study will determine whether the fecal coliform organism will be used in routine stream pollution surveys conducted by the sponsoring department. The field sampling is being conducted below a sewage treatment plant and will provide die-off rates and correlation of the coliform strains in the stream.

All bacterial counts are performed by the membrane filter technique and are accepted as being representative (equivalent to MPN) of the true fecal and total coliform populations. Analyses are performed in accordance with Standard Methods for the Examination of Water and Wastewater (12th ed.) at the Wisconsin State Laboratory of Hygiene.

SUPPORTED BY Wisconsin State Government

5.1297, RESEARCH AND REFERENCE TO SEWAGE EFFLUENT PONDS

W.C. BOYLE, Univ. of Wisconsin, School of Engineering, *Madison, Wisconsin*

The objective of this investigation is to determine base design criteria for stablization ponds by ascertaining the effects of detention time, organic loading and temperature on pond efficiencies. By the use of two partitions a 5 foot deep pond was converted into three ponds, approximately 35' by 35'. A secondary treated domestic sewage is to be fed on a controlled basis to these three ponds to give the following detention times, 3, 10 and 30 days. The effects of these different detention times are to be determined at various temperatures and organic loadings by conducting tests throughout the year.

The efficiency of these ponds under different experimental conditions are to be determined by use of the following analytical tests: B.O.D., C.O.D., methylene blue, solids, nitrogen, bacteriological (mainly fecal coliform), chlorides and phosphates. In order to avoid loss of contents by seepage these ponds have to be lined with an impermeable water barrier. Two unsuccessful attempts have been made to install such a barrier by using a butyl rubber liner. Another attempt is currently underway to permit the completion of this investigation during the next fiscal year.

This study, conducted in connection with the Ixonia (Wisconsin) aerated activated sludge treatment plant, was started in the fiscal year of 1966 and is expected to be completed in the fiscal year of 1969.

SUPPORTED BY Wisconsin State Government

5.1298, IMPROVING SURFACE WATER CONDITIONS THROUGH CONTROL AND DISPOSAL OF AQUATIC VEGETATION

H.D. BRUHN, Univ. of Wisconsin, School of Agriculture, *Madison, Wisconsin*

This research proposes to investigate methods for the more efficient handling of cut aquatic vegetation. Feasible alternatives are sought for present slow and costly methods, which are at the same time compatible with over-all water management programs. Knowledge concerning the physical processing properties of aquatic plants is quite limited. Initially research would be conducted to determine how plants are affected by such standard operations as dewatering by crushing, homogenizing, maceration, etc., the objective being to identify potentially effective procedures.

Following acquisition of certain fundamental handling and processing data, the research can proceed on an applied basis. This second, pilot scale phase will attempt to determine the most practical combinations of methods for transportation and disposal of the entire, unprocessed plant, the entire plant after processing in some manner, complete disposal at the source, or other combinations.

The objective is to alleviate some of the bottlenecks which limit the capabilities of today's aquatic vegetation harvesting machinery to small fractions of rates achieved with agricultural machinery. The high cost of systems and procedures for mechanical control of aquatic vegetation have prevented realistic evaluations of its effectiveness as a management measure in eutrophic waters.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Wisconsin

5.1299, BIOLOGICAL NITROGEN FIXATION IN LAKES

R.H. BURRIS, Univ. of Wisconsin, School of Agriculture, *Madison, Wisconsin*

A mobile laboratory will be equipped for routine analytical work including gas chromatography. This laboratory will be used to study biological N2 fixation in lakes and on the fringes of lakes. Samples of aquatic flora and of root nodules will be exposed in the field to acetylene under a close approximation of natural conditions. Reduction of acetylene to ethylene will be determined by gas chromatography and will be used as an index of the activity of the N2 fixing system.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Wisconsin

5.1300, INSECTICIDE ADSORPTION BY LAKE SEDIMENTS AS A FACTOR CONTROLLING INSECTICIDE ACCUMULATION IN LAKES

G. CHESTERS, Univ. of Wisconsin, School of Agriculture, *Madison, Wisconsin*

Detailed Objectives: a. To determine the extent of adsorption of certain insecticides by intact and fractionated lake sediments and the bonding mechanisms involved. b. To relate adsorption to a characterization and classification of lake sediments. c. To ascertain the effect of adsorption on chemical and biochemical degradability.

The extent of insecticide adsorption will be evaluated by equilibration and chromatographic techniques utilizing gas chromatographic and radioisotopic methods for insecticide determination. Properties of the insecticides and the sediments controlling the extent of adsorption will be ascertained. The effect of adsorption on the chemical and biochemical degradability will be determined by comparison of degradation rates in the presence and absence of adsorbents. Properties of sediments will also be related to their origin, environment of deposition and location to obtain a classification useful for prediction of the extent of insecticide accumulation in lakes.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Wisconsin

5.1301, CHANGES IN WATER ENVIRONMENT RESULTING FROM AQUATIC PLANT CONTROL

G. COTTAM, Univ. of Wisconsin, Graduate School, *Madison, Wisconsin*

Heavy overgrowths of rooted aquatic plants, with their attached filamentous algae, constitute a distinct problem in multiple use of lakes for a growing human population. Harvesting of the rooted aquatics clears the lakes of growth that impedes swimming and boating, and also removes the attached filamentous algae. While this harvesting does result in removal of some of the nutrients present in the lake waters, this benefit is probably of little value, since the quantity of nutrients so removed is small in proportion to the total quantity present.

The major questions to be answered in this project are (1) what species are responsible for the majority of the objectionable growth? (2) How do these species respond to the control measure applied? This involves a knowledge of the life history of the species. (3) What is the sequence of species replacement when species are removed? (4) How will differences in depth, currents, and types of bottom affect development of vegetation?

The major emphasis so far has been an analysis of the distribution of the rooted aquatics in relation to water depth, type of substrate, etc., and a study of the response of the plants to different cutting treatments. Chemical control has not been studied because of the difficulty of controlling rate and locale of application, and because of the detrimental effects of poisons on other biological organisms present in the lake.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Wisconsin

5.1302, SIGNIFICANCE OF ARTHROBACTER IN ECOLOGY OF WATER AND SOIL

J.C. ENSIGN, Univ. of Wisconsin, School of Agriculture, *Madison, Wisconsin*

Bacteria belonging to the genus Arthrobacter are found in large numbers in soil and water. In some environs they are the predominating single group of bacteria. They comprise an important part of the stable autochthonous microflora. The purpose of this investigation is to explore the role of Arthrobacter in soil and water ecosystems. The mechanisms whereby these bacteria are able to maintain fairly constant and large populations, regardless of variations in environmental conditions, will be studied. Resistance to starvation, desiccation, adverse temperatures and other environmental conditions will be compared in both rod and sphere stage cells of the organism. The degradation of cellular macromolecules, reserve materials and intracellular pools will be followed during starvation. The results are to be compared to those obtained with Pseudomonas, which are part of the fluctuating, or zymogenous, microflora.

Members of the genus Arthrobacter have been found to actively degrade pyridine-ring compounds. A second aspect of this investigation involves studying the pathways and enzymes involved in catabolism of pyridine, nicotinic acid and several herbicide and insecticide derivatives of the pyridine ring.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1303, DETECTION OF LIMITING AND SURPLUS NUTIENTS IN ALGAE

G.P. FITZGERALD, Univ. of Wisconsin, School of Engineering, *Madison, Wisconsin*

5. WATER QUALITY MANAGEMENT AND PROTECTION

Previous reports have described techniques developed for the detection of limiting or surplus phosphorus in algae. The present work involves the evaluation of a technique for determining if algae were limited by their nitrogen supply. It has been shown that labile carbohydrate reserves tend to build up in algae when they are deprived of sufficient nitrogen for normal growth. It is possible to detect these reserves considerably before the total nitrogen content of the algae starts to decrease. The development and loss of the reserve carbohydrate has been used to follow the development of nitrogen starvation and reversal of starvation by the addition of ammonia or nitrate nitrogen. The significance of these tests to algae in general and to the ecology of nitrogen nutrition in water pollution will be further evaluated.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1304, ALGAL BIOASSAY TO DETERMINE THE EXTENT OF NUTRIENT REMOVAL BY AWT AT THE WASTE TREATMENT PLANT AT ELY, MINNESOTA

G.P. FITZGERALD, Univ. of Wisconsin, School of Engineering, *Madison, Wisconsin*

Algal bioassays will be used in the determination of the extent of nutrient removal by the advanced waste treatment process at the Waste Treatment Pilot Plant at Ely, Minnesota. The project provides for measurement of algal growth using two algae in 60 preliminary samples and two algae in 110 composite samples representing the feed, the final product, and three intermediate stages from the Shagawa Lake Project pilot plant.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1305, BOTULINUM FOOD POISONING IN RELATION TO FISHERY PRODUCTS

E.M. FOSTER, Univ. of Wisconsin, Agricultural Experiment Sta. , *Madison, Wisconsin*

Objectives: To study (1) ecology of C. botulinum type E in the Great Lakes; (2) conditions affecting spore formation by C. botulinum type E; (3) the heat resistance of C. botulinum type E spores with the view of establishing minimum times and temperatures that will destroy the majority of spores without damaging marketability of the product; and (4) to establish conditions necessary to prevent growth of C. botulinum type E fishery products.

Procedure: Samples of fish, water and mud from the Great Lakes will be tested for C. botulinum type E to see if its occurrence can be related to specific environmental conditions. Study cultural conditions of spore formation of C. botulinum, observing effects of nutrients, pH, incubation temperature, and time on sporogenesis. Establish minimum temperature and time which will destroy all heat sensitive spores. Determine efficacy of various food additives for purpose of preventing growth of spores which survive the heat process. Salt, benzoate, nitrite and polyphosphate hold promise. When an effective control procedure is found in the laboratory it will be tried on a pilot scale basis with full size equipment operated under normal commercial conditions. Determine consumer acceptability of finished product by qualified taste panels.

SUPPORTED BY U.S. Dept. of Agriculture
Wisconsin State Government

5.1306, INSTITUTIONAL DESIGN FOR WATER QUALITY MANAGEMENT - A CASE STUDY OF THE WISCONSIN RIVER BASIN

I.K. FOX, Univ. of Wisconsin, Water Resources Center, *Madison, Wisconsin*

The Problem: Although a substantial amount of research is going forward on the technical and economic aspects of water quality management, relatively little attention is being devoted to the legal, policy, and administrative aspects. New policies and organizational arrangements are being tried but little scientific basis is being provided for institutional change that will assure proper implementation of the kinds of programs required for effective water quality management in the future.

The Objective: Using the Wisconsin River Basin as a region for study the specific objectives are: 1. To assess the advantages of a regional approach to water quality management 2. To evaluate the effectiveness of alternative institutional arrangements for conducting desirable programs of water quality management 3. To appraise the obstacles that are likely to be encountered in seeking desirable institutional changes.

Procedures: The research falls into two broad areas. One group of studies will seek to define the nature of effective programs for water quality management in the Wisconsin River Basin through application of recognized methods of water system design. The other group of studies will evaluate the effectiveness of alternative institutional arrangements for conducting water quality management programs through application of techniques of economic, political, legal, and administrative analysis.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

5.1307, STUDY OF THE APPLICABILITY OF EFFLUENT CHARGES TO WATER QUALITY MANAGEMENT IN THE STATE OF WISCONSIN

I.K. FOX, Univ. of Wisconsin, Water Resources Center, *Madison, Wisconsin*

Many cities and communities in the United States have levied charges upon those who utilize the public sewage collection and treatment systems. However, to our knowledge there is no case where charges have been levied against those who discharge effluents directly into waterways. It is evident that the applicability and utility of effluent charges have not been thoroughly examined on the basis of carefully developed empirical information anywhere in the United States. This proposed study would seek to review the literature and experience on this subject and then test alternative concepts on the basis of empirical data developed for a specific river system.

The objectives of this study are as follows; (1) to arrive at alternative concepts of effluent charges, which may be applicable to the State of Wisconsin and to assess the potential advantages and limitations of each concept, (2) to examine the quality and economic consequences of applying alternative concepts of effluent charges in the Wisconsin River Basin by using empirical engineering and economic data presently being developed at the Water Resources Center.

It is to be emphasized that the report of this study will not recommend for or against the use of effluent charges in Wisconsin, nor will it offer other kinds of recommendations. The goal of the study will be to present completely objective, scientific analysis of all data and materials that can be marshalled so that State policy officials can make intelligent estimates of the physical and economical consequences of adopting one policy or another.

SUPPORTED BY Wisconsin State Government

5.1308, EXPERIMENTAL REVERSAL OF THE LAKE EUTROPHICATION PROCESS

A.D. HASLER, Univ. of Wisconsin, Graduate School, *Madison, Wisconsin*

The proposed research program will attempt to evaluate the hypothesis that artificial acceleration of eutrophication (assuming a fixed, irreducible influx of nutrients) will ultimately result in a decrease in the rate of eutrophication and a temporary increase in production of food and other organic matter.

The majority of experimentation will be done IN SITU, using natural and artificial lake basins (Chippewa and Vilas Counties, Wis.). The acceleration of eutrophication at a predetermined, fixed level of nutrient influx, will be attempted by means of artificial lake circulation and artificial lake warming.

Biological indices of eutrophication, including photosynthetic rates, (14C method), diversity of bacteria and phytoplankton, and rates of zooplankton and fish production will be measured.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Wisconsin

5.1309, EFFECT OF PESTICIDES ON WILDLIFE,(SONGBIRDS, HERRING GULLS AND FISH)

J.J. HICKEY, Univ. of Wisconsin, Agricultural Experiment Sta. , *Madison, Wisconsin*

The object of these studies is to evaluate the wildlife side effects of insecticidal use and to work out the kinetics of DDT transfer through different ecosystems.

The avian effects of DDT in Dutch elm disease control have been evaluated on 7 Wisconsin study areas and the transfer of DDT through soils, earthworms and birds is now being measured. A second project is measuring residues in Lake Michigan sediments, fish, and gulls. A third is evaluating the current status of the peregrina falcon in eastern U.S.

SUPPORTED BY Wisconsin State Government

5.1310, SURVEY OF CLOSTRIDIUM BOTULINUM TYPE E

S. HIROSHI, Univ. of Wisconsin, School of Agriculture, *Madison, Wisconsin* (FDA)

Current investigations have stressed the relationship between the vegetative cells and spores of C. botulinum type E and living and dead fish. The following preliminary observations have been noted: (1) Vegetative cells of type E when fed to living fish do not become established in the gastrointestinal tract. (2) Similar results were obtained when spores were fed to fish. (3) The organism is unable to establish itself and multiply in the surface slime of living fish. (4) Conversely, the presence of type E toxin in dead fish confirms the expectation that type E can multiply in dead fish in nature and suggests a possible source of contamination of the aquatic environment with this organism. (5) The intestinal tract of fish may become contaminated with type E in the absence of food, if the levels of the organism in the water is high.

Multiplication of type E in muds has been accomplished under laboratory conditions. It has been shown that the nutrient available in autoclaved muds of two geographical areas can support spore germination and growth of type E; however, no growth was observed in the unsterilized replicates. Multiplication of the organism is substrate and temperature dependent but not affected by the incubation atmosphere when phosphate buffer is present.

An enrichment medium containing either potato flesh or peel was evaluated as an improved medium for the detection of type E. This potato infusion medium was compared with Johannesen's medium. The results suggest that the addition of potato infusion may improve the detection of type E in mud and soil samples. The conclusions are tentative and more experimental data are required.

Identification of toxigenic type E colonies using the development of antigen-antibody halos around deep colonies has been unsuccessful. The lack of success is due primarily to false positive reactions. Investigations concerning the establishment and multiplication of type E in or on living fish, conditions necessary for the multiplication of the organism in muds and a practical method of identifying toxigenic colonies are continuing.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - F.D.A.

5.1311, BACTERIOLOGICAL ANALYSIS OF THE FLOCS OF ACTIVATED SLUDGE OF DOMESTIC SEWAGE

E.F. MCCOY, Univ. of Wisconsin, Agricultural Experiment Sta. , *Madison, Wisconsin*

Engineers have been handicapped by not knowing the identity or having for study pure cultures of the bacteria in activated sludge flocs. Among 300 isolates we have obtained 11 of Zoogloea ramigera and the remainder are in 12 other genera of bacteria. Only Z. ramigera forms flocs like those in sewage, grows well in sterilized sewage or in several simple and synthetic media we have devised. Its metabolism and function in sewage disposal is being investigated. The remaining non-floc organisms can be adsorbed to the Z. ramigera flocs, when they are growing together, and thus one can re-assemble the flocs of composite activity. Z. ramigera is a very unusual organism and its metabolism extremely interesting on theoretical grounds.

SUPPORTED BY Wisconsin State Government

5.1312, RETENTION OF NUTRIENTS AND OTHER POLLUTANTS IN SEWAGE BY SOILS

L.B. POLKOWSKI, Univ. of Wisconsin, School of Engineering, *Madison, Wisconsin*

The objective of this study is to determine the ability of a given soil type in retaining or removing nutrients and other indicators of pollution from the effluent of a septic tank-soil absorption system under actual field conditions. The site of this investigation is the Wisconsin Heights High School near Mazomanie, Wisconsin. After determining the direction of groundwater travel, 24 driven point wells were installed in the vicinity of the tile absorption field. The soil consists of a silty clay loam changing to sandy loam underlain by outwash sand and gravel.

Groundwater samples were taken from the wells weekly from April September (1967) and on a bi-weekly schedule thereafter. Analyses were made for BOD, chlorides, detergents (MBAS), nitrogen, phosphorous and coliforms.

SUPPORTED BY Wisconsin State Government

5.1313, INVESTIGATIONS OF ZOOGLOEAL FLOCS

G.A. ROHLICH, Univ. of Wisconsin, School of Engineering, *Madison, Wisconsin*

The proposed work has been divided into the following general areas: Floc Formation - Studies are being undertaken to determine the quantitative and qualitative factors affecting the flocculation of bacteria of the genus Zoogloea.

Metabolism and Growth of Zoogloeal Species - Further work is being undertaken to better understand the metabolism of the Zoogloeal species. Identification and taxonomic studies are also being made.

Kinetic and Diffusional Studies - The diffusion of nutrients (including oxygen) through pure culture floc is being studied. Both kinetic and diffusional models will be investigated and tested.

Gravity Settling of Flocs - Preliminary studies are being made to better ascertain the factors affecting the density, specific surface and shape of pure culture flocs that might affect settling properties.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1314, EUTROPHICATION OF NATURAL WATERS

G.A. ROHLICH, Univ. of Wisconsin, Water Resources Center, *Madison, Wisconsin*

The research objectives of this multidisciplinary program are to make indepth studies on the eutrophication of natural waters. Among some of the specific objectives are: 1. Determine the cause-and-effect relationship between natural aging of lakes and inadvertent enrichment which leads to short-term changes in water quality in terms of physico- chemical and biological factors. 2. Develop methods of forecasting variations in quality of lake waters by the examination of early trends. 3. Contrive methods of management to control optimum quality of lake waters for municipal, industrial, agricultural, and recreational uses and to arrest or reverse eutrophication trends. 4. Examine the interrelationships among several variables pertaining to the process of eutrophication and exclude those which prove to be of doubtful value for continuing interdisciplinary comprehensive studies. 5. Establish a research program that will generate the kinds and amounts of data needed for systems analysis of the total problem by a competent environmental scientist.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1315, ENTEROCOCCI, COLIFORM BACTERIA AND BACTERIOPHAGES IN LAKE WATER

W.B. SARLES, Univ. of Wisconsin, Agricultural Experiment Sta. , *Madison, Wisconsin*

This project is inactive at present because a qualified assistant could not be found. The purpose of the work is to ascertain whether bacteriophages specific for coliform bacteria and for entercocci can be detected in polluted water, and to determine their persistence in water. Information on persistence of bacteriophages in water is needed to complement knowledge on longevity of coliform bacteria and of enterococci in polluted waters. During the past three years preliminary studies have been made, but these have not yielded conclusive results.

SUPPORTED BY Wisconsin State Government

5.1316, SHALLOW GROUND-WATER FLOW SYSTEMS IN RELATION TO INDUSTRIAL AND MUNICIPAL WATER SUPPLY AND WASTE DISPOSAL REQUIREMENTS

D.A. STEPHENSON, Univ. of Wisconsin, Graduate School, *Madison, Wisconsin*

The occurrence and seasonal fluctuations of shallow ground-water flow systems in various geologic environments of Wisconsin will be investigated within the framework of their relation to waste disposal practices of selected industries and municipalities. Solid and liquid waste disposal sites of the canning, dairy, and paper-pulp mill industries, plus municipal sanitary land fill sites will be areas wherein shallow flow systems are to be investigated.

It is anticipated that limited site selection criteria for the specified disposal practices can be developed based on the hydrogeologic framework. Where liquid wastes are being disposed of through spray irrigation or ponding, formulas will be developed to control rotation of equipment used for the waste effluents. It is further anticipated that more extensive investigations can be initiated following this preliminary study.

Surface and subsurface geologic, hydrologic, and geophysical data are to be collected, compiled, and interpreted. Laboratory and field studies will be interpreted to provide a basis for practical application of results.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Wisconsin

5.1317, OPERATION AND EVALUATION OF A DEMONSTRATION ROTATING BIOLOGICAL CONTACTOR

F.M. WELCH, Allis Chalmers Mfg. Company, *Milwaukee, Wisconsin*

The purpose of the contract Allis-Chalmers now has with the F.W.P.C.A. is to design, construct, operate and evaluate an in-line (adjacent to an existing sewer) waste treatment device. The waste treatment device to be investigated is termed a Rotating Biological Contactor (R.B.C.) and will be utilized to treat combined sewage flows.

The R.B.C. system is a biological process which consists of fungi and bacteria that have grown on a series of rotating discs. The rotating discs act as a support media for the bio-mass and an aeration device. The proposed R.B.C. in-line system will treat both dry-weather and storm flows by subjecting said flows to screening, grinding, sedimentation and biological oxidation.

The contract will consist of three phases. Phase one will involve tests on a laboratory unit at which time design criteria will be obtained. The second phase will consist of constructing an actual field unit in the Milwaukee area. The third phase of the contract will be the actual operation and evaluation of the field unit.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1318, LUXURY METABOLIC STORAGE OF PHOSPHORUS IN THE ACTIVATED SLUDGE FLOC

S.K. MALHOTRA, Marquette University, School of Engineering, *Milwaukee, Wisconsin* 53233

The relative ineffectiveness of the activated sludge waste water treatment process in removing phosphorus is a major cause of progressive fertilization of natural bodies of water receiving treated waste waters. Phosphorus enrichment often results in algal blooms, which frequently result in objectionable odors and many other deteriorating effects on the quality of water.

Recently it has been reported that the activated sludge process can be adapted to make the organisms store phosphorus during their endogeneous respiration phase, far in excess of their metabolic uptake in the logarithmic growth and declining growth phases. This excess phosphorus uptake, 'Luxury Storage,' has also been reported to be affected by the cations in the environment.

The objectives are to examine the storage of phosphorus in the activated sludge flocs as the microorganisms pass through different growth phases, and to determine the proportions of the total stored phosphorus in each of the growth phases; the effects of ionic and surface adsorption and storage of phosphorus by cationic colloidal formations.

Batch processes with a synthetic substrate under controlled parameters of pH, food/microorganisms ratio, cationic concentrations, dissolved oxygen concentrations and the degree of mixing will be employed.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Marquette University

5.1319, EUTROPHIC EVALUATION OF A SMALL MULTI-LAND USE WATERSHED

A.E. ZANONI, Marquette University, School of Engineering, *Milwaukee, Wisconsin* 53233

The proposed project involves the determination of the quantities of nitrogen and phosphorus which originate from various land use activities in a small river watershed tributary to Lake Michigan in the Milwaukee metropolitlan area. The watershed in question is the Menomenee River watershed which includes agricultural, residential, industrial, commercial, park and recreation, woodlands and wetlands, and governmental-institutional land uses, and yet encompasses a drainage area of only 135 square miles. Based on the results of preliminary surveys, sampling locations will be located at critical points along the river for discharge measurements and nitrogen and phosphorus analyses. These data will then be used to estimate the nutrient quantities from the various sources in the watershed. The data will also be correlated with hydrological and climatological data to establish the manner in which these watershed factors might influence nutrient quantities from the various sources.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Marquette University

5.1320, EFFECT OF TEMPERATURE AND RELATIVE HUMIDITY ON C. BOTULINUM SPORE SURVIVAL IN WHITEFISH CHUBS DURING SMOKE PROCESSING

P.J. PACE, Milwaukee Department of Health, *Milwaukee, Wisconsin* 53202

A need to provide smoked fish processors with methodology to eliminate Clostridium botulinum from fish continues to exist. Recent investigations at this and other laboratories indicate that heat (82.2 degrees C for 30 min.) alone does not free fish of experimentally introduced C. botulinum type E spores. Experiments, at this laboratory, in which internal temperature of the fish and relative humidity of the kiln are simultaneously controlled have been encouraging. Thus far studies have been conducted with spores prepared from a single type E straim isolated from smoked whitefish chubs. Experiments are to be extended employing combined spore suspensions prepared from 50 type E isolates obtained from raw and smoked fish. Two non-proteolytic type B isolates, obtained from fish, also will be employed. Corollary studies, employing spores prepared from proteolytic types A and B C. botulinum strains and a type E strain, of known high heat resistance, also will be conducted.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

5.1321, SEWAGE PHOSPHORUS REMOVAL BY AN ACTIVATED SLUDGE PLANT

L.A. ERNEST, Milwaukee Sewage Commission, *Milwaukee, Wisconsin* 53201

The objectives of this project are to demonstrate the optimization of activated sludge process parameters for maximum sewage total phosphorus removal, to determine if a correlation exists between activated sludge dehydrogenase activity and phosphorus removal and evaluation of process parameter effects on phosphorus levels in an aeration tank. An appropriate sampling and analysis program will be initiated to evaluate the effects of process variations.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Milwaukee City Government - Wisconsin

5.1322, A MATHEMATICAL MODEL FOR THE FINAL CLARIFIER OF AN ACTIVATED SLUDGE PROCESS

W.J. KATZ, Rex Chainbelt Incorporated, *Milwaukee, Wisconsin* 53214 (14-12-194)

Develop a mathematical model expressed in computer format which will enable the prediction, with a high degree of reliability, the quantity and quality of the effluent and underflow of a final clarifier in an activated sludge treatment system as a function of the mixed liquor flow rate and characteristics.

The subsidence characteristics of activated sludge relates to the clarification and thickening properties of the sludge. Measurements such as sedimentation rates, suspended solids concentration, volatile suspended solids concentration, zeta potential, etc. are required to identify the performance of the clarifier. The relationship of these basic parameters and other variables with respect to the performance of the final clarifier is what the mathematical model must express. It is the objective of this proposal project to measure and evaluate those parameters which have interrelationships to each other that influence the operational performance of the clarifier, and to relate them, if possible, in terms or parameters which are normally available to the consulting engineer concerned with the basic design of the final clarifier.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

5.1323, ECOLOGICAL STUDIES OF THE SURFACE WATERS OF THE WHITEWATER CREEK WATERSHED, WALWORTH, ROCK, AND JEFFERSON COUNTIES, WISCONSIN

S.G. SMITH, Wisc. State University, Graduate School, *Whitewater, Wisconsin* 53190

Distribution and relative abundance of selected plants and animals will be correlated with physical and chemical features of the surface waters of the Whitewater Creek watershed. Although primary emphasis will be placed on the streams, preliminary studies will be made of the lakes which have been formed by the damming of the streams. Detailed studies will be primarily concerned with vascular plants, fishes and selected algae. Although the primary objective of the project is to initiate a long-range interdisciplinary research program, certain specific problems will also be investigated, i.e. 1) the movements of selected species of fish within the stream system, and 2) the genecology of hybridizing or otherwise genetically variable populations of the roundstemmed bulrushes (Scirpus spp.) and possibly Potamogeton in relation to habitat disturbance and other ecological factors. Organisms studied will be evaluated as to their usefulness as indicators of water quality and other environmental conditions.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Wisconsin State University

5.1324, POLLUTANTS IN PRODUCT AND PROCESS WATERS FROM OIL-SHALE RETORTING OPERATIONS AND METHODS FOR THEIR REMOVAL

S.S. TIHEN, U.S. Dept. of Interior, Petroleum Research Ctr. , *Laramie, Wyoming*

This project is directed toward the determination of organic and inorganic pollutants in process and product waters from and oil-shale processing operation in order to devise methods for removing the contaminants or reducing their concentrations to harmless levels.

Becsuse Green River oil shale deposits are located in arid or semiarid regions, process water will be scare and provisions must be made for its reuse. It would also be desirable to augment existing water supplies by reclaiming the water product during retorting. In either case, the pollutants must be either removed or reduced to such low concentrations as to render them harmless. Detailed knowledge of the compositions and amounts of pollutants may be removed or reduced to harmless or unobjectionable levels. Organic contaminants might be present in sufficient quatities to make recovering them economically attractive.

SUPPORTED BY U.S. Dept. of Interior - Bureau of Mines

5.1325, AERATION OF LAGOONS IN RIGOROUS CLIMATE AREAS

R.L. CHAMPLIN, Univ. of Wyoming, School of Engineering, *Laramie, Wyoming* 82071

Demonstration Grant: Two Parts. Part I. A water balance for the City of Laramie, Wyoming is being measured. This includes measuring all incoming flow (municipal, surface and ground water) and all outgoing flow (storm drainage, sewage flow, ground water and streams).

Part II. Aeration of a pilot lagoon is being investigated. Due to the rigorous climate, treatment of sewage by the lagoon system in inadequate during much of the year. The parameters being investigated are: amount of air, loading and detention time, and temperature effects. The effects of present treatment on the Laramie River is being monitored.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
University of Wyoming

5.1326, DEGRADATION - DEPLETION OF HERBICIDES IN IRRIGATION WATER AND ACCUMULATION OF HERBICIDE RESIDUES IN CROPS FROM TREATED WATER

F.L. TIMMONS, Univ. of Wyoming, Agricultural Experiment Sta. , *Laramie, Wyoming* 82071

Object: (a) To develop sensitive quantitative methods for laboratory determination of selected aquatic or ditchbank weed herbicides and their degradation products or metabolites, including methods of extraction from plants, water and soil, and deterioration of samples before analysis. (b) To determine quantitatively the movement and accumulation of herbicides and their degradation products in water, soil, and crops on field plots irrigated with water containing herbicides. (c) To follow quantitatively degradation, depletion, dilution, sorption, and uptake of herbicides by water, suspended sediments, substrata and aquatic biota in irrigation canals.

Plan of work: During the first year, studies will be with acrylaldehyde: 2-propenal (acrolein) and, to a lesser extent, with copper sulfate. The second year studies are tentatively planned with 2,4-dichlorophenoxyacetic acid (2,4-D) and 2-(2,4,5-trichlorophenoxy) propionic acid (silvex) and the third year studies with 6,7 dihydrodipyrido (1,2-a:2',1'-c) pyrazidinium salt (diquat) and xylene. The second and third year choices of herbicides are subject to later review after early results in the research program. Some procedures and techniques may be revised as experience and results show changes to be desirable.

SUPPORTED BY U.S. Dept. of Agriculture
Wyoming State Government

5.1327, FATE OF HERBICIDES IN WATER AND CROPS IRRIGATED WITH WATER CONTAINING HERBICIDES

F.L. TIMMONS, Univ. of Wyoming, Agricultural Experiment Sta. , *Laramie, Wyoming* 82071

Object: To determine: (1) the degree to which certain herbicides commonly used for aquatic and bank weed control are retained and assimilated in edible parts of irrigated crops; (2) differences between crops in assimilation of herbicides; and (3) degree to which herbicides applied in irrigation water under field conditions are retained in the edible tissues of certain crops.

Plan of Work: Seven herbicides to be used include: 2,4-D, silvex, amitrole, dalapon, dichlobenil, diuron, and simazine. Seven crops will be considered including potatoes, carrots, onions, tomatoes, romaine lettuce, soybeans and milo. Irrigation water containing two concentrations of test herbicide will be applied to each crop at two stages of growth. Water will be applied on the surface and by overhead sprinkling. Samples of edible parts of each crop will be taken after each irrigation and analyzed to determine amounts of herbicide, toxic metabolites or degradation compounds. If deemed desirable, samples of treated water and irrigated soil will be analyzed. Samples of crops on field plots, irrigated with water containing different amounts of amitrole, will be analyzed.

5. WATER QUALITY MANAGEMENT AND PROTECTION

SUPPORTED BY U.S. Dept. of Agriculture

5.1328, CONTROLLING WEEDS ON DITCHBANKS AND OTHER NONCROP AREAS

F.L. TIMMONS, Univ. of Wyoming, Agricultural Experiment Sta., *Laramie, Wyoming* 82071

Object: In noncrop land to (a) develop improved chemicals and procedures to control or suppress plant growth, (b) establish the relations of climate, time and rate of treatment, and fertility, structure, and texture of soil to herbicide phytotoxicity and persistence in soil, (c) determine the effects of chemical, mechanical, and biological control treatments on the succession of plants, on soil erosion, and on other aspects of vegetation and soil management.

Plan of work: Herbicides will be applied along ditchbanks, fencelines, roadsides, and similar areas. Retreatments and observations will be made over a period of years to determine responses to different treatments and combinations. Indicator crops will be used to determine the length of time that phytotoxic concentrations remain in the soil. Mixtures of desirable low-growing grasses or other plants will be seeded at various intervals following herbicidal treatments to determine which species of plants and time of seeding are most suitable for establishing a desirable vegetative cover on various noncrop areas following elimination or reduction of the stand of weed species by different effective herbicides. Results from similar experiments in different areas with different climatic and other environmental conditions will be correlated to discover general trends and basic principles.

SUPPORTED BY U.S. Dept. of Agriculture

5.1329, PRINCIPLES AND PRACTICES FOR THE CONTROL OF SUBMERSED, FLOATING, AND IMMERSED AQUATIC WEEDS

F.L. TIMMONS, Univ. of Wyoming, Agricultural Experiment Sta., *Laramie, Wyoming* 82071

Object: To investigate the herbicidal properties of new chemicals that show promising photocidal activity on aquatic weeds including techniques for evaluation; effectiveness and optimum time, rate, and method of application under various climatic conditions; the influence of water movement, temperature, turbidity, pH, and hardness; effect of texture and fertility of bottom soils on effectiveness; and biological control.

Plan of work: Promising chemicals will be evaluated in greenhouses and growth pools on submersed, floating and emersed species, and on emersed species in static water, flowing water, and soil-applied tests. Herbicides showing promise in greenhouses and pools will be further evaluated in canals, ponds, lakes, etc. to find the best application methods for each herbicide on all important species. The rapidity and extent of plant kill, increase in waterflow and reduction of water level in canals, and duration will be observed. Water temperature, turbidity, pH, total salt content, specific gravity of chemical, emulsifier, etc. will be correlated with herbicide effects. Surfactants and other spray additives, type of carrier, spray volume, size and type of granules, and application method will be related to herbicidal effects. Techniques for biological control studies will be developed.

SUPPORTED BY U.S. Dept. of Agriculture

5.1330, PERSISTENCE AND FATE OF HERBICIDES IN WATER AND AQUATIC SOILS AND THE EFFECTS OF HERBICIDES IN IRRIGATION WATER ON CROP PLANTS

F.L. TIMMONS, Univ. of Wyoming, Agricultural Experiment Sta., *Laramie, Wyoming* 82071

Object: To determine herbicide persistence in waters and soils of treated canals, ponds and lakes; effects of temperature, pH, salt and silt content, light penetration, soil properties, etc. on dissipation of herbicides in aquatic soils; effects on crops of herbicides in irrigation water; and occurrence and concentration of herbicides in crops irrigated with such water.

Plan of work: Water samples will be taken after herbicide applications in canals, ponds, and lakes and downstream from points of application in canals or impounded water, and the persistence of each herbicide in water and rate of dilution and disappearance determined. Similarly bottom soil samples will be taken from aquatic situations after herbicidal applications and analyzed. Determination will be made of the effect of various climatic, water quality, and soil property factors on persistence and fate of herbicides in water and aquatic soils. Herbicides will be introduced in irrigation water at selected concentrations and representative crops irrigated to find the relation of stage of growth of crop, method of irrigation, soil texture and fertility, etc. to the effects of herbicides on the yield and quality of crops.

SUPPORTED BY U.S. Dept. of Agriculture

6. WATER RESOURCES PLANNING

Techniques of Planning; Evaluation Process; Cost Allocation, CostSharing, Pricing, and Repayment; Water Demand; Water Law; Institutional Problems; Non-structural Alternatives; Ecologic Impactof Water Development.

6.0001, ECOLOGY OF SOME WADING BIRD POPULATIONS AFFECTED BY THE INVASION OF THE CATTLE EGRET INTO ALABAMA

J.L. DUSI, Auburn University, School of Agriculture, *Auburn, Alabama* 36830

Wading birds have a considerable impact upon their aquatic habitat because they are large birds. They add much to the aesthetic values of any water area. Since by their adaptations these birds are an integral part of the communities of our water resources, understanding of the ecology of this group of birds is important in the wise use of our water resources. Studies to be done include: 1. Using the new probe of radio telemetry, track Cattle Egrets and the native species to determine: daily movements; the zone of influence of each species; and their migration. 2. Study population trends by aerial reconnaissance along established transect lines, to secure population density, distribution, and establishment or abandonment of colony areas. 3. Determine behavioral-ecology of the Cattle Egret and its direct impact on the native species in the colonies, using observations supported by photographs and recorded vocalizations. 4. Continue studies on growth rate of the young, food habits, nesting success, parasitism, and others.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Auburn University

6.0002, ENGINEERING DESIGN CRITERIA FOR SOIL AND WATER MANAGEMENT

J.G. HENDRICK, Auburn University, Agricultural Experiment Sta., *Auburn, Alabama* 36830

OBJECTIVES: 1. Develop improved design criteria and techniques for the construction and maintenance of terraces, waterways, and other erosion control methods which will be compatible with mechanized farming using 4-row and larger equipment. 2. Establish design limits for row lengths, turn strips, point rows and row curvatures for improved operating efficiency consistent with good soil and water management practices for 4-row and larger equipment.

Develop design criteria and techniques for construction and maintenance of terraces, waterways, and other erosion control methods compatible with field operations using 4-row and larger equipment. Existing recommendations of terrace interval channel cross-section, and gradient variations will be followed unless modification of such recommendations appears practicable. Erosion control techniques other than terraces will be investigated.

Develop design criteria for field waterways. Equipment length, overhangs, wheel bases, and clearances will be measured and channel cross-sections designed that may be crossed by modern field equipment.

Establish design limits for row lengths, turn strips and row curvatures for improved operating efficiency consistent with good soil and water management practice for 4-row and larger equipment.

SUPPORTED BY U.S. Dept. of Agriculture
Alabama State Government

6.0003, PHYSICAL AND CHEMICAL PROPERTIES OF ALABAMA WATERS LIKELY TO SUPPORT STRIPED BASS, ROCCUS SAXATILIS

E.W. SHELL, Auburn University, Graduate School, *Auburn, Alabama* 36830

Objectives: To determine if adult striped bass are present in river systems emptying into estuarine waters of Alabama, and if present, determine if reproduction of the striped bass occurs in these waters, and to determine the physical and chemical properties of these waters.

Procedures: Conservation Officers, commercial and sports fishermen and other individuals residing near areas where striped bass were once known to be present will be contacted to obtain information about the past and present status of the striped bass in local waters.

Physical and chemical properties of the waters will be analyzed to determine the most likely areas best suited for survival and reproduction of striped bass and to locate areas where striped bass fingerlings might be stocked for best results in attempting to re establish runs of the species.

Creel census or interviews with fishermen will be made and sampling of streams with rotenone and by seining will be done in certain areas to determine the presence and abundance of striped bass and to determine if spawning of striped bass occurs in the waters studied.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.
Alabama State Government

6.0004, SOME LEGAL ASPECTS OF WATER RESOURCE USE WITH RESPECT TO ECONOMIC DEVELOPMENT IN ALABAMA

D.R. STREET, Auburn University, Water Resources Research Inst., *Auburn, Alabama* 36830

The purpose of this study is to examine the socio-economic phases of water resource use in economic development, stressing the legal aspects with implications for the present and future. Specific objectives of the study are: A. To isolate socio-economic problems existing in the State of Alabama which are the result of inadequacies in present water use laws; and B. To illustrate possible solutions to problems of water use, and model legislative proposals, with their implications on economic development in Alabama in the future.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Auburn University

6.0005, PINK SALMON INVESTIGATIONS - FRESHWATER ECOLOGY

W.R. HEARD, U.S. Dept. of Interior, Biological Laboratory, *Auke Bay, Alaska*

Total freshwater mortality of pink salmon (Oncorhynchus gorbuscha) has been measured in Sashin Creek since 1940. For the average brood year, only 6 percent of the total eggs potentially available for deposition produce fry migrating to the estuary, but survival may vary between 0.2 and 23 percent. Since 1943, odd year runs have consistently produced a greater magnitude of spawners and higher freshwater survival than even year runs. Most mortality occurs between the time of egg deposition and fry emergence.

One of the goals of this research is to identify the factors causing mortality in spawning beds, determining which are density dependent and which are non-density dependent. Environmental factors including water flow and temperature, dissolved oxygen supply, gravel composition, permeability of the stream-bed, rates of oxygen removal due to decomposing organic matter and the mechanics and kinetics of spawningbed siltation, are studied in relation to mortality rates. Biological factors, including density, temporal and spatial distribution, fecundity and size of spawning adults are also measured in Sashin Creek and related to mortality rate.

Four experimental spawning channels in nearby Lovers Cove Creek provide similar natural environments where spawner density is controlled. Factors studied here, as related to spawner density, include distribution and other behavior patterns on the spawning beds, efficiency of egg deposition, egg retention and total freshwater mortality.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0006, AUKE LAKE STUDIES

W.A. SMOKER, U.S. Dept. of Interior, Biological Laboratory, *Auke Bay, Alaska*

The many small lakes tributary to the Gulf of Alasks, together with their outlet streams and watersheds, serve as spawning and rearing areas for a significant proportion of the salmon runs in this region of Alaska. Despite their importance, little is presently known concerning the limnology, ecology, and productive capacity of these small lakes. Auke Lake was selected in 1962 as the site of a long range research program designed to delineate and investigate the physical, chemical and biological dynamics of such a small lake.

Physical and chemical parameters of the lake system and temporal changes in these parameters are being determined. The standing crop of phytoplankton is monitored by the analysis of chlorophyll pigmentation, and primary production levels are established by the carbon-14 technique. The dynamics of the major salmon species, Oncorhynchus norka, is followed with the limnological program. Adult and juvenile salmon and associated fish species are studied to establish survival rates, age and growth patterns, and food habits.

Objectives are: (1) accurate determination of numbers, age composition, condition, and biomass of salmon and interrelated fish in the system and their variability with time; (2) establish the importance of various physical, chemical, and biological factors in the salmon environment and assess their variability with time; and (3) investigate possible correlations between variations in salmon numbers and biomass and variations in environmental factors.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0007, WATER QUALITY REQUIREMENTS IN ALASKA CAMPGROUNDS WITH PROJECTIONS OF RECREATION DEMANDS AND BENEFIT/COST ANALYSIS FOR SITE SELECTION

R.S. MURPHY, Univ. of Alaska, Graduate School, *College, Alaska* 99735

Alaska's outdoor recreation resources represent a major income producing sector of the State. To a large extent its further growth appears restricted by insufficient and inadequate campgrounds. Existing camping facilities have not been examined thoroughly in terms of water quality problems, and the role of water in benefit/cost analysis in evaluating recreation in Alaska barely has been touched. The product of the study would provide important information which would aid directly in the programming of new recreation sites.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Alaska

6.0008, ECONOMIC CONSIDERATIONS IN RESOURCES UTILIZATION CONFLICTS WITH PARTICULAR REGARD TO THE COOK INLET BASIN

A.R. TUSSING, Univ. of Alaska, Inst. of Soc. Ec. & Govt. Rel., *College, Alaska* 99735

The objective of the proposed research is two fold: First, a generalized survey of existing and developing areas of resource utilization conflict in the Cook inlet Basin; second, an identification of where and to what extent economic theory may be effectively employed in bringing about a more efficient and equitable resolution of such conflicts. Particular attention will be devoted to the methodology of benefit-cost theory and its analytical usefulness in cases where input data can only be estimated with a high degree of uncertainty.

6. WATER RESOURCES PLANNING

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Alaska

6.0009, INVESTIGATION OF SPAWNING GROUND POTENTIALS AND GROWTH AND SURVIVAL OF JUVENILE SOCKEYE SALMON IN FRAZER LAKE SYSTEM

W.R. MEEHAN, State Dept. of Fish & Game, *Juneau, Alaska*

The objectives of this phase of the project are:

1) To evaluate spawning ground potentials of Frazer Lake in terms of quantity and quality of available gravel.

2) To determine present utilization of spawning areas by tagging upstream-migrant sockeye adults at Dog Salmon weir, and observing their distribution on spawning tributaries of Frazer Lake.

3) To enumerate and sample downstream-migrant sockeye salmon to obtain data regarding age, size and timing of smolts in the system.

4) To obtain preliminary limnological information concerning productivity of the lake itself, in terms of physical characteristics and plankton abundance and distribution.

A weir will be installed in the Dog Salmon River (outlet of Frazer Lake) in early May 1965. Smolt sampling and enumeration will continue until the migration ceases.

Adult spawners will be enumerated and tagged as they enter the system, from early June through their migration, and spawning ground surveys will be made during July and August of 1965 to determine utilization of spawning areas and related factors.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.
Alaska State Government

6.0010, THE DEMAND FOR MUNICIPAL WATER IN CENTRAL ARIZONA

M.T. FARRIS, Arizona State University, Graduate School, *Tempe, Arizona* 85281

The quantity demanded as related to the price of municipal water used in Central Arizona is a pivotal factor in the economic feasibility of any proposal for the development of additional water sources for the area. One plan, the Central Arizona Project proposal, assumes water sales to municipal and industrial users at $50 an acre-foot with 312,000 acre-foot of potential sales.

Little is known about the demand for domestic water in Arizona. Some rough estimates of future demand for domestic water can be gained by ascertaining the relationship between water use and the principal factors influencing its price, income and population in the service area.

Cross-sectional and time-series data will be obtained by field survey of municipalities in the study area. This data will be analyzed by statistical procedures to derive estimated relationships between per capita consumption, price , and income. This relationship can then be used in conjunction with population projection to estimate the range of probable water consumption for the study area.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Arizona State University

6.0011, ECONOMIC IMPLICATIONS OF WATER POLICY IN ARIZONA

M.M. KELSO, Univ. of Arizona, School of Agriculture, *Tucson, Arizona* 85721

The hypothesis under investigation is that the content of water policy affects aggregate economic efficiency with which water resources are developed and used and, possibly, the distribution of income resulting therefrom.

The test of this hypothesis will be undertaken by examining existing water law and water-managing organizations in Arizona to determine whether and how they constrain contemporary decision making by water- using 'firms' as to water development, use and transfer. It will be presumed that present water development, use and transfer are the result, in part, of contemporary constraints on water-using firms found in present water policy. Further test of the hypothesis will involve synthesizing an array of seemingly practicable changes in water policy and testing the constraints peculiar to each by programming them into economic models of the water-using firms. This will determine whether such modifications in water policy might, in fact, increase the magnitude of economic rent produced by the aggregate water input and whether such increases, if any, will be accompanied by changes in the distribution of that return.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Arizona

6.0012, THE ECONOMICS OF WATER TRANSFER - AN APPRAISAL OF INSTITUTIONS

M.M. KELSO, Univ. of Arizona, Agricultural Experiment Sta. , *Tucson, Arizona* 85721

Objectives: Under conditions of security and flexibility of water rights and of competition among water uses peculiar to Arizona: 1. To appraise the legal-institutional-administrative devices and processes through which transfers of water between uses and users take place and 2. To asses the consequences of these devices and processes on the economic efficiency and equity of water use and 3. To suggest desirable modifications in these devices and processes that might enchance economic efficiency or equity in the use of water resource.

DESCRIPTION OF WORK; The general approach will be to describe the functional structure of the selected water right complex vis-a-vis the marginal value product of water use in each category of use in each area; to determine the effects on the marginal value product of water that result from varying the relevant water right complex among categories of uses in each area; relevant hypothetical modifications of the institutional restraints will be analyzed to determine their probable effects on the marginal value product of water use; to appraise the results from such alternative modifications against the criterion of maximized marginal value product to water use; to asses the relative attainability of each of the programed alternatives by examining the attitudes and values of affected persons toward such possible institutional changes; to conclude as to the hypothetical ideal of efficiency and the political ideal of attainability relative to each of the programed modifications.

SUPPORTED BY U.S. Dept. of Agriculture
Arizona State Government

6.0013, WATER IN RELATION TO ECONOMIC GROWTH IN AN ARID ENVIRONMENT

M.M. KELSO, Univ. of Arizona, School of Agriculture, *Tucson, Arizona* 85721

Only about one-third of the approximately four and one-half million acre-feet of groundwater pumped annually in Arizona is replaced by natural recharge. The resulting overdraft of some three million acre feet per year is lowering the water table at an estimated average rate of six feet per year. As a consequence, costs of recovering groundwater are increasing. It is expected that changes in farm organization, output level, size of operation and resource demands will result. Changes are also expected in the rest of the economy, particularly in those sectors processing agricultural commodities and supplying inputs to the agricultural sectors.

Objectives - 1. Predict the impacts of declining water table on the organization, output and resource use in the irrigated crop sector in Arizona. 2. Predict the impact of changes in agricultural production and resource demand on other sectors of the economy.

Procedures - 1. Mathematical programming models designed to predict effects of increasing costs of water on output, organization and resource demand of typical farm situations in the irrigated agriculture sector are being developed. The programming models will be linked with an electrical analog model of the groundwater system. 2. An interindustry model of the Arizona economy has been developed which comprises 26 endogenous sectors and seven exogenous sectors. 3. The effects of changing conditions of water supply over time on the growth and development of any sector of the state's economy can then be predicted by 'plugging in' the predictions of the programming models into the interindustry model.

SUPPORTED BY University of Arizona
Rockefeller Foundation

6.0014, AN ECONOMIC STUDY OF THE DEMAND FOR OUTDOOR RECREATION

D.A. KING, Univ. of Arizona, Agricultural Experiment Sta. , *Tucson, Arizona* 85721

Description of Work Proposed: Subobjective 1: The general theory of demand and, in particular, recreation demand will be examined for its applicability to estimating demand functions for motor-boating in an arid environment. Based on this examination, modification of existing methods will be made as necessary. Subobjective 2: The method developed above will be applied. A survey of boatowners will be made to gather necessary information. This will include cost data, socioeconomic characteristics, distribution of use among reservoirs. The data will be used to develop demand functions and derive value estimates. Use distribution data will be used to estimate cross elasticities of demand between reservoirs.

SUPPORTED BY U.S. Dept. of Agriculture
Arizona State Government

6.0015, OPERATIONS RESEARCH STUDY OF WATER RESOURCES DEVELOPMENT AND MANAGEMENT IN THE TUCSON AREA

C.C. KISIEL, Univ. of Arizona, Graduate School, *Tucson, Arizona* 85721

The general objective of the project is to undertake a preliminary application of the methodology of operations research to water resources development and management in Tucson area. Implicit in the objective are: (1) an analysis of existing data collection systems in the face of future planning responsibilities, (2) establishment of quantitative objective functions and their constraints, and (3) establishment of design criteria, formulation of a set of feasible alternative designs, and determination of the optimal design(s) through mathematical programming and simulation techniques. Ultimately, an optimal dynamic plan(s) would be recommended for the conjunctive development and management of ground and surface water resources within and without the region. The methodology may prove useful for similar studies in other arid-land regions.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Arizona

6.0016, LIFE HISTORY OF LONGEAR SUNFISH

R.L. BOYER, U.S. Dept. of Interior, South Cen. Reservr. Invtgs. , *Fayetteville, Arkansas*

Due to their feeding habits and abundance in Beaver and Bull Shoals Reservoirs, the longear sunfish assumes a place of importance.

The objective of this study is to obtain information basic to a more through understanding of the behavior of longear sunfish in reservoirs.

Using SCUBA, direct observations are made underwater, sometimes being recorded on film for later analyses. Seasonal and diurnal behaviors are followed and environmental factors are monitored. Barrel trapping studies are carried out to determine the extent of horizontal and vertical movement. Collections are made for determinations of seasonal gonadal body weight ratios, the number of eggs spawned per nest, seasonal changes in ova diameters, and the size, age, and food habits of spawning fish.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0017, MOVEMENTS OF SPORT FISHES IN BEAVER RESERVOIR

T.O. DUNCAN, U.S. Dept. of Interior, South Cen. Reservr. Invtgs. , *Fayetteville, Arkansas*

The objective of this research is to determine the movements of several important reservoir sport fish species and the contribution of populations from various life zones of Beaver Reservoir to the upper reservoir spring fishery. White bass will be the most numerous fish studied and others will include walleye, northern pike, channel catfish, blue catfish and flathead catfish. The factors which influence the spring migrations and other movements shall be investigated.

Trapnets will be used to capture large quantities of fish in fall, winter, and early spring for tagging. Electrofishing devices shall be used in shallow upstream spawning areas to capture these species for tagging purposes and to recover previously tagged fish. Fishermen returns are expected to supplement recaptures by gill-netting, etc.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0018, DEVELOPMENT OF IDENTIFICATION KEYS TO LARVAL, AND JUVENILE RESERVIOR FISHES

T.O. DUNCAN, U.S. Dept. of Interior, South Cen. Reservr. Invtgs. , *Fayetteville, Arkansas*

Work units at this Investigation are being revised to determine the best methods of measuring survival of larvae, and environmental factors influencing their survival (or mortality). Photographic larval fish keys to the important species in the reservoirs under investigation are required.

The objective is to prepare a photographic key of reservoir fishes using modern photomacrographic techniques to prepare plates of major changes of body structure from hatching through known characteristic features of juveniles. To provide supplemental information on spawning and hatching periods, and other features of the development of reservoir fishes. Using fish specimens collected by electrofishing devices, strip and fertilize eggs, hatch and rear in laboratory experimental hatchery, preserve specimens daily and photograph. Use reflected and transmitted light, and stains to accentuate features desired in keys.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0019, POPULATION ESTIMATES FROM MIDWATER TRAWL SAMPLING

A. HOUSER, U.S. Dept. of Interior, South Cen. Reservr. Invtgs. , *Fayetteville, Arkansas*

The technique of estimating the size of shad populations developed by Houser and Dunn (1967) through midwater trawl sampling has provided a new approach to the study of fish population dynamics in reservoirs. This method will be used to estimate the size of shad populations and for any other species occurring in the catch in sufficient numbers to permit computation. These samples will also provide data on recruitment, mortality, growth and distribution. A series of 60 nighttime hauls conducted during one week provides sufficient data for an estimate. Three estimates will be attempted annually in Bull Shoals and Beaver Reservoirs.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0020, COLLECTION AND COLLATION OF AVAILABLE BIOLOGICAL, PHYSICAL AND CHEMICAL DATA ON U. S. RESERVOIRS

R.M. JENKINS, U.S. Dept. of Interior, Natl. Reservoir Res. Prog. , *Fayetteville, Arkansas* 72701

Extensive search and procurement of all pertinent physical, chemical and biological data on reservoirs from the literature and from the Branch River Basin Studies, BSFW, USGS, Bureau of Reclamation, Corps of Engineers, USPHS, TVA, Branch of Federal Aid, BSFW, and State fishery agencies.

Development of methods of storage and retrieval of large masses of data, and statistical analysis of interrelations between reservoir environmental conditions, biological productivity and sport fish production and harvest.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0021, EFFECTS OF ENVIRONMENTAL FACTORS ON STANDING CROP AND HARVEST OF FISHES IN U. S. RESERVOIRS

R.M. JENKINS, U.S. Dept. of Interior, Natl. Reservoir Res. Prog. , *Fayetteville, Arkansas* 72701

Exploratory multivariate analysis has been completed on effects of nine environmental factors (reservoir area, mean depth, total dissolved solids, storage ratio, shore development, age, fluctuation, outlet depth and growing season) on fish standing crop and sport commercial harvest. In this new study, standing crop and harvest estimates on about 250 reservoirs will be subdivided by fish species (involving up to 80 species) in relation to environmental factors. Sport fish harvests will also be examined in relation to fishing pressure and success rate. Calculations will be performed on IBM 7040 computer, with programming by Dr. Dunn.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0022, EXPLORATORY SAMPLING PROGRAM FOR YOUNG-OF-THE-YEAR FISH

N.F. NETSCH, U.S. Dept. of Interior, South Cen. Reservr. Invtgs. , *Fayetteville, Arkansas*

Background--The majority of the fish population dynamics studies on large impoundments are concerned with fish 1 year or more old. Research done by this and other agencies has shown that the most dynamic period in the life of at least some species is during their first year. The purpose of this work unit is to develop a population dynamics program for age-group O fish in the upper White River reservoirs.

The objectives are to: (1) develop sampling techniques for age group O fish suitable for the upper White River reservoirs; (2) determine gross distribution patterns for the major species; and (3) develop a population dynamics program for young fish.

The procedures to be followed are to: (1) obtain monthly samples from four areas on each study reservoir--major habitat types will be sampled in each area; (2) use gear which will include depth controlled tow nets up to 1/8 inch mesh, seines, rotenone samples, small mesh gill nets and electrofishing; (3) analyze data so that catch can be correlated with date, reservoir, area, habitat type and gear.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0023, SPOTTED BASS REPRODUCTION IN BULL SHOALS

L.E. VOGELE, U.S. Dept. of Interior, South Cen. Reservr. Invtgs. , *Fayetteville, Arkansas*

The spotted bass is an important sport fish in Bull Shoals Reservoir and appears to have increased in abundance since impoundment. Little is known about reproductive requirements or their ability to compete with other black bass for preferred spawning habitat.

The objectives of this study will be to determine the habitat, substrate, water depth, temperature and other environmental requirements for successful reproduction, and to describe the spawning behavior in detail.

Observations underwater will utilize scuba and will include filming with an underwater movie camera to provide detailed analysis of spawning behavior. Nest contents will be enumerated at egg and larvae stages to determine hatching success.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0024, IMPOUNDMENT EFFECTS ON WATER QUALITY AS REFLECTED IN PARASITISM OF RESERVOIR BASSES

D.A. BECKER, Univ. of Arkansas, Water Resources Research Ctr. , *Fayetteville, Arkansas* 72701

The proposed study is the first pre-impoundment through early impoundment investigation of this nature to be conducted in the United States.

Field investigations will employ electrical shocking gear for the live collections of the black basses Micropterus dolomieui Lacepede, M. punctulatus (Rafinesque), and M. salmonides (Lacepede).

Basses will be examined in the laboratory for helminth and copepod parasites in an effort to follow the quantitative and qualitative dispersons and fluctuations of these parasites as the water quality is effected by the water level fluctuations from a river to a reservoir environment. Standard and total length, weight, and scale samples will be obtained to ascertain the effect of parasitism on the aging and growth rates of basses which may help explain why sport fishing declines after several years in recently impounded reservoirs effecting the recreational economy of the municipalities surrounding reservoirs. Parasitism will be related to the whole food chain in an attempt to establish another parameter for water quality.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Arkansas

6.0025, LEGAL-ECONOMIC ASPECTS OF WATER USE IN ARKANSAS

H. ELLIS, Univ. of Arkansas, Agricultural Experiment Sta. , *Fayetteville, Arkansas* 72701

Overall objectives of this study are as follows: 1. To appraise the current status, and selected aspects of the historical development, of Arkansas laws regarding water use. 2. To evaluate such laws in light of existing and emerging or potential water use and development problems of farmers and others. 3. To evaluate alternative legislative or other remedial measures for coping with such problems.

DESCRIPTION OF WORK - Conduct study of (1) reported Arkansas Appellate Court decisions, statutory and constitutional provisions, and attorney general opinions regarding the use of the various water resources, surface and underground, natural or artificial, in the State; (2) relationship of water-rights and associated laws to the functions of districts or other local organizations; (3) actual administration and operation of selected statutes regarding water use. Evaluate (1) water-use laws in light of existing and emerging or potential water-use and development problems of farmers and others; (2) adequacy of existing water-use and associated laws; (3) alternative legislative or other remedial measures for coping with problems that appear in need of correction.

SUPPORTED BY U.S. Dept. of Agriculture
Arkansas State Government

6.0026, GROUND WATER, RESOURCES AND RECHARGE - RICE

K. ENGLER, Univ. of Arkansas, Agricultural Experiment Sta. , *Fayetteville, Arkansas* 72701

Determine by use of a vertical well hydrologic conditions set up in recharge; effect of chemical compatibility and bacteriological contamination, if any amount, if any, of surface filtration and other treatments necessary for successful recharge using surface water; make estimates of cost of artificial recharge using results of project as a basis for these determinations; check depth-to-water in irrigation wells of the rice growing areas to determine water level trends and verify or disprove safe yield calculations previously made.

DESCRIPTION OF WORK - The annual depth-to-water measurements in approximately 275 rice irrigation wells was conducted in cooperation with the Federal Land-Bank of St. Louis and the United States Geological Survey. These wells were measured in the Grand Prairie Region and in the Northeast rice producing area. A 45 ft. sq. No.7 rock media filter was constructed and tested. The recharge well was redeveloped to a specific capacity of approximately 20 gal/per min. per ft. and one test was run to verify the effect of air in the recharge water. Considerable time was spent in preparation of reports.

SUPPORTED BY U.S. Dept. of Agriculture
Arkansas State Government

6.0027, SEASONAL VARIATIONS IN THE PHYTOPLANKTON - BACTERIA POPULATIONS AND THE NUTRIENT CONCENTRATION IN BEAVER RESERVOIR

R.A. GEARHEART, Univ. of Arkansas, School of Engineering, *Fayetteville, Arkansas* 72701

The objectives of this research on Beaver Reservoir are: (1) to determine chemical nature and amounts of nitrogen and phosphorus; (2) to quantify and qualify the phytoplankton and bacterial population; and (3) to evaluate the relationship between the type and amount of nutrient and the phytoplankton-bacterial population. Determinations and analysis will be based on: (1)

monthly vertical samples at 20 foot intervals at three stations; (2) chemical and physical parameters; (3) enumeration and identification of phytoplankton samples and determination of physiological groups of bacteria present; (4) analysis of type and amounts of nitrogen and phosphorus; and (5) correlation of plankton -bacterial population with nutrient concentration and chemical species.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0028, WATER RESOURCES PLANNING STUDIES - ARKANSAS AND OKLAHOMA

L.R. HEIPLE, Univ. of Arkansas, Water Resources Research Ctr. , *Fayetteville, Arkansas* 72701

The proposed research will include a comprehensive planning study of the watercourses which flow between the states of Arkansas and Oklahoma. Included in these basin studies will be the quantity and quality of stream discharge at selected stations and the effect of proposed conservation storage on the quantity and quality parameters. A major purpose of this investigation will be to permit future allocation of this water resource between the two adjoining states. Previously collected field data will comprise the primary source of data for this study.

The investigative approach proposed is: 1. Investigative review of all water planning of all other agencies within the basin limits. 2. Preparation of flow duration curves for all basins using mean daily flow records ready for computer processing. 3. Make a review of established water quality data with additional evidence collected as required. 4. Determine the effect of proposed storage sites on stream flow duration curves and on water quality at each storage site.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Arkansas

6.0029, DISTRIBUTION AND GROWTH PATTERNS OF THE GIZZARD SHAD (DOROSOMA CEPEDIANU) AND THREADFIN SHAD (DOROSOMA PETENENSE) IN RESERVOIRS

R.V. KILAMBI, Univ. of Arkansas, Graduate School, *Fayetteville, Arkansas* 72701

The objectives of the research are: (1) to determine the abundance and distributional patterns of the young of the year gizzard and threadfin shad; and (2) to describe early growth history of the young shad. Analysis will be based on monthly samples from two reservoirs in main channel and cove areas, including information on unit of effort in collecting, estimates of relative abundance and seasonal fluctuations, length and weight data, and biotic and abiotic characteristics. Collections will be made by Bureau of Sport Fisheries and Wildlife, South Central Reservoir Investigations.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0030, EFFECTS OF WATER DIVERSION ON BIOTA AND WATER QUALITY IN THE STATE OF ARKANSAS

R.V. KILAMBI, Univ. of Arkansas, Water Resources Research Ctr. , *Fayetteville, Arkansas* 72701

The proposed study is to evaluate biological characteristics of fish in Arkansas Reservoirs and the King's River, the latter serving as an unaltered environment. The emphasis is on the population structure in relation to the environment with special reference to meristic and morphometric characters, age and sex composition, rate of growth, fecundity, and interaction between populations or species and their environment. Laboratory experiments will be planned to study the effects of temperature on hatching and survival of eggs, critical period in the development of eggs, and the fixation of the meristic characters.

It is also planned to tabulate and correlate plankton data with physical and chemical variants collected from five small Arkansas impoundments over a period of 28 years. Emphasis will be placed on seasonal cycles of plankton species characteristics of these environments, their possible use as indices of trophic levels, and the succession of species along with physical chemical change in two small artificial lakes over 28 years. Laboratory experiments will be performed to determine effects of controlled physical and chemical factors on resident plankters and the results compared with field data.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Arkansas

6.0031, A STUDY OF PHYTOPLANKTON DYNAMICS IN LAKE FAYETTEVILLE AS A MEANS OF ASSESSING WATER QUALITY

R.L. MEYER, Univ. of Arkansas, Graduate School, *Fayetteville, Arkansas* 72701

The proposed research plan involves an investigation of the algae as primary producers in a lake typical to northwestern Arkansas, Lake Fayetteville. The investigation will include field and laboratory analysis of the chemical, physical and biological factors effecting algal biomass, primary productivity and algal succession.

Field investigations include observation on: 1. The abiotic and biotic factors effecting primary productivity in an intensively studied lake. 2. Samplings from similar lakes will be compared with base lake.

Laboratory investigation would employ isolated and cultured naturally occuring algal species: 1. To identify the parameters to which influence the presence or absence and growth rate. 2. To identify those factors which determine its life cycle.

Field and laboratory data would be correlated to determine which parameter are the most applicable in influencing primary productivity and water quality.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Arkansas

6.0032, GEAR RESEARCH-RICE FARM PRODUCED FISH

J.C. HALL, U.S. Dept. of Interior, Gear Research Station, *Kelso, Arkansas*

Design, fabricate, test, and develop fishing equipment and systems to increase effectiveness and efficiency of farm pond harvesting operations. Critical to the profitability of the farm pond fish industry are: (1) cost of harvesting, (2) cost of handling live fish, (3) conservation of water, and (4) convenience for taking any portion of the fish stocked in ponds ranging in size from 5 to 160 acres.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0033, THE EFFECTS OF LIGHT WAVE LENGTHS ON THE RATES OF PHOTOSYNTHESIS AND ITS REALTION TO OXYGEN LEVELS IN PONDS

D.L. TACKETT, U.S. Dept. of Interior, Fish Farming Exptl. Sta. , *Stuttgart, Arkansas* 72160

Penetration values of selected wave-lengths will be determined by use of a limnophotometer. Simultaneously, measurements of dissolved oxygen and pH will be made. Weather data will be incorporated into the study to evaluate photosynthesis and respiration.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0034, UTILIZATION OF INSECT ENEMIES IN THE CONTROL OF INSECT PESTS AND WEEDS

L.A. ANDRES, U.S. Dept. of Agriculture, *Albany, California*

Object: To determine the basic relationships between weeds and weed-feeding insects and to effectively carry out all domestic phases of a program designed to use insects as biological agents to control weeds.

Plan of Work: Basic research is undertaken on interrelations between weeds and insects to determine factors of host plant selection and host specificity. When a program to control a weed is necessary, a thorough study of the weed is undertaken in the United States, its distribution is determined and the types of habitats it occupies.

Exploration for and preliminary studies on host specificity of insect enemies of aquatic weeds is undertaken at Castelar, Argentina and use is also made of information developed by P. L. 480

grants. Species are selected as candidates for introduction, and material is shipped to the Entomology Research Division quarantine facility at Albany, California, where the final tests are conducted to determine that no useful plant will be attacked. After clearance has been obtained from appropriate State and Federal agencies, colonization of the insect begins. When the insect becomes established and builds up adequate colonies, redistribution of the insect to additional areas is carried on. As a rule, the redistribution program involves arranging cooperative programs with State and county organizations. Evaluation of the effectiveness of the insect as a control agent is conducted.

SUPPORTED BY U.S. Dept. of Agriculture

6.0035, SYSTEMATIC ANALYSIS OF MANAGEMENT EFFECTIVENESS OF THE WATER QUALITY CONTROL BOARD SYSTEM OF CALIFORNIA

J.A. HARMON, Engineering Science Inc., *Arcadia, California*
DOWD

This study is an evaluation of the actions of the California State Water Quality Control Board System to derive fundamentals of management practices that will be systematically catalogued and summarized in a form that can be adapted on a nationwide basis to the workings of other boards or agencies in the generic fields of water resources management of water quality control. Through an understanding of the mechanism of this board and its interrelationship to other elements of water resources management programs, and by development of criteria that can be utilized to measure the performance of such an agency, considerable knowledge will then have been gained that will be directly related to the management problems inherent in a total water resources program.

Detailed output from the study will be in the format of an analytic report of environmental factors affecting water quality management, a behavioral analysis of the functioning of an actual board, a decision process model representing the actions of an 'ideal' board, a set of standard problems consistent with the decision process model, and recommendations for decision-making techniques appliable to water management boards.

Current on-going research in water quality management appears to be generalized toward survey and analysis of large cross-sections of the management activity. This study will emphasize the systematic analysis of a water quality management agency's decision making processes. In this respect this study complements existing research work.

The study will be performed utilizing techniques of microdata analysis and computer printouts which symbolize actual board proceedings. From this, a model of an 'ideal' board will be developed.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0036, SOIL MOISTURE DRYING CURVES-MANAGEMENT RELATIONS

M.B. RHEA, Humboldt State College, Graduate School, *Arcata, California* 95521

Objective: The objective of this research is to determine the nature of the soil moisture depletion curves under varying vegetative cover types and under varying management practices in Humboldt County, California.

Work Proposed: Long range plans call for intensive sampling of soil moisture depletion on varying vegetative and soil types and under varying management practices.

The present proposal is directed at 1) bracketing the extremes expected by sampling depletion on ungrazed range land and on undisturbed upland redwood forest, and 2) on north and south aspects of recently- cut redwood lands.

SUPPORTED BY U.S. Dept. of Agriculture

6.0037, A SYSTEM APPROACH FOR INTEGRATING GROUNDWATER AND SURFACE-WATER USE

R.E. MITCHELL, Aerojet General Corporation, *Azusa, California*

This program will produce an analytical technique by which the most efficient utilization of water resources may be determined. The influence factors of potential surface supplies, quantity and quality needs of the users, waste-water treatment, groundwater pollution, community growth characteristics, economics, and legal/organizational needs will be included.

This research program is undertaken to present a systems approach to the preservation of the quality and quantity of the groundwater resource.

The research program will evaluate the projected needs of a typical expanding urban/rural community currently using groundwater supply and evaluate the steps to be taken to best provide the future water supply. The various sources of surface water and groundwater and their quality management will be considered. In addition, all the system constraints will be included so that a useful approach will be defined. To validate the approach, the study will be related to an existing groundwater problem area. The program will relate all the factors, both direct and indirect, to provide a master plan for this area.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0038, SAN PABLO BAY STUDY

F.A. NUDI, U.S. Dept. of Interior, Tiburon Marine Lab., *Belvedere - Tiburon, California* 94920

Objectives: To determine the effects on marine life caused by increased dredging and spoil disposal by the Army Corps of Engineers at pre-selected areas in San Pablo Bay in cooperation with U.S.B.S.F.W. River Basins.

Procedure: Monthly sampling will be made for the collection of water samples and marine organisms at five separate areas involving twelve station from Tiburen Peninsula to Carquinez Strait. Sampling areas include past, present and future dredged and spoiled areas as well as areas yet undisturbed. The type of sampling to be done will include trawling with a 15-foot otter trawl to determine the abundance and distribution of benthic swimming animals, bottom samples taken with a Birge-Ekman dredge to determine the types and abundance of smaller, more sedentary benthonic animals and water samples taken at surface and off-bottom to measure the temperature, and dissolved oxygen present.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0039, CONSUMER ATTITUDES TOWARD MINERAL TASTE IN DOMESTIC WATER

H.J. ONGERTH, State Dept. of Pub. Health, *Berkeley, California* 94704

The major specific aim of this research is to measure consumer attitudes toward mineral taste occurring in 30 carefully selected California water systems, and then to develop, by statistical procedures, the best fitting mathematical function which will describe the relationship between amount of mineral content in water and measured consumer attitudes. The function relationship, once developed, will allow limiting standards to be recommended for mineral content in domestic water. Recommending such standards on the basis of scientific data constitutes the general purpose of this research. The standards recommended will also represent an important step toward the attainment of long range goal of this type of research: the establishment of definitive limiting standards for mineral content in domestic water in order to fully ensure potability for daily consumption.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

6.0040, LEGAL ASPECTS OF WATER RIGHTS IN THE WEST

W. HUTCHINS, U.S. Dept. of Agriculture, *Berkeley, California*

Objectives: To review, analyze, and compare the development and current status of the laws relating to water rights in the 19 western states. This includes the states lying west of or along the 100th meridian.

Approach: Analyses are made of the development and status of the statutes, constitutional provisions, and reported court decisions regarding water rights in each western state with respect to various sources of water. Significant comparisons are made among the applicable laws in the different states. Separate publications on the water rights laws of individual states have been or are being prepared as well as a comprehensive report covering all of the western states. It will include discussions of applicable state and Federal laws and interstate or international matters.

SUPPORTED BY U.S. Dept. of Agriculture

6.0041, GENESIS AND MORPHOLOGY OF PYGMY FOREST-BLACKLOCK SOIL ECOSYSTEM

H. JENNY, Univ. of California, Agricultural Experiment Sta. , *Berkeley, California* 94720

In the regional redwood-Douglas fir forest of Mendocino County, there occur on ancient marine terraces pygmy forests of dwarfed pines and cypresses. They are confined to extremely leached and improverished podsol soil with impenetrable iron hardpan layers. These sites are a challenge to the understanding of plant growth and soil fertility.

The work proposed will ascertain the role of the fluctuating water table by installing recording devices along the transition zone from pygmy to regional forest. On other sites, drainage systems will be installed to permanently lower the water table; hardpan layer will be broken up with jackhammers; soil acidity will be neutralized and fertilizer treatments will be initiated to build up the depleted nutrient level. Growth rates will be determined on natural and planted vegetation.

SUPPORTED BY California State Government

6.0042, PUBLIC ATTITUDES TOWARD REUSE OF RECLAIMED WATER

A.L. KNUTSON, Univ. of California, School of Public Health, *Berkeley, California* 94720

The research here proposed has three specific objectives: 1) to assess the attitudes, beliefs, and behaviors regarding reclaimed water expressed by respondents chosen from four selected california communities: 2) to examine relationships between measured attitudes toward reclaimed water and selected personal characteristics of respondents;and 3) to examine relationships between measured attitudes toward reclaimed water and general climatic conditions, abundance of fresh water supply, and the limited reuse of reclaimed water.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of California

6.0043, ECONOMIC GROWTH AND OPTIMUM WATER RESOURCE DEVELOPMENT

I.M. LEE, Univ. of California, Agricultural Experiment Sta. , *Berkeley, California* 94720

The objective of this project is to develop criteria and quantitative procedures for analyzing the economics of water development and so to formulate them to make them useful for policy formulation and operation. The study will contribute to the knowledge of economic growth since it will consider methods of appraising alternative development programs for water in a setting of economic growth. It is expected that the methodological approaches considered will be applicable to the analysis of allocation and development problems of other resource than water.

An investigation will be made by study of a particular water development system of existing procedures for estimating resource demands in a dynamic economy and hypotheses formulated about the determinants of water demands and the relationships among them. A conceptual framework will be developed for quantitative analysis of development under conditions involving different rates and patterns of economic growth.

SUPPORTED BY California State Government

6.0044, ECONOMIC EVALUATION OF WATER - A' DYNAMIC INTERREGIONAL IMPUT-OUTPUT PROGRAMMING MODEL OF CALIFORNIA AND THE WESTERN STATES WATER ECONOMY

P.H. MCGAUHEY, Univ. of California, School of Engineering, *Berkeley, California* 94720

Part IV of this series of studies on the Economic Evaluation of Water involved the development of an 81 sector tranactions table for the California economy from secondary data. The table was then aggregated to a 24 order model for which water withdrawal coefficients were derived. The model was cast in a linear programming format in which water availability constraints were varied. Resulting changes in the format in which water availability constraints were varied. Resulting changes in the value of the objective function, which was taken to be value added for the productive sectors, and the value of the dual solution were noted. A so-called 'time path' of the 'shadow price' of water was analyzed. The results will appear in 1968 in a report to the supporting agency by Dr. E.M. Lofting and entitled 'An Input-Output and Linear Programming Analysis of California Water Requirements.'

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of California

6.0045, ECONOMIC EVALUATION OF WATER, A DYNAMIC INTERREGIONAL INPUT-OUTPUT PROGRAMMING MODEL OF CALIFORNIA AND THE WESTERN STATES WATER ECONOMY

P.H. MCGAUHEY, Univ. of California, School of Engineering, *Berkeley, California* 94720

The work reported in Part V of this series of studies on Economic Evaluation of Water involves the development of multiregional input- output table for the western states. For purposes of analysis a set of fifteen water use coefficients was estimated for each of the regions of the model and a western states' interregional 'water content' matrix was constructed. This matrix was then used in the development of interstate water dependency coefficients and water use multipliers. The determination of embodied water transfers among the states, as well as water-constrained projections are examined. A report authored by Dr. H. Craig Davis and entitled 'Multiregional Input-Output Techniques and Western Water Resources Development' has been submitted to the supporting agency.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of California

6.0046, ECONOMIC EVALUATION OF WATER QUALITY

P.H. MCGAUHEY, Univ. of California, School of Engineering, *Berkeley, California* 94720

The general objectives of the research are to develop and demonstrate methods of utilizing modern computer techniques in water quality management problems presently unresolved for lack of a systems engineering approach. The specific objectives now nearing completion are to minimize the cost of achieving water quality goals by waste water treatment. For this purpose mathematical models have been developed, programmed for the computer, and applied to examples to illustrate their use. Ongoing work is directed to the development of waste water treatment coefficients by which to determine the limitations on economic growth, resulting from increased beneficial use of water, that are imposed by the associated cost of treating waste water at higher levels.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

6.0047, THEORETICAL AND EMPIRICAL STUDIES OF STOCHASTIC MODELS FOR THE ANALYSIS OF FLOOD CONTROL AND RELIEF POLICIES

C.B. MCGUIRE, Univ. of California, Graduate School, *Berkeley, California* 94720

The purpose of the proposed research is to improve the methodology of designing flood control and flood relief systems. An economic, stochastic model of rational investment behavior in the face of floods now under development is briefly presented. This model which relates economic objectives, production technology, engineering and hydrological analysis and governmental planning, will be applied to a number of quite different alternative policies for flood control and flood relief. The proposed research would (a) explore the relationship of the model to the mathematical theory of reliability, optimal maintenance theory, and the theory of Markov processes, and explore the dynamic characteristics of the model, (b) subject the model to sensitivity analysis, (c) bring risk more explicity into the model, (d) apply the model to inter-governmental flood-related programs, (e) improve the hydrological assumptions of the model, and (f) subject the model to empirical verification.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0048, NUCLIDE UPTAKE BY ALGAE AND ZOOPLANKTON

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In the past few years studies of strontium and calcium accumulation by Chlorella cultures and by Daphnia magna have provided the basis for concluding that there are no food chain effects on the uptake, rate of uptake and equilibrium levels of calcium and strontium in these organisms. The only important factors are the concentrations of calcium and strontium in the water and growth rates of the organisms. The effect of other environmental variables on the accululation of these elements by Chlorella and Daphnia is the main interest of present studies. Most of the studies are oriented toward biota-sediment interrelationships and how they affect water concentrations of isotopes.

For this purpose sediments are being collected from California and Nevada lakes and streams which differ widely in their calcium and magnesium concentrations and also in their total ionic concentrations. The sediments are dried and tagged with radioactive cations. For example, upper layer sediments from Lake Tahoe, which have very little in the way of inorganic dissolved nutrients, will be compared with the uptake patterns from sediments from Pyramid Lake in Nevada, which have very high and complex dissolved inorganic milieu. Preliminary results indicate that fish have an interesting feedback on the amount and rate of sediment-sorbed radioactivity released into the water and the feedback effect is dependent on the type of sediment.

SUPPORTED BY U.S. Atomic Energy Commission

6.0049, THE ECONOMICS OF PUBLIC INVESTMENT IN RESOURCES DEVELOPMENT

S.V. WANTRUP, Univ. of California, Agricultural Experiment Sta., *Berkeley, California* 94720

1. To analyze the basic problems in evaluating benefits and costs. 2. To improve methods of allocating benefits and costs. 3. To appraise the economics of alternative technical measures. 4. To analyze the institutional aspects.

Work proposed: The project will continue to be undertaken in separate but related phases. Phases active during 1962 are the following: 1. Projections of Water Requirements in the Economics of Water Policy. 2. Evaluation procedures for Extramarket Benefits and Costs. 3. Problems of Pricing Natural Resources. 4. Organizing the Planning of Land and Water Resources. 5. Economic Appraisal of Water Conveyance Systems.

SUPPORTED BY California State Government

6.0050, CALIFORNIA-ARIZONA ECONOMIC INTERDEPENDENCE AND THE COLORADO RIVER CONFLICT WITH PARTICULAR REFERENCE TO AGRICULTURE

H.O. CARTER, Univ. of California, School of Agriculture, *Davis, California* 95616

The current conflict between California and Arizona over the joint use of the Colorado River water has precipitated widespread discussion and speculation as to the probable effects on development and growth of the respective state economies. Specifically, information is needed to answer such questions as: What is the extent and nature of the dependence between agriculture in California and nonagriculture in California, agriculture in Arizona and even nonagriculture in Arizona? What are the technical water requirements of different sectors in California and Arizona and how are these requirements related with economic activity within California regions or between California and Arizona? To what extent does the economic prosperity in each of these states depend on the use of the water from the Colorado River? Given this interdependency, and given the capacity of the Colorado River, how would the different states be affected by alternative schemes to allocate this water? While the proposed study covers only Northern California, Southern California, and Arizona, it is meant to be a pilot study conducted in such a manner that it will serve to indicate the problems of connecting state economies in an input-output framework.

We intend to develop an interregional input-output model for California and Arizona with the agricultural sectors spotlighted and examined in greatest detail. A transaction table for California (1958) by Carter is in the process of being completed. A similar table for Arizona (1958) by Martin is also in the processing stage. The proposed study will draw on and build upon this work. These two matrices will be combined with trade matrices into an interstate matrix capable of relating production in any sector to the activity level in all other sectors in the two-state economy.

SUPPORTED BY California State Government
University of California

6.0051, ON-FARM IRRIGATION WATER SUPPLIES AND COSTS IN RELATION TO CROPPING SYSTEMS AND PRODUCTION ADJUSTMENTS IN THE SACRAMENTO VALLEY

T.R. HEDGES, Univ. of California, Agricultural Experiment Sta., *Davis, California* 95616

To complete study of irrigation water quantities and costs in the Sacramento Valley and choices enabling farmers to obtain maximum profits from land and other resources. Analysis for the Central rice-growing area is completed; this renewal will focus on general crops on the more fertile recent alluvial soils in the Southern Sacramento Valley. Rice, winter grains, safflower, and grain sorghums are the predominant alternatives on the basin soils. Dry edible beans, corn, and, for certain soils, alfalfa, and sugar beets also are adapted to the older alluvial soils, particularly those with well-drained surface soils. To the south, alfalfa, beans, sugar beets, and other irrigated summer crops dominate crop choices. Also, water supplies are limited, and relatively costly, compared with those in the rice areas. In both the rice and general crop areas, the analysis relies on linear programming and budgeting to evalute alternative crops in various proportions, considering price relationships, marketing, marketing conditions, institutional forces, and other determinants, plus water supplies and costs. The study will yield quantitative criteria for farmers and others to use in allocating water and making profit-maximizing decision. These criteria will identify with specific soils according to characteristics that govern crop adaptation.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of California

6.0052, EFFECTS OF ON-FARM IRRIGATION WATER SUPPLIES AND COSTS ON CROPPING SYSTEMS AND PRODUCTION ADJUSTMENTS

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Identify physical attributes of sources of water and of water distribution systems on farms to establish current cost structures, flexibility components, uncertainty elements, and long-term trends. Establish input-output relationships of adapted crops, within relevant output ranges. Establish criteria and analyses to guide choices for particular cropping systems and for evaluating opportunities for adjustment.

Description of Work: Fixed, variable, and total costs for modal sizes of wells and pumping plants in 16 San Joaquin Valley hydrographic areas have been determined from sample data. These data will be related to specific farm sizes and types according to analyses based on both primary (survey) and secondary data. Irrigation District structure, services, and water delivery costs also have been determined through published materials, questionnaires, and field visits Amounts of water delivered to farmers, pricing policies and practices, and the cost structure, including fixed, variable, and total outlays per acre foot, according to water availability conditions, are being summarized by Irrigation Districts. We will use typical farm models and linear programming analysis to construct discrete demand functions for irrigation water and discrete supply functions for major crops under normative conditions. This analysis also will determine the marginal productivity of water and other resource inputs under alternative supply and price conditions; the point where individual crops will drop from the optimum farm organization, and determine price to be paid for water.

SUPPORTED BY California State Government

6.0053, IRRIGATION IN RELATION TO CROPPING SYSTEMS

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Objectives: 1. To identify the physical attributes of irrigation water sources in the Sacramento Valley and determine the physical and economic characteristics of supply schedules for irrigation water. 2. To establish physical input-output relationships for water and crop yields, the impact of project prices and input costs upon water allocations and optimum crop combinations for different crops under varying water quantities and costs. 3. To establish appropriate criteria and analytical guides for crop choices, cropping systems, and evaluating opportunities and limitations for profit-maximizing adjustments.

Procedures: 1. Hydrological, technical, price and cost, and farm survey data will be assembled to construct physical irrigation water supply schedules, cost schedules according to sources and fixed versus variable cost components, estimated measures for uncertainties and their impacts, and characteristics of water distribution systems. 2. Input-output relationships at various yield levels will be established for farm crops, and the impact of relative gross receipts, costs, and net returns under varying levels of availability and costs for water and other resources will be analyzed to determine compatibility of such crops in cropping systems. 3. Data from 1 and 2 will be analyzed jointly in relationship to each other and under varying assumptions for water sources, availability, and costs, type and cost for distribution systems, adequacy and costs for capital, price levels for inputs and products, and other physical and economic factors to determine optimum allocations for water, land, and other resources under varying sets of assumed conditions. Linear programming and budget analysis will be the primary tools used in these analyses; they will be applied to establish effective criteria and planning guides for optimum managerial decisions directed to profit maximization within the specified physical, institutional, and economic context for the Sacramento Valley.

SUPPORTED BY California State Government

6.0054, OPTIMIZATION OF WELLS AND RECHARGE FACILITIES IN CONJUNCTIVE USE OF GROUNDWATER RESERVOIRS

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Investigation of the response of wells and water tables to cyclic pumping operation, and programming of optimum pump cycle schedules for economic utilization of ground water.

Evaluation of the performance of various well patterns and systems with regard to well interference effects and economical groundwater exploitation.

Study of the potentials for transferring excess water from the surface or subsurface to deeper lying aquifers for storage, future reuse and possible conveyance to other regions. Specific geologic and hydrologic data from the San Joaquin Valley shall be studied and the results of theoretical analysis applied to these physical models.

Analysis of field data from existing recharge installations to check the validity of theoretically developed formulas or to find possible generally applicable empirical relationships.

Development of general criteria, possibly by dynamic programming, for optimization of recharge and pumping facilities in conjunctive use of ground and surface water reservoirs.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of California

6.0055, THE ECONOMICS OF WATER TRANSFER - AN APPRAISAL OF INSTITUTIONS

J.H. SNYDER, Univ. of California, Agricultural Experiment Sta., *Davis, California* 95616

To identify and establish physical and economic characteristics of water sources and water distribution systems in order to evaluate costs, flexibility, and uncertainity components in production adjustments of vegetable producers in both short- and long-run situations in the Salinas Valley. To estimate short- and long-run demand and utilization of agricultural and nonagricultural water uses in the Salinas Valley. To identify and evaluate institutional forces that influence water use transfers within agriculture and between agricultural and nonagricultural water uses and users.

Collection, assembly, and analysis of primary and secondary data relating to vegetable crop production and water use and nonagricultural water use in the Salinas Valley. Various analytical techniques including linear programming, variate difference analysis, and Markov chain techniques will be used. Evaluation of institutional arrangements influencing water use and water use transfer in terms of criteria and strategies for management of the water resource. Case study method analysis of such institutions as the Monterey County Flood Control and Water Conservation District will be supplemented by regional input output analysis and may involve some river systems analysis.

SUPPORTED BY U.S. Dept. of Agriculture
California State Government

6.0056, A COMPARATIVE STUDY OF THE USE TAX AS A MEANS OF ALLOCATION OF WATER RESOURCES IN A CONJUNCTIVE USE SYSTEM

L.F. WESCHLER, Univ. of California, Graduate School, *Davis, California* 95616

The primary purpose of this project is to examine the use tax as a means of permitting local water districts to secure rational allocation of ground and surface water supplies among competing users.

The California legislature has authorized eight public water districts to levy a use tax on the production of ground water. Four of these districts have actually applied this authorized power in attempting to regulate the relative consumption of ground and surface water within their respective boundaries. The comparative performance of the use tax systems utilized in the four districts will be tested on the basis of three sets of criteria: efficiency (devotion of water resources to their most valuable use), equity (distribution of benefits and costs), and progress (growth rate of the public water economy).

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of California

6.0057, STUDIES OF PHOTOSYNTHETIC HALOPHILES FROM OWENS LAKE

S. WITZ, Space General Corporation, *El Monte, California*

(U) Objective: a. Problem: The specific objective is to gain knowledge on the growth processes of the photosynthetic and sulfate- reducing microorganisms found in alkaline saline salt lakes. b. Application: The extrapolation of the efficacy of these environmental adaptations to the conditions prevalent on Mars. c. The physical and chemical characteristics of the saline environments will be determined with emphasis on water economy and energy requirements, and their effects on Halophiles.

(U) Approach: The specific environment selected for the proposed investigations is that of a 'triple layer' desert lake characterized by the presence of salt cakes precipitated from brines containing high concentrations of carbonates and sulfates. The proposed investigation of terrestrial brine organisms found in this lake should yield significant clues as to the biochemical and physiologic mechanisms that would permit growth of Martian life under conditions of extreme aridity and would allow its survival during periods of intense cold.

SUPPORTED BY U.S. Natl. Aero. & Space Adm.

6.0058, UPTAKE OF ORGANIC COMPOUNDS BY MARINE INVERTEBRATES

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A number of soft-bodies marine invertebrates are capable of removing small organic compounds from solution in the ambient medium. This has been established for almost 100 genera in 11 phyla. The present project is designated to explore the potential significance of the process: a. as a source of nutrition, b. as a source of specific required dietary constituents, and c. as a source of information for the organisms.

The project is also designed to exploit the capability of pulse labelling the free amino acid pools of the organisms studied in order to study their metabolism. Finally, we propose to study the mechanism of uptake of small organic compounds.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

6.0059, A GENERALIZED, PROBABILISTIC APPROACH TO REGIONAL WATER SUPPLY ASSESSMENT

J.A. DRACUP, Environmental Dynamics Inc. , *Los Angeles, California* 90048

This research is directed toward the development of a methodology to predict, for a region, a spectrum of available water supply levels including both ground-water and surface-water. This spectrum of available water supplies will be stipulated with probability confidence limits.

The work will be oriented toward determination of the probable regional water supply levels in regions where long-term precipitation records are available with only relatively short-term or no surface- water runoff records. Therefore, the research effort will be divided into three distinct parts:

1. Development of the system identification model of the non linear, time-dependent precipitation-runoff relationship.
2. Streamflow runoff records will be generated using long-term available precipitation records with the model developed in Part I.
3. Development of a probabilitistic model which will stipulate levels of available water supply at certain confidence levels.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0060, THE LOCAL WATER DISTRICT AS AN URBAN WATER-POLICY DETERMINING ENTITY

W.W. CROUCH, Univ. of California, Graduate School, *Los Angeles - U.C.L.A. , California* 90024

The municipal water district, in the area studied, is a special purpose government organized as result of local initiative. Most have been organized in response to a decision by the metropolitan water district to admit only municipal districts (not individual cities) into its membership. Such districts are usually composed of cities and unincorporated fringe areas. All are undergoing intensified urban development.

Of the districts studied, only two were not affiliated with the metropolitan water district. Both non-members were formed to develop and protect local water resources, but they have also looked to the state water plan for an alternative source of urban water.

Municipal water districts have been formed at the insistence of water-user groups, but the action requires approval of the general voters in a referendum. Land owners interested in suburban development and subdividion often have become concerned after the district has been formed. Districts, once formed, are governed by a board elected from district constituencies (instead of at-large). District operations are financed by taxes upon property and resale of water purchased from the metropolitan district's imported supply.

Few elections of board members were discovered to be contested. District government, after the initial formation referendum, tends to have relatively low visibility. Groups of water users tend to influence district policy making. Voting of board members on agenda items tends to show very few divisions. In most instances, district policy is negotiated informally among water-users and related interest groups outside the formal framework of district organization and is ratified at board meetings. Two districts showed exceptional behavior. In one a division occured over expansion of program; in the other the division was over proposed membership in the metropolitan district.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of California

6.0061, THE MUNICIPALITY AS A WATER POLICY DETERMINING ENTITY

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Eighty percent of the cities in the four counties studied which were incorporated prior to 1930 (the metropolitan water district was formed in 1928) organized municipal water storage and distribution systems. None of this group organized new systems after 1930. Although many cities have annexed territory actively they have expanded their water systems slowly, except where political demand arose as a result of conspicuously inadequate service from non-municipal systems. The State Public Utility Commission has played a vigorous role in determining service areas in the fringe sections where municipal annexation has been active, although it has no direct jurisdiction over cities.

Of the cities incorporated after 1930, only 18 percent organized a city water system. For the most part, this group has found no great demand being made upon the city to invest public funds in acquiring and integrating the local water systems.

Those cities studied which were members of the metropolitan district had almost no controversies over water distribution, rates, or adequacy of supply. No interest groups appeared to be actively engaged in making demands upon the city political system relative to water. Decisions were largely initiated by administrators and ratified by elected officials. Some complaints were raised about water quality (hardness or discoloration) but no organized efforts were made to change the situation.

The most clearly open political situation encountered in the study was in a city which had withdrawn from the metropolitan district and was attempting to supply needs from local (non-imported) resources. It had been split on four occasions by referendum votes in which local interest groups had polarized over specifically state water issues. On at least one occasion, the groups which normally dominated city policy-making were defeated by a coalition of groups (large low-income home owners who saw no advantage to themselves in expanding the city water system) which were normally not influential.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of California

6.0062, SYSTEM IDENTIFICATION AND MULTI-LEVEL OPTIMIZATION OF INTEGRATED GROUND WATER SYSTEMS

J.A. DRACUP, Univ. of California, School of Engineering, *Los Angeles - U.C.L.A. , California* 90024

Objectives: The principal objectives of this research effort is to investigate the feasibility of applying the mathematical techniques of system identification and multi-level optimization to a general model for integrated ground water aquifer systems.

System identification is described as follows: Given a mathematical model describing the behavior of the ground water regime, and given some observational data on that system, determine the transfer functions of the model such that the future response of the system can be predicted if the input to the system is specified.

Considering a ground water aquifer system, a mathematical mode describes the hydrologic behavior of the system using observation data of production and basin level response. The transfer functions are determined from the physical characteristics of the basin. In multilevel optimization, the dependent ground water subsystems need to be uncoupled using pseudo-variables. The resulting second-level optimization results in a general model for optimal development and operation of integrated ground water basins.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of California

6.0063, THE DEVELOPMENT OF WATER RESOURCES IN CALIFORNIA IN RELATIONSHIP TO PLANS AND PROGRAMS FOR WESTERN REGIONAL WATER DEVELOPMENT

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The State of California's water resources figure prominently in current proposals for western-wide water development and inter-basin transfers. Presently, no adequate picture is available concerning the forces, influences and conflicts which have shaped the California State Water Plan. In view of the plans which are being formulated in the West for inter-basin diversions, a study of the agreements that were reached in the formulation of the Plan and the arrangements which were established for implementing the Plan become increasingly important for further Federal and State decision making in the water resources field. This study will be conducted through examination of newspaper files, official documents and reports, and through interviews with major water leaders and participants in crucial decisions. The influence of political, economic, sectional, and other groups in determining specific features of the Plan will be examined. Hopefully, light would be cast upon group strategies for future water developments within the State and within the Western states region. The findings and conclusions would be available for use by officials of the State of California, the Secretary of Interior, and the Western States Water Council on Water Development in connection with their projected studies of inter-basin diversions.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of California

6.0064, OPTIMIZATION OF WATER RESOURCES DEVELOPMENT--II

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A comparative evaluation is to be made of the use, in water resources engineering, of 'critical period hydrologies' to develop optimum operating policies as contrasted to more sophisticated but more expensive analytical procedures. A preceding project has used a critical period of seven dry years (1928-1934), and decisions on firm outputs have been based on this. The decisions will be reexamined to evaluate the extent to which conclusions based on the critical period depart from those using other methods. The critical period procedure will be evaluated first on simple systems and then later applied to large integrated systems.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of California

6.0065, DEVELOPMENT OF METHODS FOR PLANNING AND TIMING OF WATER RESOURCES INVESTMENTS

W.A. HALL, Univ. of California, Water Resources Center, *Los Angeles - U.C.L.A., California* 90024

Methods are being developed to determine the optimum staging policy for water resources development using operations research techniques. Costs of shortage or over-construction are included in the treatment, along with hydrologic risk. Particular emphasis is being placed upon the consequences of shortages on agricultural production, since this industry is expected to accept the first shortages in most multiple-purpose systems.

SUPPORTED BY University of California

6.0066, HISTORY OF THE DEVELOPMENT OF THE WATER RESOURCES OF THE COLORADO RIVER-PHASE ONE. THE COLORADO RIVER COMPACT

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This project represents the first phase of a larger study dealing with the historical development of the water resources of the Colorado River. This first phase will focus on the period from the late nineteenth century, when the first major attempts to develop the Colorado were made, through the passage of the Boulder Canyon Act of 1928, when Congress took a landmark step in harnessing the river. Occurring between these events--and occupying a central position in this study--was the Colorado River Compact of 1922, which divided the waters of the Colorado between the upper and lower basins and which has figured prominently ever since in every important discussion concerning the river. The study will be based primarily upon official papers housed in the National Archives and in the archives of each basin state, private correspondence and manuscript holdings, interviews, solicited opinions, and the minutes of the Colorado River Commission. Because of the Colorado's important role in western development, the findings of this first phase should be of major interest to government officials, lawyers, political scientists, geographers, and historians. Indeed, the successes and failures met with by those involved in this early stage of river development should provide a useful case study for all those currently charged with national and state water resources development.

SUPPORTED BY University of California

6.0067, ALLOCATIVE IMPACTS OF FEDERAL AND STATE WATER DEVELOPMENT LAW

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The research studies the effects of water law on the allocation and development of water. The effects of water law have been noticed in the settlement patterns of agricultural land, in the allocation of water between urban and agricultural uses, in the division of water between in-stream and consumptive uses in addition to other allocational and development aspects. The research is positive, attempting to describe the legal impacts rather than attempting normative judgments. The economic forces leading up to the governmental intervention into the allocational process will be analyzed including any contributions of the legal process itself. The development statutes and their subsequent court construction will be studied in depth. An attempt will then be made to synthesize the legal and economic analyses in order to determine the allocational impacts, by way of the alterations of property rights involved. The specific area of inquiry is as follows: the Central Valley Project of the Bureau of Reclamation with particular reference to the Sacramento River Diverters case and public vs. private power controversy. This is intended as an initial effort, to be expanded later.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of California

6.0069, THE DECISION SEQUENCE IN WATER RESOURCE PLANNING

R.K. LINSLEY, Stanford University, School of Engineering, *Palo Alto - Stanford, California* 94305

Decision flow chargs for simplified, typical single-purpose projects will be constructed identifying data inputs, judgement decisions, role of standards and criteria, and effects of computations. Possible uncertainty in each item of input to the decisions will be evaluated and the combined effects of these uncertainties on ultimate project form evaluated. Strategies for planning that will minimize the uncertainty will be explored and research needs, data requirements, etc., will be specified.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Stanford University

6.0070, STUDY OF WATERFOWL BOTULISM

C.M. FERREL, State Dept. of Fish & Game, *Sacramento, California*

Objectives: To determine the microecology of Clostridium botulinum Type C organisms as related to production of botulism in waterfowl. Special attention will be given to cool weather outbreaks and the control of such outbreaks.

Procedures: Examine by fluorescent antibody technique soil, aquatic plants, and invertebrate animal samples from epizootic botulism areas. Determine the botulism organism's growth pattern and toxic production. Samples will be collected throughout the year, with emphasis on Klamath Basin and Yolo and Sutter by-passes.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
California State Government

6.0071, A STUDY OF THE BENTHIC FAUNA OF MERLE COLLINS RESERVOIR (VIRGINIA RANCH RESERVOIR)

R.R. RAWSTRON, State Dept. of Fish & Game, *Sacramento, California*

Objectives: To determine whether changes in species composition and production of benthic organisms is related to changes in fish yield, production, or both. Premises: Scandinavian workers have reported changes in the species composition of benthic fauna in impounded waters after the first year. These changes have a profound effect on the production of fishes. If the more herbivorous benthic forms are replaced by more predatory species, a less efficient energy transfer should occur.

Procedure: During the early years of the study we will examine the species composition and the relative abundance of the benthos of Merle Collins Reservoir. Efforts to obtain annual production estimates will also be made.

Samples will be taken monthly at three stations on different bottom types and depths. Samples from each station will be combined and subsamples drawn to reduce laboratory and analysis time. Identification will be made to the species level, if feasible.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
California State Government

6.0072, DEVELOPMENT OF AN OPERATIONS CONTROL PLAN

A.R. GOLZE, State Dept. of Water Resources, *Sacramento, California*

This is an applied research program to study various concepts for instrumentation and control of large water storage, conveyance, and distribution systems, with emphasis on control by a real-time control computer

This research program utilizes a 300 cfs aqueduct system and consists of the instrumentation of approximately 21 facilities along the aqueduct, such as, at turnouts, pumping plants, and other hydraulic control and diversion structures, with an eight-channel medium speed (300-1000 hits/sec) digital PCM control and telemetry system. These 21 remote facilities will be connected by land line and/or microwave communication to two parallel control centers, one of which will have complete computer-control capability.

This control system will be operated for a minium of two years. During this period data will be collected, analyzed, and evaluated; tests will be made of different concepts of aqueduct flow modification; control concepts will be tested; and control center procedures developed. Logic will be developed and programs prepared for computer control of the facilities for reporting operational status; and for compiling flow data for billing of water customers.

SUPPORTED BY California State Government

6.0073, HYDROLOGIC SIMULATION - DAILY STREAMFLOW

L.R. BEARD, U.S. Army, Engineer District, *Sacramento, California* 95814

Analysis of multipurpose reservoirs and reservoir systems indicates need for examining a great many ways that floods can occur in combination with antecedent streamflow sequences over a period of many months or years. The number of such combinations in a record of ordinary length is extremely small, consequently there is a great need in water resources studies for a method of generating synthetic floods in conjunction with monthly streamflow generation, and for a new approach to estimating magnitudes and frequencies of large flood events (only a few of which are observed in an ordinary streamflow record). Short-interval streamflow simulation is a promising approach to satisfying this need.

A report on Daily Streamflow Simulation is now being processed for release. Work will begin on a multi-station simulation model which will be for use on problems where more than one stream influences project operation.

SUPPORTED BY U.S. Dept. of Defense - Army

6.0074, HYDROLOGIC SIMULATION - MONTHLY AND ANNUAL STREAMFLOW

L.R. BEARD, U.S. Army, Engineer District, *Sacramento, California* 95814

Accurately evaluating the amount and dependability of water supplies that can be developed from one or more streams has become increasingly important in connection with supplies for a wide variety of uses. Critical review of factors affecting the dependability of water supply forecasts indicates that a great element of uncertainty stems from traditional practice of presuming repetition of historic events in the future. Stream-flow simulation allows examination of many ways in which streamflows might occur for locations where data is sparse or abundant.

The basic monthly streamflow simulation model of the Hydrologic Engineering Center is being continuously developed and tested. Possible improvements to the model and associated computer programs, adding increased utility, have been investigated, these being the addition of a routine to estimate missing flows at a station or within a group of stations and the addition of a non-random start routine to permit use of the simulation technique as a predictor of future flows, given flows to the current time at a location or at several locations. Other interesting facets have also been pursued in trying to isolate a possible source of upward bias in the model. These include the determination of effect and desirability of smoothing of parameters such as mean, standard deviation, skewness, and correlation coefficients and the desirability of adjustment to the universe of the several statistics. New techniques of regression analysis are being employed in order to maximize the use of information in available data.

SUPPORTED BY U.S. Dept. of Defense - Army

6.0075, OPTIMIZATION TECHNIQUES FOR HYDROLOGIC ENGINEERING

L.R. BEARD, U.S. Army, Engineer District, *Sacramento, California* 95814

Many problems too complex for direct solution have been solved by trial and error methods. Ingenious mathematical techniques and electronic computers have served to speed the solution of such problems, thus providing a tool for greatly reducing the cost and time of complex problem solutions. More important by far, it can make possible solutions of many hydrologic engineering and other water resources problems whose complexity has heretofore precluded even an approximate solution, ultimately saving construction costs and increasing project accomplishments.

A generalized optimization procedure has been developed in the Hydrologic Engineering Center, particularly in connection with the problem of deriving the best unit hydrograph and loss characteristics to reconstitute observed floods from observed rainfall. It has also been applied to the derivation of streamflow routing coefficients from observed hydrographs and to flood prediction. Tests of procedure have resulted in continued modification and improvements. More extensive applications will be made and other techniques will be developed with the view of ultimately applying the techniques to comprehensive reservoir system optimization. Application of such large problems can result in prohibitive electronic computer times and costs, so optimization efficiency will become the critical criterion for devising procedures.

SUPPORTED BY U.S. Dept. of Defense - Army

6.0076, ARTIFICIAL FLOODS

L.R. BEARD, U.S. Army, Engineer District, *Sacramento, California* 95814

Regardless of cause, failure of a storage facility can result in downstream flooding of disastrous proportions. Timing and degree of flooding is extremely difficult to predict. In view of the increasing number of dams that have been constructed, expectancy and frequency of failure from natural and military causes might tend to increase. While considerable study of this phenomenon has been made under military programs, results of studies are not up-to-date and have not been adapted to modern computers.

Procedures developed for computing flood waves resulting from various types of dam breaching will be generalized and will be programmed for use in electronic computers. Computer program is to be designed for simplicity and flexibility of input so that it will be useful for actual predictions in a variety of circumstances, as well as for hypothetical studies.

SUPPORTED BY U.S. Dept. of Defense - Army

6.0077, VALUE OF STREAMFLOW DATA

L.R. BEARD, U.S. Army, Engineer District, *Sacramento, California* 95814

Streamflow data are necessary for the design of economical and safe water resource systems. The adequacy of design is related, although not directly, to the amount of hydrologic data available in the area of concern. The purpose of this research project is to relate the cost of lost benefits (underdesign) and excessive construction costs (overdesign) to the length of streamflow record and other pertinent factors such as streamflow variability, availability of records at nearby stations, and inter-correlation coefficients.

This research project is a cooperative project between the U. S. Geological Survey and the Hydrologic Engineering Center. The U.S.G.S., as a data collection and research agency, is interested in how long stream-gaging stations need be operated to provide the optimum amount of information for design and construction decisions; therefore, must know the reliability of a design based on a given amount of recorded hydrologic information.

A pilot study was conducted during FY 1967 relating value of streamflow data at one particular location to length or record, assuming a highly simplified design use of the data. A report describing the results of this study has been prepared.

By a detailed analysis of streamflows for 4 stations having characteristics ranging from very stable to very erratic streamflows, generalized relations of design value of streamflow data to lengths of records at a project site and at nearby locations will be derived. These will be expressed in terms of project cost, since design value of data is a function of project cost.

SUPPORTED BY U.S. Dept. of Defense - Army

6.0078, PLAN FORMULATION AND EVALUATION STUDIES - RECREATION DESIGN CRITERIA AND DEMAND

D.A. CRANE, U.S. Army, Engineer District, *Sacramento, California* 95814

Project will be accomplished essentially in the following three phases. Phase I - Refine and standardize essential recreational use data collected at existing projects through a pilot program with six other Districts with the objective to develop ADP programs effecting cost savings and adequate analysis of recreational use data. Phase II - Establish acceptable procedures for use of such data in estimating and projecting recreational use, and recreation facility design load. Phase III - Apply the above procedures to statistically reliable mathematical model suitable for ADP treatment of those factors influencing recreation benefits and cost determinations.

Phase I is scheduled for completion by 1 August 1968 which will result in a recommended recreation survey for adoption throughout the Corps of Engineers. Interim results of Phase II study are presently being combined into a Recreation Planning Manual scheduled for completion by January 1969. Continuing studies of Phase III will be maintained using data from 52 reservoirs throughout the United States.

SUPPORTED BY U.S. Dept. of Defense - Army

6.0079, GENERALIZED HYDROLOGIC DESIGN CRITERIA

A.J. FREDRICH, U.S. Army, Engineer District, *Sacramento, California* 95814

Greatly increased activity in water resources development in the United States and throughout the world, produces critical need for procedures for formulating generalized design criteria for water resources projects. This need is for less duplication of work and more uniformity of design in projects as well as for obtaining reliable design criteria in regions of little or no hydrologic data. This is an area where the United States can make a major contribution toward the International Hydrological Decade as well as toward the President's program of Water for Peace.

A draft of report on Hydrologic Design Procedures with particular emphasis on applications to areas of little data is in preparation.

Many generalized hydrologic relations such as envelope curves of rainfall and runoff amounts, intensity-duration relations, frequency relations, etc., have evolved from hydrologic investigations during the past 30 years or more. These relations will be re-examined and supplemented by more elaborate analyses made possible by recent development in mathematics, electronic computers and aerial photography in order to formulate basic procedures for deriving generalized hydrologic design criteria. This will be directed principally to determination of reservoir storage and outlet requirements, powerplant requirements, conveyance and terminal storage requirements, levee and channel sizes, and coordinated design of a water resources system.

SUPPORTED BY U.S. Dept. of Defense - Army

6.0080, SYSTEMS APPROACH TO WATER RESOURCE MANAGEMENT

J.R. BURNETT, T R W Incorporated, *San Bernadino, California*

The objective of the proposed study is to structure a process utilizing the systems approach which will examine the inter-relationship of the hydrological, engineering, institutional, legal, social, and economic facets of water resources. The process shall define, classify and inter-relate the activities necessary to achieve the objectives of water resource management. The resultant model would be the basis for establishing criteria, interface identification, decision parameter and finally resource allocation.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0081, ESTIMATION OF RECREATIONAL BENEFITS AT SOME EXISTING WATER DEVELOPMENT SITES IN CALIFORNIA

L. MEREWITZ, Planmetrics Incorporated, *San Francisco, California*

The proposed research involves estimating demand curves for recreation at selected existing water projects in California. The demand curves will be used to estimate recreational benefits by using the concept of consumer surplus.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0082, PHYTOPLANKTON, SUSPENDED MATERIALS, AND TURBIDITY

R.W. HOLMES, Univ. of California, Graduate School, *Santa Barbara, California* 93018

The objective of the proposed research is to establish and evaluate the relationships between water turbidity and organic and inorganic particles concentration (i.e. seston) in a turbid inshore marine environment.

Visual observations have shown the existence of turbid water in the zone between the kelp and shore along the sparsely inhabited coastal region between Santa Barbara and Point Conception. Very high mussel growth rates have been observed in this zone, suggesting the existence and production of sizeable quantities of suspended organic materials which almost certainly contribute appreciably to water turbidity. The suspended organic material is probably locally produced by planktonic algae and/or by the fragmentation of kelp. The sources, relative contribution, and relationships between the inorganic and organic fractions of the seston and its correlation with water turbidity will be evaluated seasonally and geographically.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

6.0083, DEVELOPMENT OF METHODS FOR VALUING WILD RIVERS

G.T. ORLOB, Water Resources Engineers Inc. , *Walnut Creek, California* 94529

The overall objective of this work is to provide a methodology for evaluating the worth of preserving river basins in their wild state, as opposed to developing them to serve traditional economic purposes. Two methods in particular are proposed to be studied: 1) benefits foregone and subjective decision, and 2) nonmonetary benefit expressions. These benefit evaluation methods will be incorportated in the traditional benefit-cost ratio method of analysis for evaluating water resources projects.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0084, AQUATIC ECOSYSTEM

G.W. OZBURN, Lakehead University, Undergraduate School, *Port Arthur - Ontario, Canada*

(a) The Proposed Research: To determine the pH tolerance range of Daphnia middendorffiana, using different acids and alkalis added to a variety of diluent waters

(b) The objectives, briefly: To evaluate the pH effect in terms of influence on distribution of other organisms.

SUPPORTED BY Canadian Government

6.0085, WETLANDS EVALUATION AND DEVELOPMENT - MARITIMES

P.B. DEAN, Canadian Wildlife Service, *Sackville - New Brunswick, Canada*

To provide reports on the evaluation of wetlands designated Development Areas in Eastern Canada with proposals for habitat alteration and improvement for increased productivity of waterfowl and furbearers.

SUPPORTED BY Canadian Government

6.0086, DETERMINATION OF CRITICAL PHOSPHATE AND NITRATE CONCENTRATIONS FOR ALGAL BLOOM CONDITIONS IN LAKE ERIE

P.H. JONES, Univ. of Saskatchewan, School of Engineering, *Saskatoon - Saskatchewan, Canada*

(a) Proposed Research: Collection, culture and quantitative measures of growth of nuisance blooms in Lake Erie.

(b) Objective: To determine the critical concentration of phosphate and nitrate which Lake Erie can reach before nuisance conditions prevail.

SUPPORTED BY Canadian Government
North Carolina State University
North Carolina State Government

6.0087, DEMAND FOR WATER UNDER DYNAMIC CONDITIONS

J.E. FLACK, Univ. of Colorado, School of Engineering, *Boulder, Colorado* 80304

An empirical study of the effects of metering and price increase on the demand for water over time by residential users in Boulder, Colorado. The relationships of climate, lawn sprinkling, socioeconomic status and other factors on household and total water use in residential areas will be investigated.

SUPPORTED BY Resources For The Future Incorporated

6.0088, CHEMICAL ECOLOGY OF DIAPTOMID COPEPODS OF COLORADO

R.W. PENNAK, Univ. of Colorado, Graduate School, *Boulder, Colorado* 80304

NO SUMMARY HAS BEEN PROVIDED TO THE SCIENCE INFORMATION EXCHANGE

SUPPORTED BY University of Colorado

6.0089, SEDIMENT PROCEDURES DEVELOPMENT AND RESERVOIR SEDIMENTATION

W.M. BORLAND, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Studies to develope or improve the techniques of computing sediment transport in channels; determining stable channels; computing degradation below dams; and determining the efficiency and effectiveness of settling basis and sediment control facilities at diversion dams. Existing reservoirs are periodically resurveyed to determine their current area and capacity amounts. Added research value of the surveys include collecting basic data related to watershed unit sediment yield rates; unit weight of deposited sediments; reservoir delta formation patterns; sediment distribution; and trap efficiencies. Improvement is continually sought in instrumentation techniques and in developing better equipment to conduct the reservoir surveys. Computer programs are being written for specific sediment and hydraulic problems that require iterative processing of the collected field data.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

6.0090, FLOOD HYDROLOGY INVESTIGATIONS

H.P. GROUT, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

A study to analyze meteorological records of observed storms to verify assumptions presently in use, and to improve techniques for determination of maximum probable precipitation that could be expected above Bureau dams and the related service facilities. The study also includes the analysis of large flood events to verify or improve the present techniques of estimating retention loss rates, lag times, unit hydrographs, routing techniques, frequency techniques, and snowmelt- runoff relationships.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

6.0091, CORRELATION OF ECONOMIC PHYSICAL FACTORS AFFECTING SELECTION OF LANDS FOR IRRIGATION

E.O. HEADY, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Research to provide the basis for improving conceptual and theoretical bases of field procedures for the classification of land and the estimation of returns and payment capacity from irrigation investments; and conduct experiments, data collection, and analyses for improvement in estimating crop yield functions in relation to classifying lands and estimating economic returns.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

6.0092, IRRIGABLE LAND SUITABILITY STUDY
J.T. MALETIC, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Research is being conducted to develop procedures for application of new concepts to problem solving in the fields of land classification, soil salinity control, and quality of irrigation return flows. Work will be done in linking a computer program for determining the change in water quality as it percolates toward the ground water, to a viscous analogy model, which would approximate the ground water hydrology to thus obtain an estimate of the return flow water quality from irrigation.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

6.0093, ECONOMIC ANALYSIS OF RESOURCE AREAS
J. MARGOLIS, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

A study into the external economies of water development projects. The objective is the development of improved procedures for implementing new standards and concepts in economic analysis.

Completed work includes three reports published by Stanford University:

1. Annotated Bibliography, External Economic Effects, with Speical Reference to Water Resources Projects, by Julius Margolis, Thorwald Moe, Peter Philip, Philip Vincent, Report EEP-18, November 1965. 2. External Economic Effects, An Analysis and Survey, with Special Reference to Water Resources Projects, by Julius Margolis and Philip E. Vincent, September 1966. 3. Water Resources Development and Agglomeration Economics, A Preliminary Statistical Study, by Dennis Cox, Julius Margolis, Frank Mathewson, Report EEP-25, March 1967.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

6.0094, USE OF WATER ON FEDERAL IRRIGATION PROJECTS
H.R. MCDONALD, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225
THOMSON

This study is collecting data from representative farms throughout the Reclamation West, on an individual field and crop basis, and in sufficient detail and accuracy to allow reliable evaluation of present and attainable farm irrigation efficiencies. It was undertaken to evaluate the improve present design criteria frfor the sizing of storage and diversion facilities, outlet works, pumping plants, and conveyance systems. Data on irrigation water applied, precipitation, and surface runoff on an individual field basis for each irrigation are being obtained. Crop consumptive use is being estimated by a modified Jensen- Haise procedure using solar radiation and temperature data collected at the site. Present irrigation efficiencies are being evaluated and attainable efficiencies estimated on the basis of these data. Data being collected on irrigation and cultural practices will be used later in a more comprehensive anlaysis. Data on canal and lateral seepage losses are also being collected and analyzed in an attempt to improve present methods of estimating such losses in planning and design.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

6.0095, RESERVOIR AND RIVER OPERATION PROCEDURES
H.R. MCDONALD, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

A study to improve and develop procedures for the operation of reservoir and river systems to obtain optimum use of available water. This activity is directed towards evaluating stochastic hydrology as a tool for planning and sizing of project features and the development of procedures to program reservoir and project releases to optimize the use of available water.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

6.0096, WATER SALVAGE STUDY
H.R. MCDONALD, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

A study to develop a method of evaluating the water transpired by phreatophyte growth and the amount of water that can be salvaged by eradication or control of this growth. The water saved will provide a more dependable supply to existing Bureau developments, as well as affecting the scale of future water resources development. The methods of eradicating or controlling phreatophytes will be evaluated as to effectiveness in assuring continued salvage of water.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

6.0097, ECONOMIC ANALYSIS OF RESOURCE AREAS
J.G. MILLIKEN, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

A study of economic and social impacts of recreational usage at selected reservoirs of the Colorado-Big Thompson Project.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

6.0098, ECONOMIC ANALYSIS OF RESOURCE AREAS
K.C. NOBE, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

An historical investigation to assess adjustments and changes in Federal water resource development objectives since 1902 in response to the changing social and economic environment.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

6.0099, DESALINIZATION AND INTERREGIONAL STUDIES
W.W. REEDY, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

To keep abreast of technological advancements in the field of water development, the Bureau is studying the potential of salt water desalination plants to determine costs for comparison with other sources of water. Field studies of plant locations, demands for water, and the economic and financial aspects are areas of study. Cooperation is maintained with the Office of Saline Water and the Atomic Energy Commission to obtain costs and feasibility of evaporators and energy plants.

A report entitled 'Siting Study on Large Nuclear Desalting Plants' was published in June 1967. This report investigated suitable sites and the economic incentives for large nuclear dual-purpose desalting plants.

Bureau personnel are currently participating on a U.S. team studying with Mexico the possible joint development of large nuclear dual-purpose plants.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

6.0100, ECONOMICS OF WESTERN STREAMFLOW ACCRETIONS
R.L. ANDERSON, Colorado State University, Agricultural Experiment Sta. , *Fort Collins, Colorado* 80521

Objectives: The general objective is to determine how the benefits of water conservation activities would be distributed on selected streams in the Missouri River Basin and other drainage areas in the Western States. Working objectives are: To assemble data on water rights on the streams under study; to identify the marginal water right holders; and to determine the effects of changes in streamflow on water users, considering both costs and benefits of such changes.

Approach: Records of water rights filed on irrigation streams are being collected from State and county records, and from major distributing agencies. This information will permit the identification of marginal water users, who would be affected most by changes in streamflow. Sample stream reaches will then be selected and the effects of changes in water availability in terms of changes in acreage irrigated, crops grown, and other changes in farm operation will be analyzed. Schedules of benefits and/or losses to water users on the sample streams will be analyzed.

SUPPORTED BY U.S. Dept. of Agriculture

6.0101, ECONOMICS OF ALTERNATIVE ROUTINES FOR DELIVERING IRRIGATION WATER

R.L. ANDERSON, Colorado State University, Agricultural Experiment Sta., *Fort Collins, Colorado* 80521

Objectives: The major objective is to evaluate routines for delivery of irrigation water to farms and fields within farms from the standpoint of economic efficiency and selected other decision rules or criteria.

Approach: A simulation program was designed in cooperation with the Graduate School of Public Administration of Harvard University. The program computes production, gross returns and net income from various systems of irrigation, enabling the researcher to determine the most profitable system on a per-farm and an aggregate basis. The program can evaluate up to 40 farms, each farm producing as many as 10 crops, with the irrigation season divided into 14 time periods. It simulates the decisions a farm operator would make according to various economic and other criteria in the course of an irrigation season where water availability is limited. The program is designed to consider the effects on crop yields when one or two irrigation waterings are missed.

SUPPORTED BY U.S. Dept. of Agriculture

6.0102, FISHES OF THE ARKANSAS RIVER BASIN, COLORADO

R.J. BEHNKE, Colorado State University, State Coop. Fishery Unit, *Fort Collins, Colorado* 80521

A survey of the fishes of the Arkansas River drainage will be conducted. Distribution and species composition will be related to changes in the aquatic environments precipitated by human use of the land and the water.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Colorado State University

6.0103, EFFECTS OF CHEMICAL VARIATIONS IN AQUATIC ENVIRONMENTS

W.H. EVERHART, Colorado State University, Graduate School, *Fort Collins, Colorado* 80521

Human population pressures and the ecological alterations that follow are the greatest challenge to worldwide natural resources management today. Whether habitat is removed by great highways or by subtle chemical changes, natural resource agencies are necessarily forced to provide for continuing production through increasingly intensive management.

Chemical alteration of our environment appears to be an integral part of our present and future civilization, and yet, too little background information is available on the natural chemical characteristics of our water resources and the changes we may expect in them. How then can we accurately assess the effects of man-induced changes in our waters ('pollution') without a base of extensive research data concerned with these natural variations and their biological effects? Increasingly more and more individuals are beginning to emphasize the idea that water is naturally polluted if you accept distilled water as a base.

The purpose of the research proposed herein is to gain some insight into the ecological impact of subtle changes in the chemistry of natural waters, utilizing fish as much as possible as indicator organisms. Correlative information of this kind would be of especial value to pollution specialists and fishery managers, but it should also find widespread application among other workers in both scientific and administrative echelons throughout the natural resources field.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

6.0104, AN EXPLORATION OF COMPONENTS AFFECTING AND LIMITING POLICYMAKING OPTIONS IN LOCAL WATER AGENCIES

C.L. GARRISON, Colorado State University, Graduate School, *Fort Collins, Colorado* 80521

The project seeks to specify and assess the impacts of system elements and parameters which influence and restrict the effective range of options available to policymakers in local water agencies of Northeastern Colorado. The research is operationalized to measure, in comparative community and group contexts and on a sequential-interval basis over a three-year period, the relationships among policymaking sub-systems and (1) general community publics, (2) relevant special publics, and (3) other influential factors such as the legal framework and the economic systems. The major community classification schema for comparison categorizes communities along two dimensions, (1) levels of administrative development; (2) levels of community political participation.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Colorado State University

6.0105, A STUDY OF THE SOCIAL MECHANISM OF RURAL-URBAN WATER TRANSFERS WITH SPECIAL REFERENCE TO EXTERNAL EFFECTS

L.M. HARTMAN, Colorado State University, Agricultural Experiment Sta., *Fort Collins, Colorado* 80521

Objectives: 1. To investigate the institutional structure of water transfers in New Mexico and contrast the process there with that used in Colorado. Water transfers in Colorado are handled through a judicial process, while in New Mexico transfers are supervised by an administrative agency of the state government.

2. Conceptualize an analytical model in terms of which allocative efficiency of water supplies can be judged, giving specific consideration to the physical inter-relatedness of such supplies. In the framework of this model evaluate the relative merits of Colorado and New Mexico water right transfer process. 3. Estimate secondary effects resulting from water transfers from a well-developed, irrigated agricultural area and the costs associated with these effects.

Objectives (1) and (2) involve an investigation of transfer procedures in both states and an economic analysis of the procedures in terms of efficiency criteria. This analysis has been largely completed. Objective (3) required the empirical estimation of income and product flows within a regional economy. An initial study of this objective has been completed.

SUPPORTED BY Colorado State Government

6.0106, AN EXPLORATION OF COMPONENTS AFFECTING AND LIMITING POLICYMAKING OPTIONS IN LOCAL WATER AGENCIES - PHASE II

D.W. HILL, Colorado State University, Graduate School, *Fort Collins, Colorado* 80521

The research will be devoted to the investigation of how planning functions in hydrological systems are related to goal fulfillment. Systems will be selected and compared in accordance with a systematic design which employs local community and water agency typologies. Measures will be utilized within a framework of social attitudes, perceptions, and patterns of activity containing bases of support and opposition to the goals of the local water agencies.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Colorado State University

6.0107, THE ECONOMICS AND ADMINISTRATION OF WATER RESOURCES

K.C. NOBE, Colorado State University, Natural Resources Center, *Fort Collins, Colorado* 80521

The objectives of this research are (1) to estimate the economic value of alternative, high altitude, watershed manipulation practices; (2) to relate Colorado's system of legally defined water rights to engineering - hydrologic criteria for the improved specification of the rights; (3) to specify how water management organization can best adapt to a changing pattern of public water management objectives in a historically developed water management system where existing supplies are fully appropriated; (4) to specify the relationships between 'base studies' of a regional economy and the economics of system design to meet specific demands; and (5) to estimate the value of water and wet lands in wild life recreation use in comparison with alternative uses.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Colorado State University

6.0108, ECONOMICS OF GROUND WATER DEVELOPMENT IN THE HIGH PLAINS OF COLORADO

D.D. RONDY, Colorado State University, Graduate School, *Fort Collins, Colorado* 80521

Much of eastern Colorado depends upon a large underground reservoir for its water supply. This reservoir has a low rate of recharge and even if additional wells were not drilled, depletion of this reservoir would be possible. In recent years many agricultural wells have been drilled in this area. The proposed research is intended to describe alternative patterns of ground water development and to isolate the economic effects of each alternation on individual firms and on the area as a whole. Field investigations will be conducted to obtain data from present and potential users. These data will be used as the basis for economic programming models. The programming models will investigate static and dynamic conditions. The static-model will describe necessary on farm adjustments to a given set of conditions while the dynamic model will aid in determining optimum intertemporal adjustment patterns. Results of the empirical work will be used as an aid for making policy recommendations. The research will begin FY 66 and end in FY 69. Four years will be required to complete the work.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Colorado State University

6.0109, STOCHASTIC STRUCTURE OF HYDROLOGIC SERIES

V. YEVJEVICH, Colorado State University, School of Engineering, *Fort Collins, Colorado* 80521

The general objectives of this research are the same as those sought by the investigator's previous work and may be summarized as follows: 1. To determine the structure in time series (continuous or discrete series) or other sequences of river flow and precipitation for any unit measure of discrete time series (i.e., day, month, year, or others) at various measures of other sequences; 2. To find the physical explanations for any deterministic component and dependent stochastic processes in these sequences; 3. To study regional distribution of hydrologic properties (stochastic regional processes); 4. To develop a better bridge between the statistical (probabilistic) and the geophysical approach to the analysis of runoff and rainfall sequences; 5. To study theoretically the problems of water storage with the development of new methods in storage problem analyses; and 6. To study various problems of stochastic processes encountered while studying under the above five objectives.

SUPPORTED BY U.S. National Science Foundation

6.0110, INVESTIGATION AND CONTROL OF ALGAE BLOOMS AND NUISANCE GROWTHS OF WATER WEEDS

R.J. BENOIT, General Dynamics Corporation, *Groton, Connecticut*

Samples of water are collected from selected lakes and tributaries. The samples are analyzed for total phosphate, plankton composition, and other characteristics as appropriate. Recommendations on chemical treatment for bloom control (pro or con) are made, and the treatment plan is prepared. The treatments are carried out by local volunteer workers and supervised by us. The effects of treatment are evaluated.

SUPPORTED BY Connecticut State Government

6.0111, STUDY OF THE RIVER PHASE OF THE LIFE HISTORIES OF ALOSA PSEUDOHARENGUS AND AESTIVALIS

W.A. LUND, State Board of Fish. & Game, *Hartford, Connecticut*

To study the life histories of Alosa pseudoharengus and aestivalis under the most ideal field conditions available and then utilize the results in large river systems, like the Connecticut River, where an intensive study such as this would be extremely difficult to do.

In general, it is proposed to construct a weir at a narrow section of the brook to obtain: a. The range in temperature when the fish enter the stream. b. The size composition, sex ratio and age structure of the entering groups. c. The effects of illumination on the movements of the fish to the spawning grounds. d. An estimate of the total numbers of fish entering the brook. e. An estimate of the total numbers of fertilized eggs which might be produced. f. An estimate of the mortality rate of adults on the spawning grounds by estimating the total number of fish returning to the sea. g. Fish for marking. The objectives of the mark are: 1. To establish whether it is possible to estimate total numbers of fish on the spawning grounds by a mark and recapture study. 2. To determine length of time fish remain on the spawning grounds. 3. To determine the degree of homing, and 4. if a high degree of homing is found, estimate the mortality at sea.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.
Connecticut State Government

6.0112, DEVELOPEMNT AND IMPLEMENTATION OF A MANAGEMENT STRATEGY FOR WATER RESOURCES RESEARCH

H.K. GAYER, Travelers Research Center Inc. , *Hartford, Connecticut*

The proposed research involves the development of an overall research strategy for the planning and management of water resources research by OWRR. The project involves the following steps: 1) Development of an analytical or conceptual framework 2) Development of projections of relevant technical, economic, and demographic factors 3) Identification of water research problems 4) Development of research guidelines 5) Recommendation of research programs, areas of study, and associated study approaches.

The project will employ the 'systems' approach to deal with the complexity of the interactions and interrelationships inherent in the water resources research management problem.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0113, PHYSIOLOGY AND BEHAVIOR OF LARVAE (PHYSIOECOLOGY OF SHELLFISH PROGRAM)

H.C. DAVIS, U.S. Dept. of Interior, Biological Laboratory, *Milford, Connecticut*

The development of routine methods for rearing bivalve larvae has enabled us to determine the effect of various ecological factors on larvae of the American oyster, Crassostrea virginica, and the hard clam, Mercenaria mercenaria. Studies have been made of the effect of the type and quantity of food, salinity, temperature, turbidity, pH, and of various pesticides and detergents on embryonic development and on growth of the larvae of these two species. In some studies we have observed the combined effect of varying two or more of these factors simultaneously.

We are currently experimenting to determine the pH range for spawning of oysters and the effect of the pH at spawning on viability of the sperm and eggs. We are also currently studying the effect of keeping oysters at lowered salinities, during gonad development and spawning, on subsequent embryonic development and larval growth at different salinities. We expect to soon have methods developed for studying the behavior of larvae and the effect of light, gravity, temperature, salinity and currents on the behavior of larvae of different ages and sizes. Such studies are urgently needed to develop an informational basis for field work on distribution of larvae.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0114, ECOLOGICAL FACTORS AFFECTING REPRODUCTION OF SHELLFISH (PHYSIOECOLOGY OF SHELLFISH PROGRAM)

H.C. DAVIS, U.S. Dept. of Interior, Biological Laboratory, *Milford, Connecticut*

This project has developed largely in an attempt to discover the origin and distribution pattern of the oyster larvae that set in Long Island Sound. Studies of the intensity of setting in the Bridgeport- Milford-New Haven area have shown that, while certain sections are more likely to get a heavier set than others, setting is usually very spotty, i.e., some sections may get a heavy set while nearby sections receive almost none at all. Plankton samples have shown that, even during the spawning season, oyster larvae are not numerous and that the earlier stages, 75-250 microns in length, are rarely encountered. The 250-325 micron larvae appear suddenly in the plankton samples and setting starts immediately.

At present we are attempting to locate the 'nursery areas' where these larvae develop to the 250-325 micron stage before they appear in Long Island Sound. Once these 'nursery areas' have been discovered, we shall attempt to determine the attributes that enable the larvae to develop there and to increase recruitment by replenishing the spawning stock in these areas.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0115, COMPETITION, PREDATION, AND BODY SIZE IN LAKE ZOOPLANKTON

J.L. BROOKS, Yale University, Graduate School, *New Haven, Connecticut* 06520

This research is an evaluation of the relationships between body size and relative competitive success of broadly related species of zooplankters. According to the size-efficiency hypothesis (Brooks and Dodson, 1965) the larger species tend to be the more successful competitors, but also the more vulnerable to predation. When predation pressure is low, the larger forms replace the smaller; when it is high, the reverse obtains.

The first phase of the research is a further examination of the effects that increasing the predation pressure by the introductions of planktivorous fish has upon the composition of lake zooplankton. Thorough, year-round samplings of the plankton before the introduction of alewives (Alosa pseudoharengus) and during their establishment should provide insight into the dynamics of the shifts in competitive dominance due to the increasing predation upon the larger zooplankters.

As the greater success of the larger of related cladocerans apperas to relate to their superior ability to collect their fine particulate food, the second major phase of the proposed research will examine the efficiency with which cladocerans of various sizes can remove particles (esp. in 1-15 range) from dilute suspensions, and the range of particle sizes that each zooplankter can feed upon.

SUPPORTED BY U.S. National Science Foundation

6.0116, INTEGRATION OF CONNECTICUT WATER RIGHTS LAWS AND POLLUTION CONTROL LAWS

R.L. LEONARD, Univ. of Connecticut, Institute of Water Resources, *Storrs, Connecticut* 06268

In the absence of a statutory definition of water rights Connecticut courts have settled conflicts according to common law principles. Meanwhile, the State Department of Public Health is responsible for protecting public health, and the Water Resources Commission is responsible for setting pollution control standards beyond those required for protecting public health.

Most municipal water supplies in Connecticut have been developed from high quality, upland streams. The main stems of the larger rivers are generally being utilized only for purposes having medium or low quality requirements. As demands for water increase more intensive use and reuse of water will become necessary. An integration of water rights laws and water pollution control laws will be needed to facilitate more intensive utilization of Connecticut water resources.

A detailed and exhaustive review of existing water law in Connecticut will be prepared. This review will include constitutional provisions, statutes, court decisions, and administrative regulations pertaining to rights to use water, protection of public health, and pollution control.

Criteria will be developed for evaluating water laws and institutions. Consideration will be given to the allocation of water among competing uses, the process of reallocation, and the efficient adjustment to more intensive use and reuse of water.

The information and results of specific analyses will be brought together to identify legal and institutional changes needed to facilitate more intensive use of the water resources.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Connecticut

6.0117, FARMINGTON RIVER SHAD STUDIES

W.R. WHITWORTH, Univ. of Connecticut, Agricultural Experiment Sta., *Storrs, Connecticut* 06268

Objective: To determine the ability of a section of the lower Farmington River (1) to provide a migration route for American shad and anadromous salmonids, and (2) to hatch and rear eggs and young of the above fishes.

Procedure: Various points will be periodically sampled for plankton, bottom fauna, fish (eggs, larvae, and adults), selected chemical and physical characteristics, and a water sample taken back to the laboratory for routine bioassay. Data will be compared by analysis

SUPPORTED BY Connecticut State Government

6.0118, ECOLOGICAL PERIODICITIES OF NITROGEN AND PHOSPHORUS IN SALT MARSH FLORA AND SURROUNDING WATERS

F.C. DAIBER, State Board of Game & Fish, *Dover, Delaware*

Objectives: 1) To evaluate organic soluble and particulate nitrogen, nitrate, nitrite, total phosphorus, inorganic phosphorus, and salinity concentrations in the waters of a ditched and a natural salt marsh; 2) To evaluate concentrations of particulate organic nitrogen, nitrate, nitrite, total phosphorus, and inorganic phosphorus in the vegetation and edaphic organisms of the salt marsh; 3) To determine the significance (if any) of ecological season, lunar, diel, and diurnal periodicities on the flux of nitrogen and phosphorus within the marsh flora; 4) To consider the effects of precipitation on release of the plant nutrients into the salt marsh ecosystem; 5) To determine floral abundance of major species of spermatophytes in natural marsh and ditched marsh areas.

Procedures: Field samples of salt water marsh will be collected from selected stations in a ditched salt marsh and a natural salt marsh (natural-unaltered by man). Spermatophytes and edaphic algae samples will also be collected from the same areas. Spermatophytes will be harvested at the stem, the leaves will be placed in a plastic bag for later analyses. Edaphic algae will be collected on glass microscope slides placed on the marsh surface at least two weeks prior to the study. Three collections will be executed at equal intervals during each ecological season to evaluate water samples, spermatophytes and edaphic algae. Collections, for evaluation of diurnal cycles, will be performed every two hours during a twelve hour period. Diel periodicity will be evaluated with sampling each six hours for a twenty- four hour period. The effects of precipitation will be evaluated by collecting plant and water samples just prior to precipitation (predicted by U.S. Weather Bureau) and immediately after the precipitation has occurred. Lunar and seasonal periodicity will be evaluated through the three collections at equal intervals during each of the ecological seasons. These collection procedures are designed to facilitate statistical treatment of the data.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Delaware State Government

6.0119, ECOLOGICAL STUDIES OF WILDLIFE MANAGEMENT PRACTICES

E.P. CATTS, Univ. of Delaware, Agricultural Experiment Sta., *Newark, Delaware* 19711

Long-range Objective -- To evaluate the ecological effects of management operations designed to improve or modify wildlife habitat. Immediate Objective -- To study wildlife usage and production on low- level-impounded tidal marshes in Delaware.

DESCRIPTION OF WORK: Study areas will consist of low-level and high-level Impoundments as well as undisturbed salt-marsh. Intensive observations comparing the amount and kind of use made of these study marshes by vertebrate wildlife will be conducted at weekly intervals throughout the calendar year. Permanent observation points will be selected to place all low-level impoundments under surveillance. Other stations will be located on unditched and high-level impounded marshes for determination of comparative vertebrate activity. This census will include all birds, small mammals and fishes associated with the study marshes. Vertebrate usage will be related as much as possible to habitat or other environmental features. Local climate will be recorded and correlated with observed activity. Usage will be determined through such means as visual and audio observations, marking recapture procedures, and sign or fecal pellet analysis. Findings will be used to help determine the optimal pool and ditch sizes, the level at which low water should be held, and the influence of spoil deposits on vertebrate occurrence.

SUPPORTED BY Delaware State Government

6.0120, ECONOMIC AND ENGINEERING ASPECTS OF WATER IN DELAWARES AGRI-BUSINESS INDUSTRY

R.C. SMITH, Univ. of Delaware, School of Agriculture, *Newark, Delaware* 19711

Delaware's agri-business industry is a major user of water. Wise and economic use of water for supplemental irrigation, food processing, and waste disposal requires long-range planning now for optimum development of water resources in the State.

The project will involve the study of economic and engineering aspects of water in Delaware's agri-business industry. It will seek to provide data and analysis of water requirements for crop and livestock production, food processing and agricultural waste disposal. The analysis will be used in preparing a comprehensive long-range water development plan for Delaware agri-business industry.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Delaware

6.0121, ECONOMIC AND ENGINEERING ASPECTS OF WATER IN DELAWARE'S AGRI-BUSINESS INDUSTRY

R.C. SMITH, Univ. of Delaware, School of Agriculture, *Newark, Delaware* 19711

Delaware's agri-business industry is a major user of water. Wise and economic use of water for food processing and waste disposal requires long-range planning now for optimum development of water resources in the State.

Waste flow measurements and composite waste samples will be taken for vegetable and for poultry processing plants. The amount of recirculated water in each plant for each product will be estimated. The waste samples will be analyzed to determine the level of BOD COD, total suspended solids and pH.

Data will be obtained from each plant to determine the existing fixed and variable costs of water requirements, waste treatment and waste water disposal. The relationship between the cost of waste disposal, the method of disposal used and the level of waste in disposal water will be determined.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Delaware

6.0122, TRANSLATION OF VOPROSY IKHTIOLOGII (PROBLEMS OF ICHTHYOLOGY)

R.F. HUTTON, Amer. Fisheries Society, *Washington, District of Columbia* 20005

English translation of the 1968 volume of the Russian fisheries journal, a publication of the Academy of Sciences of the USSR.

SUPPORTED BY U.S. National Science Foundation
Amer. Fisheries Society

6.0123, COMPREHENISVE PLANNING FOR WATER RESOURCES MANAGEMENT IN METROPOLITAN ENVIRONMENTS

J.L. KNETSCH, George Washington University, Center Nat. Resou. Pol. Stud. , *Washington, District of Columbia* 20006

The proposed research is to: (1) Investigate past behavior of decision agents important in the development and management of the water resource system of metropolitan Washington. Functional subcategories of water resources to be studied are water supply, quality, recreation, flood control, urban hydrology and esthetics; (2) Assess past performances of water agencies, in terms of objective evaluation criteria such as consideration of the physical system, economic efficiency, number of alternatives considered, effective administrative and regulatory provisions and obtaining an effective political consensus; (3) Formulate some of the directions in which to proceed in order to bring about an increased capacity to attain goals in metropolitan water planning.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0124, SCHOOLS FOR CITIZENS ON WATER USE FOR TOMORROWS LIVING

A.E. WHITTEMORE, League of Women Voters, *Washington, District of Columbia* 20036

The purpose of this project is to increase the effectiveness of citizen participation in efforts to assure wise use of our interrelated water and land resources. The project will be carried out through seminars for leaders of community and civic organizations who in turn will conduct Schools for Citizens on Water Use. A handbook will also be prepared to assist in the conduct of the Schools for Citizens.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
League of Women Voters Education Fund

6.0125, USE OF THE COASTAL ZONE FOR THE U. S. COASTLINE OF LAKE ERIE AND LAKE SUPERIOR

A.B. BIGLER, Natl. Planning Association, *Washington, District of Columbia*

The contractor will conduct investigations and analyses on the use of the coastal zone for the U. S. coastline of Lake Superior and Lake Erie intended to aid in future policy planning for these areas. Specific tasks include: (1) Review of background studies of factual data about the two lakes and their utilization and the economic and social ends served; (2) Analysis of the effectiveness of measures employed in the past for determining utilization of coastal zone resources, including case studies of selected conflicts; (3) Assessment of the potentials for applying marine science and technology to achieving greater multiple use, or more optimal use, of coastal zone resources; (4) Identification and evaluation of new or different measures to protect higher-level utilization of coastal zone resources; (5) Analysis of international problems and opportunities in achieving optimal use of lake waters and lake-bed resources, and recommendations of desirable new measures.

SUPPORTED BY Natl. Council on Marine Res. & Engin.
Dev.

6.0126, POPULATION ECOLOGY OF FORAMINIFERA IN THE CHOPTANK RIVER

M.A. BUZAS, Smithsonian Institution, *Washington, District of Columbia* 20560

Replicate samples of the fauna have been taken at 3 stations across a faunal boundary every month for 13 months. At the same time measurements of temperature, salinity, oxygen, chlorophyll, phosphate, and nitrate have been made. The laboratory work is in its final phase. The data will be analyzed by means of a multivariate least squares model which will enable me to examine the relationships between samples at a time, with time, and with the measured environmental variables.

SUPPORTED BY Smithsonian Institution

6.0127, SEA NETTLE STUDIES IN CHESAPEAKE BAY, LIFE HISTORY AND ECOLOGY

L.P. SCHULTZ, Smithsonian Institution, *Washington, District of Columbia* 20560

The purpose of this study is to find out as much as possible about the life history and ecology of the summer sea nettle (Chrysaora) in Chesapeake Bay with the view to eventually controlling its abundance.

SUPPORTED BY Smithsonian Institution

6.0128, EVALUATION OF PHYSICAL AND ECONOMIC EFFECTS OF IMPOUNDMENTS AND RELEASES ON UPSTREAM AND DOWNSTREAM WATER QUALITY

UNKNOWN, U.S. Army, Environmental Branch, *Washington, District of Columbia* 20315

Objective: To provide a proper basis for formulation and evaluation of proposed projects and modifications of existing projects concerned with water quality control.

Study Plan: 1. Assemble and collate data on such physical characteristics as temperature stratification, water movement through reservoirs; chemical properties, such as oxygen content; concentration of dissolved ions, gases, and other materials and biological productivity both within and downstream for reservoir projects. 2. Establish the cause and effect relationships between storage and releases for water quality control. 3. Develop practical reservoir regulation techniques for improving water quality within reservoirs and downstream. 4. Develop a methodology for identifying and quantifying in monetary terms all gains and losses associated with storage and releases for water quality control.

SUPPORTED BY U.S. Dept. of Defense - Army

6.0129, INFLUENCE ON LAND VALUES OF IMPROVED UTILIZATION THROUGH FLOOD PROTECTION

UNKNOWN, U.S. Army, Civil Works Directorate, *Washington, District of Columbia* 20315

Objectives: To determine extent market value of land subject to flooding reflects flood losses; and to develop techniques for utilizing land value data for estimating flood damages.

Study Plan: 1. Investigation of trend in land values in: a. Several selected urban and rural areas that have had flood protection over a period of years, and b. Comparable areas without protection. 2. Develop procedure for utilizing land value data when estimating flood damages in the economic evaluation of proposed flood control improvements.

SUPPORTED BY U.S. Dept. of Defense - Army

6.0130, LEGAL ASPECTS OF WATER RIGHTS IN THE EAST

P. DAVIS, U.S. Dept. of Agriculture, *Washington, District of Columbia*

Objectives: To review, analyze, and compare the development and current status of laws applicable to water rights and regulation in the 31 Eastern States. This includes the States lying east of the Mississippi River and along its western border.

Approach: Analyses are made of State and Federal statutes, constitutional provisions, court decisions and other factors applicable to water rights and regulation such as administrative regulations and contractual agreements, problems in acquiring or exercising private or public rights to use various sources of water for agricultural and other purposes, relationships to economic and physical factors, interstate and international considerations, and possible improvements in the applicable laws or their operation. The findings may be published separately for individual States or in reports that cover and compare all or several of the States.

SUPPORTED BY U.S. Dept. of Agriculture

6.0131, LEGAL ASPECTS OF WATER RIGHTS IN THE EAST

H. ELLIS, U.S. Dept. of Agriculture, *Washington, District of Columbia*

Objectives: To review, analyze, and compare the development and current status of laws applicable to water rights and regulation in the 31 Eastern States. This includes the States lying east of the Mississippi River and along its western border.

Approach: Analyses are made of State and Federal statutes, consitituional provisions, court decisions and other factors applicable to water rights and regulation such as administrative regulations and contractual agreements, problems in acquiring or exercising private or public rights to use various sources of water for agricultural and other purposes, relationships to economic and physical factors, interstate and international considerations, and possible improvements in the applicable laws or their operation. The findings may be published separately for individual States or in reports that cover and compare all or several of the States.

SUPPORTED BY U.S. Dept. of Agriculture

6.0132, LEGAL ASPECTS OF WATER RIGHTS IN THE EAST

H. ELLIS, U.S. Dept. of Agriculture, *Washington, District of Columbia*

Objectives: to review, analyze, and compare the development and current status of laws applicable to water rights and regulation in the 31 Eastern States. This includes the States lying east of the Mississippi River and along its western border.

Approach: Analyses are made of State and Federal statutes, constitutional provisions, court decisions and other factors applicable to water rights and regulation such as administrative regulations and contractual agreements, problems in acquiring or exercising private or public rights to use various sources of water for agricultural and other purposes, relationships to economic and physical factors, interstate and international considerations, and possible improvements in the applicable laws or their operation. The findings may be published separately for individual States or in reports that cover and compare all or several of the States.

SUPPORTED BY U.S. Dept. of Agriculture

6.0133, LEGAL ASPECTS OF WATER RIGHTS IN THE EAST

H.H. ELLIS, U.S. Dept. of Agriculture, *Washington, District of Columbia*

Object: To review the development and status of statutes, constitutional provisions and court decisions governing water rights in the 31 Eastern States. To study the relationships between water rights and economic, physical and administrative factors. To explore possibilities for improving the utilization of water resources.

Plan of work: A description and analysis will be made of all statutes, constitutional provisions and court decisions relating to water rights. The relationships of water rights to economic and physical factors and to watershed improvement programs will be analyzed. Consideration will be given to measures for attaining more beneficial use of limited water resources. Studies will include consideration of the contractual and other arrangements employed for irrigation purposes; and of the problems of irrigators in acquiring and exercising rights to use water from surface and underground sources. The results of each State analysis will be published separately and/or incorporated into reports covering several States, with significant inter-State comparisons.

Cooperation: State Experiment Stations; other State agencies; law colleges

SUPPORTED BY U.S. Dept. of Agriculture

6.0134, APPRAISAL OF LOCAL SOIL, WATER AND OTHER RESOURCE ORGANIZATIONS

I. HANSON, U.S. Dept. of Agriculture, *Washington, District of Columbia*

Objectives: Analyze the organization, financing, operation, supervision, and coordination of resource and resource-related local organizations such as conservancy, recreation, wildlife, irrigation, drainage, watershed, soil conservation, forest preserve, and grazing districts and associations.

Approach: An inventory is being made of the kinds and numbers of local resource organizations found in different States. Distinctive and significant types of local organizations will be selected for analyses. Individual organizations will be chosen for case studies. The analyses will include a review of relevant statutes, regulations, organizations' reports and files as well as interviews with local and State personnel and other informed persons. Relevant bulletins, research reports, journal articles, books, and pamphlets will be collected and reviewed.

SUPPORTED BY U.S. Dept. of Agriculture

6.0135, IRRIGATION AND OTHER PRODUCTION RELATIONS IN FLORIDA CITRUS ENTERPRISES

W. HENEBERRY, U.S. Dept. of Agriculture, *Washington, District of Columbia*

Objectives: To estimate costs and returns from irrigation of citrus groves in Florida. A secondary objective is to determine the total acreage of cropland under irrigation in Florida and to identify trends in the use of irrigation.

Approach: Secondary data from the Census of Agricultural and other sources will be utilized as a basis for a general description of irrigation. The description includes the acreages of the various crops irrigated, type of irrigation, general trends in irrigation development, identification of areas of irrigated land, major sources of irrigation water supply, and values of crops harvested from irrigated land. Operations and characteristics of efficient irrigation systems will be estimated for specific soil and water resource situations in representative citrus-growing areas. Costs and returns will be estimated by applying appropriate prices of inputs and products to physical data under economically efficient irrigation systems.

SUPPORTED BY U.S. Dept. of Agriculture

6.0136, ECONOMICS OF WATER MANAGEMENT TECHNIQUES IN SOUTH DAKOTA

G.A. PAVELIS, U.S. Dept. of Agriculture, *Washington, District of Columbia*

Objectives: To determine the economic feasibility of adopting recently improved irrigation technology for use on potentially irrigable lands in selected areas of South Dakota, and to estimate the impact of such adoption on the local economy of a selected area in South Dakota.

Approach: Potentially irrigable areas will be selected according to physical criteria of water supply and suitable soil types. Determination of water supply will include consideration of the extent to which water has been allocated to other uses by existing rights and allocations. Irrigation systems suitable for use in the selected areas will be determined and labor and capital requirements estimated for each type of system. Particular emphasis will be placed on recent improvements in irrigation technology in the selection process. Budgeting and linear programming techniques will be used to determine optimum economic organization of farms using the selected irrigation systems. Data requirements will be satisfied by existing data, communication with specialists and survey of farm operators if necessary. A specific area will be selected for an input-output type of analysis to estimate the specific impact on the local economy if the irrigation potential is fully developed.

SUPPORTED BY U.S. Dept. of Agriculture

6.0137, ECONOMICS OF WATER MANAGEMENT ON THE TEXAS HIGH PLAINS

G.A. PAVELIS, U.S. Dept. of Agriculture, *Washington, District of Columbia*

Objectives: To determine optimum use of ground water based on expected demand-supply relationships in the High Plains. Working objectives are to appraise present patterns of agricultural production and water use; to estimate the production and remaining supply of ground water; and to determine the impact of declining water resources on the composition, quantity and cost of agricultural output in the region, and on agriculturally-dependent businesses.

Approach: Water production functions are being developed from hydrologic data, relating water yield to thickness of aquifer. Alternative enterprise budgets have been constructed for typical farm situations with respect to water supply. Linear programming techniques are being used to estimate optimum use of available supplies of water. Estimates of volume of business of farm-supply firms and other agriculturally-related firms are being developed.

SUPPORTED BY U.S. Dept. of Agriculture

6.0138, ANALYSIS OF RURAL ZONING ENABLING STATUTES AND ORDINANCES

E. SOLBERG, U.S. Dept. of Agriculture, *Washington, District of Columbia*

Objectives: To appraise the status of and analyze developments in rural zoning enabling statutes and in zoning ordinances and to analyze what is being done under rural zoning ordinances.

Approach: Examination, analyses, and classification are made of all State rural zoning enabling statutes which empower counties, townships or other governmental units to adopt ordinances and regulations. Rural zoning ordinances and regulations enacted by local governmental units are collected, analyzed, and classified. Analyses are made of rural zoning as it relates to agriculture and natural resources uses. Special attention is directed at significant zoning innovations and related land use control techniques.

SUPPORTED BY U.S. Dept. of Agriculture

6.0139, URBAN AND METROPOLITAN STUDIES

A.C. GERLACH, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242

1. Objective: To develop the capability to provide data inputs for improvement of urban land use, better planning and utilization of transportation systems, regional development planning, and renovation of industrial areas for more efficient utilization of resources and accelerated technology.

2. Approach: Develop research strategy and techniques for the study of urban and metropolitan problems with the aid of remote sensing data of the types that could be obtained from space. This effort will utilize: a. Multiband photography - Color, and color infrared photography - Thermal infrared images - High resolution radar - Passive microwave - Scatterometer signature products.

3. Problems addressed by these studies include recognition of details of urban interrelationships, categorization of interrelationships as social/environmental pressure indicators and development of methodologies through which phenomena detection will be transmitted to the appropriate action agency.

4. Expected benefits include, but are not limited to, urban change prediction including: a. Land use change b. Transportation demands c. Population change d. Urban area service needs e. Establishment of techniques for urban thematic mapping.

5. a. Aircraft overflights will be needed at four different times of the year, at 8 locations. Both megalopolis and town structures should be accomodated by at least 32 flights for up to two hour periods. b. Ground truth would be provided by USGS teams and/or contractor teams operating within the experimental area.

Future efforts include techniques of change prediction, prediction of social land demand, transportation new capacities, urban signature keys preparation, and automation of urban analyses tasks.

SUPPORTED BY U.S. Natl. Aero. & Space Adm.

6.0140, CARTOGRAPHIC MAPPING

T.A. HUGHES, U.S. Dept. of Interior, *Washington, District of Columbia*

Objective: To study and evaluate applications of space photography including Gemini photographs in preparing small and medium scale maps and mosaics, and to develop system specifications for space photography that may be used to compile maps at various scales.

Approach: To study methods and procedures for performing data reduction, annotation and image enhancement of space photography utilizing present know-how based on aerial photography and knowledge developed from investigations of distortions inherent in space photography. a. The sensor involved is the metric camera and Hasselblad camera; b. U.S. Geological Survey Topographic Division; c. Allocation of resources; 70% professional manpower; 26% equipment and materials; 4% overhead The problem addressed by this study--The study seeks to determine methods of compiling data from space photography and to determine appropriate products e.g., maps, mosaics, etc. and the best cartographic treatment for each product to enhance its usefulness to natural resources investigations. The benefits expected are savings in cost and time, better utilization of manpower, faster mapping and an interpretative medium for natural resource studies offering both quantitative and qualitative information. Other support a. Research staff of the Topographic Division Research Center, McLean, Va. b. Processing and reproduction facilities of the Branch of Special Maps. Past studies of Gemini Photography, ultra-high altitude photography, resolution studies, and cost benefit studies have contributed to this project. Special instrumentation and techniques to obtain the most detail from space photographs will take three to four years but present instruments and techniques can be adopted to accommodate space photographs in one year.

SUPPORTED BY U.S. Natl. Aero. & Space Adm.

6.0141, HYDROLOGY PROGRAM ADMINISTRATION AND SUPPORT

C. ROBINOVE, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242

Objective: To investigate the feasibility, utility and significance of remote sensing of hydrologic phenomena from Earth orbiting spacecraft. The field study of test areas by conventional methods and remote sensors. To achieve the ability to interpret aircraft and spacecraft data. To formulate and develop the capability to conduct a series of experiments to provide useful data for the study of water resources.

Approach: Establish scientific/technical research support offices for hydrology to a) assist in mission definition, b) formulate experiments, c) coordinate investigations to develop experiment capability by universities, Government agencies and private industry, d) correlate and integrate flight experiments. To acquire and correlate data from aircraft and later Earth-orbital spacecraft over selected test sites in which the hydrologic features are well known. To interpret data using standard techniques and develop new techniques.

Status: The U.S. Geological Survey has established a coordinating staff. There are now approximately 40 hydrological sites involving a large number of earth scientists. A number of technical letters describing laboratory, field and remote sensor data investigations have been submitted since inception of the program in 1965. These reports include descriptions of the use of data from Gemini and Nimbus satellites, ultraviolet imagery, black and white, color and multiband photography, infrared and radar imagery. A number of user experiments have been developed and submitted to the Earth Resources Survey Program Office.

SUPPORTED BY U.S. Natl. Aero. & Space Adm.

6.0142, HYDROLOGIC ANALYSIS OF LAKE SYSTEMS AND OF GLACIERS

C. ROBINOVE, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242

Objective: 1) To investigate the feasibility, utility and significance of remote sensing of various parameters of lakes as applied to regional studies of the water resources of lakes 2) to determine the annual budget and other features of glaciers as related to climate indicators and to sources of water supply.

Approach: 1) Determine the relationship of reflected and emitted electromagnetic radiation of lakes to their chemistry, biology, ecology, and sediment content. Studies will be conducted over the Salton Sea, Lake Colorado City, Texas, Roxboro Reservoir, N.C, Florida Everglades. 2) Investigations will be conducted over South Cascade Glacier, Wash. to botain information on snow accumulation. These studies will be undertaken using IR scanners, imagers, and multiband photography from aircraft.

Status: The U.S.G.S. is currently working on the South Cascade Glacier Project and several flights have been made by NASA aircraft over this site.

SUPPORTED BY U.S. Natl. Aero. & Space Adm.

6.0143, ESTUARIES AND SHORE STUDIES AND WATER SURFACE INVESTIGATIONS

C. ROBINOVE, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242

Objectives: To determine the hydrologic environment parameters of the coast and continental shelf areas that can be determined by remote sensing. To determine the feasibility of measuring thermal loading, evaporation, and distribution of river effluents and to determine the physical properties of water indicating pollution by remote sensing.

Approach: Various remote sensing techniques including those of infrared and photography will be used to determine the most effective means of obtaining data. Experiments will be conducted in the following areas; Potomac and Patuxent estuaries, Cook Inlet, Alaska, Delaware Estuary, Barnegat Bay, N.J., Connecticut River, Hudson River, Lehigh River, Missouri River and others.

Status: The work proposed is well established as tests and experiments have been carried out in the field for the past 6 years. This study will further refine and develop the method.

SUPPORTED BY U.S. Natl. Aero. & Space Adm.

6.0144, WATER EXPLORATION AND MAPPING

C. ROBINOVE, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242

Objectives: To define the physical boundaries of natural water systems and their relationship to present and potential development activities.

Approach: Investigate the basic physical properties and relationships at the boundaries of natural water bodies and systems by methods leading to the development of remote sensing instrumentation for use in the measurement of phenomena at water boundaries.

Status: A new effort. Development will be based on the research capabilities of universities and other organizations.

SUPPORTED BY U.S. Natl. Aero. & Space Adm.

6.0145, WATER QUALITY, STUDIES AND AERIAL MEASUREMENTS

SKOUGSTAD, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242

Objective: To determine the extent to which the chemical and biological characteristics of water in rivers, estuaries, and reservoirs can be determined by the use of remote sensing instruments. Determine the application of multiband remote sensing to various problems in hydrology.

Approach: 1) Fundamental studies will be made to determine the relationship between the reflection, refraction, and absorption of laser beams and quality of water. 2) Stimulated luminescence in tracer studies will be the subject of investigations in flow dispersion coefficients and of pollution indices. 3) Utilize TV cameras sensitive to various wavelength bands to determine the significant information in each.

Status: Work in multiband research has been conducted for the past three years at the Phoenix Office of the U.S.G.S. NASA and U.S.G.S. aircraft will be utilized.

SUPPORTED BY U.S. Natl. Aero. & Space Adm.

6.0146, COORDINATION AND LIAISON AT MANNED SPACECRAFT CENTER, HOUSTON

UNKNOWN, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242

Objectives: 1) To provide continual liaison and coordination between MSC Houston and USGS-Washington, Denver, Flagstaff and Menlo Park. 2) To assist on the monitoring of U.S.G.S. instrument development contracts (UV, IR and Magnetics), 3) Provide coordination for test site overflights by the NASA aircraft for geology, hydrology, geography and cartography disciplines.

Approach: To assign an experinced member of the U.S. Geological Survey on two year assignment to the office of Dr. W. Hess, M.S.C. Houston to represent the Director, Research Coordinator, EROS Program and Chief Geologist in air and space activities.

Status: Projected increase of activity under the Earth Resources Survey Program and increased responsibility of the Houston facility make it imperative that closer coordination be maintained between MSC and USGS.

SUPPORTED BY U.S. Natl. Aero. & Space Adm.

6.0147, GEOTHERMAL INVESTIGATIONS - YELLOWSTONE PARK

WHITE, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242

Objective: 1) To provide detailed surface and subsurface investigations of geothermal springs in Yellowstone National Park to provide the background data required to thoroughly interpret and understand remote sensor data acquired from air and spacecraft.

Approach: 1) To conduct detailed surface investigations of geothermal springs and their surrounding geologic environment. 2) To conduct seismic, gravity and magnetic surveys to define anomalous subsurface conditions. 3) To conduct a limited amount of shallow to moderate drilling to sample spring sources at depth for chemical, mineral and isotopic analyses to provide three dimensional temperature information, to conduct electrical resistivity surveys to determine source rock location and conditions.

Status: A continuing project approaching completion. Surface studies of cauldrons ashflows and geophysical surveys have been essentially completed but need to be correlated with remote sensor data. Drilling is underway and will be completed during the current field season under existing funding. Future funds (FY68) will provide for a final report correlating results with available imagery, if provided by MSC Houston.

SUPPORTED BY U.S. Natl. Aero. & Space Adm.

6.0148, DISTRIBUTION, ABUNDANCE, TAXONOMY, AND BIOLOGY OF MOSQUITOES AFFECTING AGRICULTURE

C.H. SCHMIDT, U.S. Dept. of Agriculture, *Gainesville, Florida*

Object: To obtain more information on the biology, taxonomy, and distribution of various species of mosquitoes under irrigation, flood, and marsh conditions to aid in the development of effective control measures.

Plan of Work: Both field and laboratory studies on the biology and behavior of numerous species of mosquitoes, especially in California, Oregon, Louisiana, and Florida, will be made. Special attention will be given to mating and resting habits of various species in the field so as to obtain basic knowledge on how to use chemosterilants and radiation for control. Natural foods of larvae and pollen foods of adults will be studies in both the laboratory and the field. Studies, particularly in California, will emphasize the relation of water management to oviposition and larval habits. Efforts will be made to determine the overwintering habits and behavior of various species. Identification studies to develop means of separating species will be done as time permits. Special attention will be given to flight behavior, dispersal and population densities and dynamics to develop basic data for the development and evaluation of new approaches to mosquito control. Cooperation is maintained with State agencies in California, Oregon, New Jersey, Florida and other States, with the Tennessee Valley Authority, Public Health Service, Armed Forces Pest Control Board and mosquito control districts.

SUPPORTED BY U.S. Dept. of Agriculture

6.0149, APPLIED CRITERIA FOR MUNICIPAL WATER RATE STRUCTURES

N.G. KEIG, Univ. of Florida, Graduate School, *Gainesville, Florida* 32601

The research will attempt to develop applied criteria for municipal water rates. Empirical work that has been completed will be synthesized and related to the problem of water rate design. The efficiency of alternative rate designs in achieving various objectives--economic efficiency, equity, financial--will be evaluated and the nature of the conflicts between competing objectives will be examined. The research will seek to answer specific questions concerning elasticity of demand and supply by reference to existing data and seek to provide authoritative answers to the questions that arise in rate design. The research will supplement the Water Rates Manual and provide a guide for local officials.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0150, PREDICTION MODEL FOR WATER USE BY POPULATION STRUCTURE

D. KUBAT, Univ. of Florida, Graduate School, *Gainesville, Florida* 32601

The investigators propose to construct a water consumption model with indicators of attitudes to water consumption for current and projected populations in the West Palm Beach-Miami urbanized area and in the Biscayne Beach agricultural irrigation area. (See map attached.) The prediction model is to control the variable of water use and socio-economic status, and is to be geared to the population projections for the next five, ten, and twenty years to come.

The project is to test the direction of the relationship between water consumption and socio-economic status. The data are to be obtained from census information and from a residential stratified probability sample of five heundred residential units in the two areas. Also, panel study on attitudes and attitude changes to alternate water sources is built into the project, the panel study being scheduled to last for three years and to yield information about the change agents and diffusion of ideas related to water use and water conservation. The fiscal year of the central project is 1968, completion of the project being expected by August 1968.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Florida

6.0151, MODEL WATER USE ACT FOR THE STATE OF FLORIDA WITH COMMENTS

F.E. MALONEY, Univ. of Florida, Graduate School, *Gainesville, Florida* 32601

This proposed project is the preparation of a model water use act for the State of Florida with comments. The investigators propose to study and analyze all available water regulatory legislation now in force in other American jurisdictions, and, following this analysis, to draft appropriate model legislation for the State of Florida accompanied by comments as to why particular legislation was proposed. The specific objective of the project will be to provide a modern and practicable system of water regulation for a state with abundant but unbalanced water supplies. The proposed legislation will be designed to encourage maximum development of the state's water resources consistent with the protection of existing property rights. The model act will take into account the role of state administrative agencies in water resources management and try to develop better legal devices by which maximum beneficial use can be made of the state's water resources for both consumptive and non-consumptive purposes. The proposed Florida model water use act will be designed for comprehensive study and consideration by federal, state and local governmental agencies interested in the protection and fair allocation of water resources within a state or hydrologic region (such as a river basin) which may transcend state boundaries. In framing the proposed model act the investigators propose to take into account insofar as practicable all known major water resources problems within the state of Florida.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Florida

6.0152, A MODEL FOR QUANTIFYING FLOW AUGMENTATION BENEFITS

E.E. PYATT, Univ. of Florida, School of Engineering, *Gainesville, Florida* 32601

6. WATER RESOURCES PLANNING

With increasing quantitative and qualitative demands being placed upon national water resources, improved management practices are vitally needed. In principle, one powerful management tool is systems analysis, wherein mathematical optimizing techniques are employed to effect rational trade-offs between competing demands for water use, but this tool, in turn, rests upon the availability of methodologies for quantifying the benefits (economic value) of each water-use category. That is, systems analysis, before it can be employed, demands a knowledge of the value of irrigation, flood control, municipal water supply, etc.

Little is known of the conomic implications of low flow augmentation, one of the important water-use categories. Beginning with the premise that the value of low flow augmentation is measured by sewage treatment costs avoided, the proposed research would construct a mathematical model of a typical river basin and, by simulation, would determine functional responses of sewage treatment levels and low flow augmentation conjunctively utilized to produce given levels of stream water quality. No single, universal answer would be forthcoming; rather, a generalized methodology would be established which other investigators could apply to their specific water pollution control situations.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

6.0153, MANAGEMENT OF FLATWOOD SOILS

W.K. ROBERTSON, Univ. of Florida, Agricultural Experiment Sta., *Gainesville, Florida* 32601

The object of this investigation is to determine crop response from water control, fertilizer and depth of plowing on flatwoods soils.

Description of Work Proposed: An area approximately 4 acres of Ona and Leon fine sand (flatwoods soils) will be cleared, surrounded by a ditch 36 in. deep, and tiled with 4-in. clay tile to drain excess water. A 6-in. well will be used to supply water during periods of dry weather. Experiments will be conducted to measure the effect of controlling the water table at 18, 24 and 30 in. on the growth of crops, permanence of the hardpan, fertility, and physical characteristics of the soil. The effect of deep tillage and placement of fertilizer to depths of 20 in. on the root development and yield of crops will be studied.

SUPPORTED BY U.S. Dept. of Agriculture
Florida State Government

6.0154, FAUNAL PRODUCTION

J.H. FINUCANE, U.S. Dept. of Interior, Biological Station, *Saint Petersburg - St. Pt. Bc., Florida* 33706

This project includes studies of species diversity and quantitative distribution and succession of animals involved in the production of harvestable seafood. It includes fish, crustaceans and molluscs which are produced or developed in the estuary. Abundance and diversity are associated with the physical, chemical and biological environment. The effects of engineering and contamination are studied in relation to estuarine condition and animal distribution and abundance. Methods of increasing consummable products by area and time period are also the responsibility of this project. Life history and larval taxonomy are studied to evaluate the dependence of developing forms on estuarine areas.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0155, PLANKTON ECOLOGY

J.K. MCNULTY, U.S. Dept. of Interior, Biological Station, *Saint Petersburg - St. Pt. Bc., Florida* 33706

A knowledge of the distribution of plankton in Gulf of Mexico estuaries and offshore areas in vital to both the Red Tide and Estuarine Research Programs at this Station. An examination of plankton succession and associated hydrology is necessary for determining the interaction of Gymnodinium breve with other plankters and the detection of factors responsible for triggering blooms. In the Estuarine Program plankters are to be investigated to determine their role in the ultimate production of harvestable seafood. Present and potential productive capacity is to be summarized for a number of estuarine systems.

Plankton is obtained by pumping from selected estuarine and offshore stations. The pumping rate is metered and the data treated quantitatively. Specific identification is made where necessary. Plankton volumes and types are subjected to between-station and between- season analysis.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0156, BENTHIC COMMUNITIES

J.L. TAYLOR, U.S. Dept. of Interior, Biological Station, *Saint Petersburg - St. Pt. Bc., Florida* 33706

The chief purpose of estuarine benthic studies is to assess the effects of hurricane barriers, dams, spoil banks, contaminants and other types of artificial alteration. The benthic species-habitat relation is under investigation to correlate fauna and flora with bottom type, salinity, depth and organic distribution. Benthic sediments and biota are obtained by steel trawls and dredges at stations located on transects in estuarine systems and neretic areas. Specimens are picked from bottom samples and identified to species. Sub-samples of bottom material are analyzed for raw weight in each size fraction of the texture, weight percent in each size fraction, and percentage of organic carbon. Mean, standard deviation, skewness, and kurtosis of size distribution are obtained.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0157, MARSH HABITAT STUDY

R.L. WILBUR, State Game & Frsh. Wtr. Fish, *Tallahassee, Florida*

Procedures: Marshes adjacent to Lake Griffin and Lake Weir will be sampled for shellcracker, invertebrates and water chemistry concurrent with the samples taken in the lake proper. These samples will essentially provide the same type of information as those taken in Job I.

Fish will be sampled with an electric shocker, or with rotenone if necessary. All other procedures will parallel exactly those of Job I. This will be done so that the utilization of the habitat can be compared with that of the lake.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Florida State Government

6.0158, THE ROLE OF AQUATIC SOILS IN THE NUTRIENT DYNAMICS OF AQUATIC ECOSYSTEMS

C.E. BOYD, U.S. Dept. of Interior, Southeast Water Lab., *Athens, Georgia*

Studies are being initiated to obtain information on the exchange of inorganic nutrients across the mud-water interface in aquatic ecosystems. Physical, chemical, and biological mechanisms will be considered. In the initial work, attention is being given to the effect of pH on the availability of phosphorus in aquatic muds, the phosphorus fixation capacity of aquatic muds from different soil series, and changes in the various phosphorus fractions in soils subsequent to flooding. Similar studies of cobalt, molybdenum, and boron are also planned.

In order to determine the availability of various nutrients which have accumulated in the bottom mud complex, investigations on aquatic soil-aquatic plant interrelationships are being designed. Aspects under consideration are: 1) Sites of absorption of nutrients by rooted vascular aquatic plants; 2) Rates of removal of nutrients from bottom soils in closed aquatic systems containing various combinations of both rooted and free-floating aquatic plants; 3) Changes in the ionic composition of the cation exchange complex following cropping by aquatic plants and following decomposition of high nitrogenous aquatic plant residues; and 4) Methods of extracting nutrients from aquatic soils that are correlated to plant response.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

6.0159, ECOLOGICAL ENGINEERING PROJECT

W.M. SANDERS, U.S. Dept. of Interior, Southeast Water Lab., *Athens, Georgia*

Continuous flow growth kinetic experiments were performed in order to map the three-dimensional response surface produced when attached slime-producing bacteria (indigenous to polluted streams) were exposed to changing velocities, temperatures and nutrient concentrations. Dependent variables such as oxygen utilization, COD utilization, CO2, production, cell production and slime thickness were measured. In addition, mass balances, carbon balances, nitrogen balances, chemical free energy balances and C-H-N ratio changes were observed. Bacterial morphology and taxonomy studies were initated. Test conditons for the current experimental set are: velocity range .75 to 1.5 fps; temperatures 25 deg to 35 deg C; and nutrient concentrations form 10 to 20 ppm, as nutrient broth.

An experimental stream channel section was consturcted and dye dispersion studied were run at various flow rates and simulated turbulence patterns.

An isotopic current analyzer was modified for use with Bromine- 82 as the tracer in order to measure water velocities at and near the mud-water interface. The bottom current analyzer was tested in an experimental channel at the University of Texas and in a natural stream in South Carolina.

Solar radiation was monitored with an ISCO Recording Spectroradiometer which recorded the intensities at various wave lengths from 380 to 1150 millimicrons.

A Varian Aerograph Chromatograph Model 1532-B was modified to receive a liquid injection for the measurements of small quantities of free CO2. Concentrations less than 1 ppm can be detected in 5 microliters of water.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

6.0160, SCORP UNIVERSITY OUTDOOR RECREATION RESEARCH STUDY SERVICE SPECIAL PROBLEMS

J.R. CHAMPLIN, Univ. of Georgia, Inst. of Com. & Area Dev. , *Athens, Georgia* 30602

This study will deal with a number of special problems related to the field of outdoor recreation: A. Meeting the needs of Urban Populations - Continuing to 10/67 - no change. B. Quality of the Outdoor Environment - Terminated. C. Access to Recreation Resources - Terminated. D. Meeting the Needs of the Aged and the Handicapped - Terminated. E. Recreation and Conservation Education - Terminated. F. Recreation Planning Research - Terminated. G. Coordination among Public Agencies - To be done by State Planning Bureau.

Library research and consultation with state agencies will be utilized in development of this study.

This is one of a series related to development of the state outdoor recreation plan.

SUPPORTED BY U.S. Dept. of Interior - Bu. Outdoor Rec.
Georgia State Government

6.0161, THE DEMAND AND PRICE STRUCTURES FOR WATER IN A HUMID AREA

R.M. NORTH, Univ. of Georgia, School of Agriculture, *Athens, Georgia* 30602

There is an immediate need for knowledge about the demands, supplies and price structures for water in humid areas. The objectives of this project are to (1) define the market structures for water in Georgia, (2) construct demand models for water by major use classification, (3) specify the rate of response of water consumption to changes in prices, incomes and resource substitution for each use classification, and (4) use these relationships to improve consumption projections and increase efficiency in the investment in additional water supplies.

The physical data on quantities, prices, incomes, substitutes and other economic variables will be collected from existing water related agencies and firms and supplemented by data from a sample of water supplying and using firms households. These data will be analyzed with the techniques of multiple correlation and other statistical methods useful in demand-price analysis.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Georgia

6.0162, A STUDY OF THE ENERGY FLOW THROUGH SELECTED COMPONENTS OF A SMALL AQUATIC ECOSYSTEM

D.C. SCOTT, Univ. of Georgia, Graduate School, *Athens, Georgia* 30602

The study herein proposed covers the bioenergetics of production at all important trophic levels in a farm pond ecosystem through an annual cyycle. Included are production, growth and respiration of primary producers, zooplankton, benthos and nekton. Integration of the dynamics of these major components of the ecosystem will for the first time give a reasonably complete picture of the dynamics of this type of aquatic ecosystem. The results should be a contribution to basic ecology research and of considerable value to those charged with the management of this very important category of surface water.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Georgia

6.0163, WATER LAW OF SOUTHEASTERN ESTUARIES

UNKNOWN, Univ. of Georgia, Inst. of Government, *Athens, Georgia* 30602

A comprehensive survey of the estuarine water law of Louisiana, Mississippi, Alabama, Florida, Georgia, and South Carolina. The resulting monograph of approximately 300 pages would draw conclusions as to the extent to which the law of these jurisdictions (1) protects commercial fishing and public recreational uses against deleterious competing uses such as pollution, land-fill, and dredging, (2) is related in this respect to the law of bordering states and to the federal regulatory power in marginal and territorial seas. Conclusions will be drawn as to overlaps, gaps, and conflicts of the present law. These can provide bases for remedial state and federal action to restore and preserve the estuaries of Southern states. The study can assist similar research in other regions of the United States.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Georgia

6.0164, PREDICTION MODELS FOR WATER QUALITY PARAMETERS

W.W. HINES, Georgia Inst. of Technology, Water Resources Center, *Atlanta, Georgia* 30332

This proposal is the second phase of a project entitled 'Prediction Models for Water Quality Parameters.' Phase II will build on the results of Phase I work. Phase II objectives are, first, to quantify the feedback and control mechanisms that exist in the total water quality system of a basin or region (the qualitative feedback network is developed as a part of Phase I); and, second, combining the quality parameter interaction (between dissolved oxygen and temperature) model from Phase I, which describes stream quality resulting from various uses and waste discharges, with the feedback control system mentioned above, general system behavior under different policies will be studied.

The need for Phase II has become clearer as Phase I has progressed. Considerable work has been done and is now in progress on various components of the total water quality system; e.g., the research being performed in Phase I on the prediction of the stream quality component. It is known that social, economic, and potitical conditions and attitudes influence the amount of waste discharge to streams, and the water quality standards result from needs and desires of the various public and private sectors, etc. Therefore, in order to put qater quality planning and management on a more rational and more socially equitable basis, the various water quality system components must be embedded in a comprehensive system which is capable of relating the actions and decision of each segment to those of the others. This approach will be of assistance in setting water quality standards that can be reasonably attained, since the total system response can be studied and changes made in the proposed standards prior to putting them into effect.

6. WATER RESOURCES PLANNING

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Georgia Institute of Technology

6.0165, INTERRELATIONS BETWEEN RIVER BASIN DEVELOPMENTS AND DEVELOPMENT OF METROPOLITAN AREAS

G.J. KELNHOFER, Georgia Inst. of Technology, Water Resources Center, *Atlanta, Georgia* 30332

The purpose of this study is to find ways to achieve better coordination between the development of river basins and the development of metropolitan areas. The interrelations between the Chattahoochee River and the Atlanta Metropolitan Area will be analyzed as a case study.

The study will have three phases. The first will be an analysis of the improvements proposed for the Chattahoochee River by government and private agencies. The effects of these improvements on the development of the Atlanta Area will be estimated. The second stage will be an analysis of the plans of Metropolitan development prepared by public and private planning agencies in the Area. The probable effects on the Chattahoochee River of this anticipated urban development will be estimated. In the third stage the conflicts between the developments proposed for the River and those projected for the Metropolitan Area will be described and suggestions made for their resolution. Finally, changes in current planning procedures will be recommended to achieve better coordination between river basin developments and the development of metropolitan areas.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Georgia Institute of Technology

6.0166, CASE STUDY OF REMEDIAL FLOOD MANAGEMENT IN AN URBAN AREA-PHASE I

C.E. KINDSVATER, Georgia Inst. of Technology, Water Resources Center, *Atlanta, Georgia* 30332

Flood plain areas along Peachtree and Nancy Creeks in Metropolitan Atlanta, Georgia, have been extensively developed during the past two decades for residential, commercial, and industrial purposes. The failure of governing authorities to exercise effective planning and regulation with respect to the development of these areas has resulted in a complex of flood-related problems that are typical of the flood problems in many urban areas of the Nation.

The proposed research will be concerned with the development and testing of techniques and procedures required to evaluate alternative remedial measures in the light of social, economic, and physical criteria. Because traditional procedures have been tried and have failed, unusual alternatives, including institutional arrangements, will be considered.

In Phase I of the study, a multidisciplinary team, working in close coordination with municipal, regional, State and Federal officials, civic groups, industrial and commercial firms and private property owners, will collect and evaluate the quality and relative significance of existing information, make preliminary hydrologic, economic, demographic, and public-opinion measurements and projections, test preliminary hydrologic-and economic-system models, and delineate potential alternatives. The end project of Phase I will be a design for succeeding phases of the research, including recommendations regarding objectives, procedure, funding, and schedule of work.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0167, MEASUREMENT OF COMMUNITY OPINION RELATING TO PUBLIC WATER SUPPLIES

C.M. YORK, Georgia Inst. of Technology, Water Resources Center, *Atlanta, Georgia* 30332

The need exists for better measurement techniques to determine citizen attitudes and knowledge about various domestic uses of water. Such measurements are needed to serve as a baseline for systematic evaluations of persuasive communications devices, such as films, leaflets, and speeches, which are used by water resources development agencies. This series of pilot studies exploits related behavioral research techniques developed by the Principal Investigator in previous studies.

Phase I of the research represented by this proposal will be devoted to two major tasks: (1) Reliability and validity analysis of a measure of community sentiment toward a water-related issue. These findings will serve as another source of information accumulated for decision- making by planning agencies. The refined instrument would also be available for research uses as mentioned below. (2) Feasibility study of procedures for evaluating communications with the public. The attitude-change literature and communications-effectiveness literature reveals little work related to water resources. Several pre-testing efforts will involve controlled exposure of college students to selected materials prepared as public information on water usage. A few major variables as potential determinants or correlates of attitude change will be assessed in this context.

Results of these research activities will contribute to knowledge regarding both individual and environmental factors which influence citizen response to information campaigns, proposed changes in quality of domestic water service and supply, and referenda on selected issues concerning water use. Project initiated in Janury 1968; to be completed December 1968.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Georgia Institute of Technology

6.0168, ATTITUDES AND ATTITUDE CHANGE RELATING TO WATER RESOURCES

C.M. YORK, Georgia Inst. of Technology, Water Resources Center, *Atlanta, Georgia* 30332

Attitudes, as relatively permanent cognitive-motivational states of individuals, appear highly relevant to the decision process in water management. Citizen response to proposed developments and their general predisposition toward use and misuse of natural resources enters significantly into program effectiveness. Broadly viewed, the influence process may be conceived in terms of the communication source (e.g., its perceived credibility, form and content) and audience characteristics and subsequent behavior.

The proposed research plan involves both literature searches (and a document which pulls together for water researchers the scattered evidence and generalizations) and an experimental investigation of the critical variable of source credibility within the attitude change process. Progress in undertaking these phenomena within other behavioral science context will be exploited for the water resources sector of society.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Georgia Institute of Technology

6.0169, ECONOMIC ANALYSIS OF AGRICULTURAL WATER MANAGEMENT IN THE SOUTHEAST

T. TOON, U.S. Dept. of Agriculture, *Atlanta, Georgia* 30309

Objectives: To determine the feasibility of supplemental irrigation as a means of increasing income on farms in the Southeast, particularly in underdeveloped regions such as Appalachia, and to estimate the optimum extent of irrigation in selected areas of the Southeast.

Approach: Current costs and benefits of irrigation of selected field and speciality crops are being developed from review and updating of previous research. Comparative advantages of selected locations for production and marketing of irrigated crops are being estimated under assumed conditions of improved transportation systems. Effects of increased production of irrigated crops on farm income are being determined.

SUPPORTED BY U.S. Dept. of Agriculture

6.0170, RESEARCH ON GEOHYDROLOGY OF THE EASTERN SLOPE OF WEST MAUI

D.C. COX, Univ. of Hawaii, Water Resources Research Ctr. , *Honolulu, Hawaii* 96822

The study of the geohydrology of the eastern slope of the West Maui Mountains is intended to investigate the relationship between present and proposed rates of draft and the safe yield of the basal ground-water aquifers using a method of correlation of rainfall variation and draft with head changes.

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SUPPORTED BY University of Hawaii
Wailuku Sugar Company

6.0171, METHODS FOR DETERMINING THE ECONOMIC PRODUCTIVITY OF IRRIGATION WATER FOR THE PRODUCTION OF SUGAR IN HAWAII

J.R. DAVIDSON, Univ. of Hawaii, Water Resources Research Ctr., *Honolulu, Hawaii* 96822

The proposed research plan involves the development of methodology for determining the economic productivity of irrigation water for the sugar producing areas in Hawaii.

Physical input-output data will be collected from actual field records and from experimental data for representative sugar producing situations in Hawaii. The relationship between irrigation water applied and sugar output obtained will be developed statistically. Value functions will be derived from these physical functions and the additional value of sugar resulting from increasing amounts of water applied at various input levels will be calculated for representative sugar producing conditions.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Hawaii

6.0172, PHYTOCHEMISTRY OF NARCOTIC PRINCIPLES IN CAULERPA

M.S. DOTY, Univ. of Hawaii, Graduate School, *Honolulu, Hawaii* 96822

Seven substances obtained in pure form from Caulerpa lamoureuxii in addition to beta-sitosterol, cholesterol, caulerpin and caulerpicin are being accumulated in sufficient quantity for identification. Pharmacological testing of the last two compounds named is proceeding. The distribution of these compounds peculaiar to Caulerpa among the species of the genus is being studied for biogenetic and phylogenetic leads.

Further efforts are being made via gas chromatography for following these peculiar compounds in the food chains dependent from Caulerpa.

Similar studies are underway with the chemical products of Dictyopteris for those cyclopropanes in addition to the already identified dictyopterene A.

A considerable effort has been made to obtain further quantities of field samples and further field observations for analysis of the chemical contents of these and other genera of seaweeds and for the development of an understanding of their production and fate.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

6.0173, OPTIMUM PATTERNS OF DIVERSIFIED CROP PRODUCTION ON THE MOLOKAI DIVERSION PROJECT

H.C. HOGG, Univ. of Hawaii, Agricultural Experiment Sta., *Honolulu, Hawaii* 96822

Objectives: To determine an optimum pattern of diversified crop production on the Molokai Diversion Project.

Approach: Production costs and yields will be estimated by land productivity class for crops suited to the area. The existing demand and supply for these crops will be estimated on the basis of the Honolulu market. These data will be used in an iterative linear programming model to derive the optimum allocation of land by quality to the production of the alternative crops. A price-quantity relationship for water will be derived by determining land use patterns resulting from varying prices of water.

SUPPORTED BY U.S. Dept. of Agriculture

6.0174, VALUE OF IRRIGATION WATER FOR THE PRODUCTION OF SUGAR CANE

H.C. HOGG, Univ. of Hawaii, Agricultural Experiment Sta., *Honolulu, Hawaii* 96822

Objectives: To determine the marginal value productivity of irrigation water for each of several distinct sugar-producing areas in Hawaii.

Approach: Physical input-output data will be collected for each sugar-producing region being considered. A statistical analysis of these data will be made to determine the relation between water applications and sugar production. The resulting physical function will then be interpreted in terms of a product value and a marginal relationship established. A corollary objective is to consider the costs of supplying water from several alternative sources to each sugar-producing area.

SUPPORTED BY U.S. Dept. of Agriculture

6.0175, USE OF WATER ON FEDERAL IRRIGATION PROJECTS

UNKNOWN, U.S. Dept. of Interior, Bureau of Reclamation, *Boise, Idaho*

Objectives of this program are to (1) document accurately the present use of water on existing projects and determine means of improving their use of water and (2) to obtain information to improve and develop procedures to insure successful and efficient planning, designing, and operating of future projects.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

6.0176, CHARACTERISTICS OF MAJOR FOREST AND RANGE WATERSHED TYPES IN IDAHO

G.H. BELT, Univ. of Idaho, Water Resources Research Inst., *Moscow, Idaho* 83843

The objective of the study is to classify the major watershed areas of the state with regard to their ecological characteristics and land use patterns. This study would identify major problem areas which will require intensive study of land uses and management practices as they influence water yield, nature of the runoff and erosion patterns. This would be a facilitating action for a long-range research program.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Idaho

6.0177, RELATIONSHIP OF PUMPING LIFT TO ECONOMIC USE OF GROUND WATER FOR IRRIGATION

G.L. COREY, Univ. of Idaho, School of Agriculture, *Moscow, Idaho* 83843

It is the purpose of this research to study farm size, cropping patterns, irrigation system design and farm management to define relationships between pumping lift and the price one can afford for water. The specific objectives include a determination of the optimum economic combination of resources available with respect to the price one can afford to pay for pumped irrigation water.

Modern technology allows water to be lifted greater distances than ever before. In some areas pumping from deep wells causes a lowering of the water table. The economic productivity of water used for agriculture is thought to vary significantly in some situtions due to size of farm unit. Although economic considerations are not the sole criteria for allocating water, knowledge of valid comparable economic values of water within agriculture will be helpful to those allocating rights or developing plans for future use of water resources.

Primary data will be obtained by interviewing farm operators. The data required will be input costs, labor requirements, yields and prices received. From these data model farms will be developed representing given practices for a given sized farm. This will be done by means of conventional budgeting analysis. For each model operation a determination of 'reasonable pumping level' will be estimated based on costs of pumping water.

The data will be collected in the upper Snake River Basin in Idaho in areas where groundwater availability is marginal and economic balance between water costs and farm operation is critical.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Idaho
Idaho State Government

6.0178, ECONOMICS OF WATER TRANSFER - AN APPRAISAL OF INSTITUTIONS

K.H. LINDEBORG, Univ. of Idaho, Agricultural Experiment Sta., *Moscow, Idaho* 83843

Objectives: 1. To appraise the legal-institutional-administrative devices and processes through which transfers of water between uses and users take place, and 2. To assess the consequences of these devices and processes on the economic efficiency and equity of water use, and 3. To suggest desirable modifications in these devices and processes that might enhance economic efficiency or equity in the use of water resources.

Description of Work Proposed: The legal-institutional administrative devices and processes through which transfers of water rights might take place will be investigated through an analysis of the complexity of laws and institutions which affect water rights in Idaho. This will improve a study of statutes, court decisions, constitutional requirements and limitations, and rulings of administrative agencies. In addition, a survey will be made of proposed legislative and constitutional changes in the state's water laws. This part of the study will be carried out in cooperation with the College of Law. The next step will be to estimate the marginal value product of water use in the category of users within agriculture. This will be done in an area of relatively large farms, and in an area of family farm units. The final step will be to determine the effects on the marginal value product of water that result from varying the relevant water right complex among users within agriculture. The effects of different modifications of the institutional restraints will be tested against the criterion of maximized marginal value product of water use.

SUPPORTED BY U.S. Dept. of Agriculture
Idaho State Government

6.0179, AN ECONOMIC ANALYSIS OF SOUTHERN ILLINOIS

R.I. ELLIS, Southern Illinois University, Graduate School, *Carbondale, Illinois* 62903

Concurrent with the enthusiastic concentration on economic growth in general since World War II has been the realization that disparities in economic development can be almost as great within nations as it is between them. This realization, as well as the recognition that regions and areas are faced with unique problems differing in nature as well as scope from those which are purely national, has resulted in increasing emphasis by a growing body of economists on the region or area as a target for analysis. The aims of the economists are multiple, ranging from the testing of various economic theories to the formulation of policies which will foster the participation of underdeveloped or depressed regions in national economic development. Southern Illinois, for a variety of reasons, is one of the regions which has not participated in national economic development. While many of the causes of this relative stagnation are generally known, much of his knowledge is based on imprecise data or on generalizations from very limited observation. In addition, the attempt to increase the participation of Southern Illinois in national economic growth necessitates a broad knowledge of past and present trends as well as future possibilities in order to determine exactly why the region is in its current state and what can be done to alter it. The aim of this study is basically to add to the stock of knowledge of Southern Illinois in order to enhance understanding of the region's present economic status and to provide a foundation for assessment of developmental policies. More specifically, the objectives are as follows: (1) The application and, when necessary, refinement of current methods of regional economic analysis to Southern Illinois on a county by county basis, concentrating particularly on those variables which heretofore have received little if any attention; (2) A general assessment of the current economic activity of Southern Illinois, including present trends in the major variables; (3) Attempt to develop new techniques for analyzing the economic structure and development of regions.

SUPPORTED BY Southern Illinois University

6.0180, A PARASITOLOGICAL STUDY OF FISHES FROM THE PINE HILLS AREA

G. GAROIAN, Southern Illinois University, Graduate School, *Carbondale, Illinois* 62903

Previous studies by Dr. William Lewis and his students have shown that there are some unusual populations of various cold water fishes in the springs of the Pine Hills area. Preliminary surveys by the investigator and his students have shown a considerable degree of parasitism of these fishes by some groups of worm parasites unique to this area of Illinois and the Mid- West, and some are probably species heretofore undescribed. Along with this descriptive study of the various fish parasites will be a more fundamental ecological study of host-parasite relationships. The preliminary studies also indicate that there is an unusually fine opportunity for this ecological study because these fish live in very restricted and isolated areas of the springs.

Method of Operation: Fish collections and various habitat data will be collected twice weekly at Pine Hills from mid June till mid September. Parasites will be removed from the fishes for preservation. Histological preparation of the various worm parasites and their specific morphological study will be done with facilities on campus, as well as analysis of host-parasite dain.

SUPPORTED BY Southern Illinois University

6.0181, PRODUCTION OF ADULT GAME FISHES BY ARTIFICIAL FEEDING

W.M. LEWIS, Southern Illinois University, Coop. Fisheries Res. Lab., *Carbondale, Illinois* 62901

The principal warmwater game fishes in the United States are usually produced on the basis of their utilizing natural foods. The limit of food supply imposes a serious limit on the ponds of fish that can be produced per acre. Some of these fish do not readily accept non-living food The present work is concerned with determining to what extent artifical feeds can be used and to what extent fishes can be trained to utilize them.

SUPPORTED BY Southern Illinois University
Illinois State Government

6.0182, FOOD INTAKE OF LARGEMOUTH BASS

W.M. LEWIS, Southern Illinois University, Coop. Fisheries Res. Lab., *Carbondale, Illinois* 62901

In this project to date we have demonstrated that the food intake of bass in at least some lakes is the same regardless of the size of the bass. This indicates that the intake is controlled by the hunting ability of the bass might characteristically be undernourished.

SUPPORTED BY Southern Illinois University
Illinois State Government

6.0183, OPERATION RIVERPORTS

A.R. MACMILLAN, Southern Illinois University, Transportation Institute, *Carbondale, Illinois* 62903

A collative study and compilation of river port and terminal facilities serving the inland waterways of the United States.

The compilation will include data on each established port with regard to its organization, description and summary listing of its facilities, services, charges, representative tariff listings, and principal import and export commodities. The study will also include comparative examples of barge, rail and truck rates between representative major river ports on the several river systems and the ocean ports they serve.

Additional data to be compiled for the river systems will cover average times for movement of barge tows, upbound and downbound between representative riverports and their respective ocean ports; also the total number of waterside terminals by category of use on each river system; together with total tonnages of principal import and export commodities.

The 'river systems' to be covered by this study are: Mississippi River, New Orleans to Minneapolis - St. Paul Missouri River - (9 foot navigation areas). Arkansas River - (9 foot navigation areas). Tennessee River, Paducah to Knoxville. Mobile/Warrior Rivers, Mobile to Birmingham. Apalachecola/Chattahoochee/Flnt Rivers. Hudson River - N.Y. State Barge Canal, New York to Buffalo. Columbia River, Astoria to head of 9 foot navigation. Ohio River, Cairo to Pittsburgh. Illinois Waterway - complete. Sacramento/San Joaquin Rivers, S.F. to Sacramento and Stockton.

SUPPORTED BY U.S. Dept. of Commerce - Maritime Admin.

6.0184, ALGAE IN ILLINOIS WATERS

R.H. MOHLENBROCK, Southern Illinois University, Graduate School, *Carbondale, Illinois* 62903

An attempt is underway to take water samples from all types of water resources in each of the Illinois counties. These samples are being analyzed as to which species of algae are present. The overall objective of the project is to account for every species of alga known to occur in Illinois.

SUPPORTED BY No Formal Support Reported

6.0185, ILLINOIS AND ITS INTERSTATE COMPACTS

M.E. RIDGEWAY, Southern Illinois University, Graduate School, *Carbondale, Illinois* 62903

Examination of the interstate compacts to which Illinois is a party, their legal status, agency and institutional arrangements, administrative powers and problems. Within determined limits, comparisons of Illinois' arrangements with those of other states to ascertain areas of possible improvements in control, direction, and achievement of compact proposals and goals. This study includes three interstate water compacts: The Ohio River Valley Sanitation Compact, the Wabash Valley Interstate Compact, and the Great Lakes Interstate Compact. Auxiliary to the water question is the Bi-State Development Compact of Illinois and Missouri. This latter compact also embraces metropolitan area problems, including water and air pollution.

SUPPORTED BY Southern Illinois University

6.0186, THE URBAN SNOW HAZARD

J. ROONEY, Southern Illinois University, Graduate School, *Carbondale, Illinois* 62903

Snow, like floods is responsible for ever increasing property damage and loss of life in the United States. This increase is partially due to the growth of urbanization and mobility, but more importantly to the knowledge vacuum surrounding the economic and social costs of snow, and the benefits to be gained from the various technological and non-structural alternatives available for the reduction of this hazard.

It is the purpose of this research to more accurately identify and measure the economic and social impact of snow at selected urban areas. A second and equally significant purpose is to analyze the factors affecting community adjustment to the urban snow hazard. The dividends from such research would be realized in the formulation and implementation of more efficient urban snow programs, a vital need in our urbanizing society.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Southern Illinois University

6.0187, AN EXPLORATION OF THE INFLUENCE OF ATTITUDES FOR DECISION-MAKING IN WATER MANAGEMENT

G.F. WHITE, Univ. of Chicago, Graduate School, *Chicago, Illinois* 60637

This proposal is for a supplement to a grant which was made in January 1965 and supplemented in December of 1965. The purpose of the project is to identify and analyze the situations in which attitudes toward water resources may play a significant role in management decisions, review present understanding of those attitudes, and outline ways in which this understanding can be deepened. This work grows out of path- breaking research on perception of, and attitudes toward, flood hazard done at the University of Chicago under Professor White's direction. Substantial progress was made under the previous grant and draft reports on various parts of the research have been prepared. These deal with both conceptual matters and empirical findings based on experiments with Navy corpsmen coming from diverse parts of the country and interviews with water managers. Preliminary results of part of these studies were presented in Professor White's paper at the RFF Forum in March. The preliminary findings are intriguing and suggest that important contributions to theory in social psychology and geography, and important insights into water management decision-making might result from a small amount of additional work on the data gathered in connection with studies done under the previous grants. The reports drafted so far could be published in journals of geography and social psychology, but additional work over the next year could produce a truly integrated book-length report. To this end the principal investigators would conduct a seminar based upon the winter quarter at the University of Chicago. The authors would then collaborate in the production of a volume to be ready for publication shortly thereafter.

SUPPORTED BY Resources For The Future Incorporated

6.0188, INTERNATIONAL RIVER PLANNING IN AFRICA

G.F. WHITE, Univ. of Chicago, Graduate School, *Chicago, Illinois* 60637

An analysis of methods followed in the planning of water development in a number of African rivers, principally the Niger, Nile, Volta, and Zambezi. Special attention is given to the methods of dealing with international collaboration, measurement of ecological impacts, and decision in the face of incomplete information.

SUPPORTED BY Rockefeller Foundation

6.0189, COMPARATIVE STUDIES OF COMMUNITIES IN ILLINOIS

P.J. CAMPISI, Southern Illinois University, Graduate School, *Edwardsville, Illinois* 62025

With the kind support of Mississippi Valley Investigations, a continuing program of comparative community studies has been underway for the past three summers. Five communities, four in southern and one in northern Illinois (all about the same size, roughly 10,000 in population) have been studied with regard to the social and political decision-making-structure of the community. This work continues this summer with the completion of the study of a northern community and the commencement of the study of a southern Illinois community in the St. Louis Metropolitan area. In addition to obtaining typical power- structure and other related social data, we expect to get a sample of 'leaders" opinions on the decision making process as it relates to community water problems.

SUPPORTED BY Southern Illinois University

6.0190, ECONOMIC EVALUATION OF NAVIGATION IMPROVEMENTS

L. MOSES, Northwestern University, Econometrics Research Center, *Evanston, Illinois* 60201

Objective: To achieve a more highly developed, yet empirically realistic, basis for evaluating the benefits and costs of inland waterways investment projects.

Study Plan:

1. Develop a proper basis for evaluating benefits: examine whether rates or costs are valid as measures of benefits. a. Formulate analytical models for dealing with problems of jointness in costs and benefits, and the concept of transportation as social overhead. b. Analyse the effect of externalities on optimal pricing. c. Develop principles governing the optimal use of resources and optimal pricing under conditions in which fixed and variable costs can be defined with respect to output and/or time. 2. Prepare a comprehensive statement on the methodology of benefit studies for public investment projects in the internal navigation area. 3. Develop information regarding the general character of long run incremental costs of alternative modes of transport. The research will also investigate possible directions of technological change as these impinge upon the costs of alternative forms of transportation. 4. Analyse the degree of intermodal competition and price response. The present and likely future influence of regulatory bodies on rates and costs will also be studied.

SUPPORTED BY U.S. Dept. of Defense - Army

6.0191, CITIZENS WORKSHOPS ON CLEAN WATER FOR AMERICA

J.W. PENFOLD, Izaak Walton League of America, *Glenview, Illinois* 60025

The purpose of the project is, by means of national and regional workshops, to equip a substantial number of citizen organization leaders to organize and conduct citizen workshops on water quality criteria at State and community levels. At these workshops, the opportunities for clean water progress, made available by the Water Quality Act of 1965, will be comprehensively discussed under the guidance of technical experts.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Izaak Walton League of America, Inc.

6.0192, ENVIRONMENTAL GEOLOGY OF MCHENRY COUNTY, ILLINOIS

J.E. HACKETT, State Geol. Survey, *Urbana, Illinois*

At the request of the McHenry County Regional Planning Commission, the Geological Survey has undertaken studies involving geology and mineral economics to aid in land-use planning. The initial studies deal with: (a) physiographic analysis of the major physiographic units, (b) relation between surficial geologic units and soil series units, (c) subsurface stratigraphy of unconsolidated deposits, (d) occurrence and character of glacial drift and bedrock aquifers, (e) geologic feasibility for water resource management programs, (f) occurrence and character of construction materials including sand and gravel, rock products, and borrow materials (g) characteristics and potential uses of clay deposits, (h) economic value of mineral resources, (i) engineering characteristics of geologic units, and (j) geologic evaluation of surface reservoir conditions and of proposed reservoir sites. These studies wil provide a basis for interpretive maps that grade areas as to their suitability for specific land uses and as sources of mineral or rock materials.

SUPPORTED BY Illinois State Government

6.0193, ENVIRONMENTAL GEOLOGY OF THE SPRINGFIELD-DECATUR AREA

K. PISKIN, State Geol. Survey, *Urbana, Illinois*

The objective of the study is to provide information on geology and mineral resources to facilitate planning for urban development. The study will include maps and information on surficial geology, physical properties of shallow earth materials, groundwater conditions, mineral resources and conditions related to specific land uses.

SUPPORTED BY Illinois State Government

6.0194, FISH POPULATION MANIPULATION AT RIDGE LAKE

G.W. BENNETT, State Natural History Survey, *Urbana, Illinois*

During four years of stable water levels, the bluegills in the bass-bluegill-warmouth-channel catfish population of Ridge Lake in Fox Ridge State Park near Charleston expanded from 59 per acre to 5,400 per acre -- this in spite of predation by bass. Growth rates of bluegills were slowed when more than 1,000 per acre were present.

Largest populations of large bass and excellent bass fishing resulted from draining the lake at two-year intervals and removing from the fish population all of the bass of less than 8 inches and bluegills of less than 6 inches. Under this system, bluegills were unable to build up excessive populations, and there was artificial selection for the fast growing bass.

Lowering the lake level in early September to reduce the surface area by 35 percent resulted in a reduction of the bluegill population from about 4,000 to approximately 1,000 per acre and increased the survival of small bass in the spawning season that followed. This was a simple and effective method for bluegill population control. Details of this 22-year investigation are given in a paper, 'The Largemouth Bass and Other Fishes in Ridge Lake, Coles County, Illinois Under Several Systems of Management,' now in the hands of the Survey editor.

By combining annual September drawdowns at Ridge Lake with supplemental feeding of bluegills with prepared pelleted fish food (32 percent protein) we have increased the hook-and-line yield of these fish to exceed any taken in the past 25 years and have doubled the average size of the bluegills caught by fishermen. This program costing $11.22 per acre per season for prepared fish food appears to have wide application in bluegill management. A paper titled, 'The Dynamics of a Bluegill Population Fed on a Prepared Food and Subjected to an Annual Fall Drawdown,' has been mimeographed for distribution.

SUPPORTED BY Illinois State Government

6.0195, HYBRID SUNFISH STUDIES

W.F. CHILDERS, State Natural History Survey, *Urbana, Illinois*

During May 1967 eggs stripped from a female largemouth bass were fertilized with sperm from males of smallmouth bass, rock bass, green sunfish, bluegills, and red-ear sunfish. A high percentage of each of the five different kinds of hybrids hatched; however, all of the rock bass x largemouth hybrids died shortly after they hatched. Approximately 75 percent of the red-ear x largemouth hybrids and 25 percent of the green x largemouth hybrids were deformed. Almost all of the smallmouth x largemouth hybrids appeared to be normal.

Small numbers of each of the four kinds of viable hybrids were kept in the laboratory and the rest were stocked in ponds as soon as they developed into free-swimming fry. The few red-ear x largemouth hybrids which were held in the laboratory died shortly after they became free-swimming and none of those which were stocked in a pond were recovered when the pond was poisoned during the fall.

One group, the bluegill x largemouth hybrids, stocked in a pond were lost when the owner added some smallmouth bass.

The green x largemouth hybrids stocked in a pond grew well during the summer. A few individuals were collected by seining at various times in June and July.

Smallmouth x largemouth stocked by themselves in a small pond grew rapidly, and by fall these hybrids ranged from 6 to 10 inches in length.

The smallmouth x largemouth, bluegill x largemouth, and green x largemouth hybrids which were retained in the laboratory are continuing to survive and grow. These fishes will be used in making morphological comparisons between the hybrids and their parent species.

SUPPORTED BY Illinois State Government

6.0196, BIOLOGICAL CONTROL OF AQUATIC VEGETATION

W.F. CHILDERS, State Natural History Survey, *Urbana, Illinois*

The capability of Tilapia mossambica, a vegetation-eating chichlid from Africa, to control aquatic vegetation in Illinois lakes and ponds has been tested during the past six summers.

When tilapias were stocked during mid May at the rate of 50 per acre in a pond containing no other fishes, the population expanded rapidly and was capable of eliminating all submergent aquatic vegetation and algae in less than six weeks. In another season predation on tilapias by an excessive population of largemouth bass prevented an expansion of tilapias and resulted in the failure of the survivors to control the vegetation. In still other years, a light to moderate population of largemouth bass or largemouth bass and bluegills allowed an expansion of tilapias which either eliminated the vegetation or prevented it from reaching nuisance levels.

According to experiments made in 1967, 211 adult tilapias per acre (average total length 6.8 inches) were capable of eliminating the vegetation in this pond and preventing its return during the entire summer. Previous results (1964) established that 121 tilapias per acre (average total length 5.8 inches) were unable to eliminate the vegetation, but they did control it so that it never reached nuisance levels.

The results of this study to date suggest that if tilapias longer than 5 inches were stocked at the rate of approximately 150 per acre in a pond containing bass and bluegills, they would control and perhaps eliminate the submergent aquatic vegetation.

SUPPORTED BY Illinois State Government

6.0197, DEPTH DISTRIBUTION OF FISH IN LAKE GLENDALE

D.F. HANSEN, State Natural History Survey, *Urbana, Illinois*

The depth distribution of bluegills and largemouth bass was determined by using trotlines suspended vertically from floats and supplied with hooks 1 foot apart. Some lines were fished in the littoral (weed) zone in water 10 feet deep and some in the open water beyond the zone of weed growth at depths of 18 to 20 feet. A record was kept of the depth at which each fish was caught.

Larger bluegills were more abundant in the open water than at the deep edge of the weed zone, and bluegills under 5 inches almost never were caught in the open water.

Larger bluegills were taken in open water at depths of 1 foot to 20 feet below the surface (bottom), but most often they were taken at depths of 8-15 feet. Largemouths were rarely taken below 12 feet.

Food studies made in conjunction with the depth distribution study have indicated that bluegills fed extensively on a large midge larva, Chironomous plumosus, which occurs only on the lake bottom where oxygen is low (usually less than 1 ppm) and where rooted weeds are absent. Since the same bluegill stomachs often contained chironomid larvae from deep water and foods such as snails and dragonfly larvae that occur only on weeds, it is evident that the bluegills move back and forth from shallow water to deep water in the collection of food.

SUPPORTED BY Illinois State Government

6.0198, LAKE MICHIGAN WATER QUALITY MODEL

R.L. EVANS, State Water Survey, *Urbana, Illinois*

The specific objective of the project is to develop a mathematical water quality model for Lake Michigan. Model formulation will be primarily based upon information regarding dissolved conservative mineral substances. The data will be from records that are available and will pertain to the chemical quality of rainfall, natural and man- made discharges, and waters of the lake. Changes in content as expressed by the model in relationship to economic growth, population shifts, etc., will serve as an instrument for water quality management.

SUPPORTED BY Illinois State Government

6.0199, ALGAL GROWTH POTENTIAL OF ILLINOIS WATERS

R.L. EVANS, State Water Survey, *Urbana, Illinois*

The objective of the study is to develop the methodology that will permit the use of algal growth potential (AGP) as a meaningful index of water quality. The experimental phase of the undertaking will be an evaluation of expressing AGP in terms of carbon fixation capacity using liquid scintillation procedures. Other methods for expressing productivity will also be investigated. Sensitivity, reproducibility, and minimum detectability are the major factors to be examined. After methodology and optimum environmental conditions have been established, a general survey of Illinois water will commence. Preliminary results should permit tentative classification of the waters based upon their potential for algal growth. The final phase of the study will relate to the applicability of bench observations to field experience.

SUPPORTED BY Illinois State Government

6.0200, WATER QUALITY MODEL DERIVED FROM SYSTEM ANALYSES

R.L. EVANS, State Water Survey, *Urbana, Illinois*

As a subsystem for an overall endeavor to develop a water management program for the Kaskaskia River Basin, the elements and their interrelations and interactions for a water quality model are being defined; once defined these elements will be used for developing a water quality model. The objective of the model will be to determine the degree of treatment required for each waste discharger in order to achieve a desired water quality objective at the minimum cost to all dischargers.

SUPPORTED BY Illinois State Government

6.0201, WATER RESOURCE DEVELOPMENT AND MANAGEMENT MODEL

R.H. HARMESON, State Water Survey, *Urbana, Illinois*

This project involves the creation of a detailed water resource development and management model that will serve state and local planners in meeting present and future water needs. A systems analysis approach is being used so that all elements of water resource development are input for the model. Thus, principal elements (supply sources, treatment, storage, transmission, distribution, disposal, and reuse) can be viewed as a whole and in relation to each other. From detailed analyses of each element, the model will provide alternative schemes of development and management on the basis of the available water resource, present and future demands for water, and costs.

SUPPORTED BY Illinois State Government
U.S. Water Resources Council

6.0202, ADVANCED METHODOLOGIES FOR WATER RESOURCES PLANNING

V.T. CHOW, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

The proposed research plan is to investigate a number of advanced concepts of water resources planning which are of basic importance but have not been generally introduced into practice. These concepts include mainly stochastic analysis and dynamic programming.

Three stages will be proceeded in the investigation. The first Stage is to ascertain the feasibility of the application of various stochastic methods of hydrology to hydroeconomic system analysis and of the application of dynamic programming for stochastic system optimization. The second state is to develop working procedures of stochastic dynamic programming to actual problems.

In the investigation, mathematical formulations will be programmed for computer analysis and data from river basins in Illinois will be tested in the working procedures to be developed.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Illinois

6.0203, STOCHASTIC ANALYSIS OF HYDROLOGIC SYSTEMS

V.T. CHOW, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

The proposed research project aims to develop practical methods which will utilize mathematical models to simulate the stochastic behavior of hydrologic systems with an ultimate goal to extend the application of the methods so developed to hydroeconomic systems for the analysis and planning of actual water resources systems. The mathematical models will be stochastic and nonlinear in nature and will be applied to river basin systems particularly in Illinois, although the concept of this mathematical simulation will be equally applicable to other kinds of hydrologic systems.

The procedure for the proposed investigation will consist of three steps: (1) to formulate mathematical models for simulating the stochastic behavior of hydrologic systems; (2) to analyse and improve the models by numerical analysis and computer technology; (3) to verify and apply the improved models to actual river basin systems.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Illinois

6.0204, WATER RESOURCES SYSTEM ANALYSIS

V.T. CHOW, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

Operations research techniques are used to optimize water resources systems for the planning and development of water projects. Mathematical models and simulation were used, involving Monte Carlo methods, Markov-chain models, and linear and dynamic programmings. A study on similarity between rail transport system and water resources system has been completed. A hydroeconomic analysis to optimize a multi-purpose project is not being investigated.

SUPPORTED BY University of Illinois

6.0205, PREPARATION OF A HIGHWAY DRAINAGE POLICY STATEMENT AND PRACTIVE MANUAL FOR THE STATE OF ILLINOIS

C.J. DRABLOS, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

The purpose of this study is to develop highway and agricultural drainage policy statements based upon specific laws and practices in Illinois. This manual will incorporate data from two previous research reports and present written policy of the Illinois Division of Highways. Although emphasis will be placed upon the relationships between highway and agricultural interests, laws relating to highway and urban drainage will be included in one section of the manual.

SUPPORTED BY University of Illinois
Illinois State Government

6.0206, HYDROLOGIC CHARACTERIZATION OF SMALL WATERSHEDS

R.N. FENZL, Univ. of Illinois, Agricultural Experiment Sta. , *Urbana, Illinois*

Several watersheds in Illinois were investigated through aerial photographs and topographic maps to provide empirical relationships between watershed area, stream density, frequency, and length. The relationships were used in the development of hypothetical watersheds used in a computer orientated mathematical model utilizing the kinematic formulation to simulate response to rainfall excess of a third order stream system representing 0.25 square miles of upland agricultural area with steep ground and channel slopes.

SUPPORTED BY U.S. Dept. of Agriculture
University of Illinois

6.0207, DEVELOPMENT OF DRAINAGE ASSESSMENT PROCEDURES BASED ON PHYSICAL FEATURES IN ILLINOIS

B.A. JONES, Univ. of Illinois, Agricultural Experiment Sta. , *Urbana, Illinois*

This project is to formulate an equitable drainage assessment procedure based upon a correlation between physical features of the land and drainage benefits. An empirical formula was developed that equates total benefits received on a tract of land to summation of three physical features each multiplied by a constant. Work this year has concentrated on refining the equation coefficients.

SUPPORTED BY University of Illinois

6.0208, DEVELOPMENT OF DRAINAGE ASSESSMENT PROCEDURES BASED ON PHYSICAL FEATURES IN ILLINOIS

B.A. JONES, Univ. of Illinois, Agricultural Experiment Sta. , *Urbana, Illinois*

This project is to formulate an equitable drainage assessment procedure based upon a correlation between physical features of the land and drainage benefits. An empirical formula was developed that equates total benefits received on a tract of land to summation of three physical features each multiplied by a constant. Work this year has concentrated on refining the equation coefficients.

SUPPORTED BY University of Illinois

6.0209, AN APPRAISAL OF FLOOD REGULATIONS IN THE STATES OF ILLINOIS, INDIANA, IOWA, MISSOURI AND OHIO

W.M. KEITH, Univ. of Illinois, Graduate School, *Urbana, Illinois*

The proposed research involves data collection and field investigations to analyze and determine the effectiveness of flood plain regulations as a tool in flood plain management in the states of Illinois, Iowa, Missouri, Indiana and Ohio. The essential object will be (1) to determine whether statutes and flood plain zoning are effectively used, (2) to determine what other alternative preventive methods are available, (3) to analyze and appraise these other alternatives.

Collected Data will be used: 1. To determine types of regulations, who administers them, and how they are administered. 2. To determine goals and values. 3. To establish a priority scale.

Field investigations will involve setting up case studies showing the effect of flood plain regulations where they exist and where they do not exist. It is the intent to show the effectiveness of proper planning controls.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Illinois

6.0210, INTERGOVERNMENTAL RELATIONSHIPS IN THE ADMINISTRATION OF WATER RESOURCES

N.G. KRAUSZ, Univ of Illinois, School of Agriculture, *Urbana, Illinois*

An appraisal and evaluation of the legal institutions and administrative structures, processes and techniques, in water development, use, management and quality control, in Illinois. This includes a study of the application of water related laws, coordination between units of government, expenditure of federal, state and local funds, adaptability to emerging federal-state effort, administrative costs, utilization of community resources, and rigidities in present government organization. It also includes an assessment of large numbers of governmental units having boundaries which circumscribe only a portion of the water problem area and which operate independently in water resource development, use, control, and in levying taxes.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Illinois

6.0211, ECONOMICS AND LEGAL FACTORS IN PROVIDING, USING AND MANAGING WATER RESOURCES IN AGRICULTURE

N.G. KRAUSZ, Univ. of Illinois, Agricultural Experiment Sta. , *Urbana, Illinois*

Objective and description of work: To complete and publish a study of Illinois laws and decisions on water use, including relationships to laws and administrative practices of other states and the federal government, and including conflicts of water use, pollution control and interstate compacts; and to determine correlations between different legal frameworks and the demand and supply of water in selected states. Laws, cases and administrative practices in Illinois and other north- central states are to be analyzed as well as federal laws and regulations. Water laws are to be classified and supply and demand data obtained and correlations, if any, determined.

SUPPORTED BY U.S. Dept. of Agriculture
Illinois State Government

6.0212, ANALYSIS OF LITERATURE ON THE RECREATIONAL ASPECTS OF WATER RESOURCES RESEARCH

E.H. STOREY, Univ. of Illinois, Graduate School, *Urbana, Illinois*

A. The objective of this project is

(1) to determine the status of research on recreational aspects of water resources through identification, retrieval and critical analysis of pertinent literature;

(2) to summarize knowledge, and identify gaps in knowledge, of recreational aspects of water resources planning, use and management; and

(3) to develop a research program on recreational aspects of water resources planning, use and management.

B. Procedure

The procedure to be followed in the study will be as follows:

(1) An intensive retrieval program on literature pertinent to recreational aspects of water resources will be carried out.

(2) Development of a classification system for this literature.

(3) Critical analysis of the literature and summarization of existing knowledge about recreational aspects of water resources, including use, management and planning.

(4) Identification of gaps in knowledge of recreational aspects of water resources.

(5) Development of a research program on planning and management of water resources for recreational use.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Illinois

6.0213, ECONOMIC ANALYSIS OF WATER USE IN ILLINOIS AGRICULTURE

E.R. SWANSON, Univ. of Illinois, School of Agriculture, *Urbana, Illinois*

Estimates will be made of the profitability of the irrigation of corn and other high-profit crops in selected areas of Illinois. In order to place decisions concerning irrigation within the context of the total farm business the analyses will be performed with linear programming methods. The influence of a number of price, cost, and technical factors upon the profitability of irrigation will be examined.

On rented farms the adoption of irrigation will be conditioned by the leasing arrangement. Alternative leasing methods will be compared with the objective of finding those lease types which facilitate adoption of irrigation. Since the equity of leasing arrangements depends on land values, the influence of irrigation on land values in Illinois will also be studied.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Illinois

6.0214, AN ECONOMIC AND LEGAL APPRAISAL OF THE USE OF WATER FOR IRRIGATION AND OTHER PURPOSES ON ILLINOIS FARMS

UNKNOWN, Univ. of Illinois, Agricultural Experiment Sta., *Urbana, Illinois*

Irrigation study objectives, including the economics of irrigation in Illinois and the effect of irrigation on the total farm business, have been completed and publications released as reported in 1961.

A portion of the legal study, including an analysis of water use law in Illinois with cases and administrative practices, has been completed, and responsibility for publication has been shifted to Project 05-390.

The balance of the legal work, to study constitutional problems in changing water laws, to determine what revisions to Illinois water laws are needed, and to write a model water code, is scheduled for 1964.

SUPPORTED BY Illinois State Government

6.0215, EAST CHICAGO TREATMENT LAGOON

C. LEAHU, East Chicago Sanitary District, *East Chicago, Indiana*

The project will evaluate the effectiveness of treating combined sewer overflows in a very deep detention basin having aerobic and anaerobic levels of treatment. The aerobic treatment is accomplished by large oxygen transfer units suspended on surface of basin waters.

The major features of this project are: 1. One 20-acre, 40-foot deep, 200 million-gallon capacity detention basin. 2. Nine 50-HP, oxygen transfer units. 3. 2500 lineal-feet of prestressed concrete pressure pipe, 84 inches in diameter. 4. Chlorination equipment necessary for treating effluent from detention basin. 5. Necessary water quality and quantity monitoring equipment. 6. Necessary evaluation required to meet demonstration program objectives.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
East Chicago City Government - Indiana

6.0216, HYDROLOGIC, THERMAL AND TEXTURAL PROPERTIES OF SOILS

H. KOHNKE, Purdue University, Agricultural Experiment Sta., *Lafayette - West Lafayette, Indiana* 47907

(1) To determine the effects of moisture content and structure of various soils on their thermal conductivity and diffusivity; (2) To determine the interrelation between texture, specific surface and the moisture retention in the dry range for various soils; (3) To determine the degree of availability of soil moisture for plants at various levels of total moisture tension, for water held matrically and osmotically.

Soils selected for individual studies under this project will be analyzed for a number of important properties including mechanical composition, predominant clay types, exchangeable cations, moisture retention curve, organic matter content and aggregation. Thermal diffusivity, heat capacity, specific surface, availability of soil water and molar free energy of this water will be determined for the soils in question and related to the first group of properties in order to achieve the stated objectives. Modern instrumentation including thermal probes, transistors, and a microcalorimeter, will be used in these studies.

SUPPORTED BY U.S. Dept. of Agriculture
Indiana State Government

6.0217, EFFECTS OF WATER PROPERTIES IN THIXOTROPIC CLAY SYSTEMS ON BIOLOGICAL ACTIVITY

P. LOW, Purdue University, School of Agriculture, *Lafayette - West Lafayette, Indiana* 47907

Bernal has suggested fine clay sediments as a site for the early polarizations and condensations for various primordial compounds. Clay seems to absorb selectively certain molecules and could have served as a concentrating mechanism by means of which protein molecules could have appeared in sufficient concentration in the early seas. The specific objectives are as follows: 1) to determine the effects of the sol-gel transformation of the properties of water in a clay suspension, 2) to determine the effect of the sol-gel transformation on the activity of organisms in a clay suspension.

Experiments will be conducted on the structure-sensitive properties of water and clay sols and gels and on changes that occur in these properties during the sol-gel transformation. In particular, the apparent and partial specific heat of the water will be studied by means of an ultra-sensitive calorimeter. Then using the same calorimeter, the thermal kinetics of bacteria and suspensions in two physical states will be investigated. If the results of the initial experiments are promising, additional experiments will be designed.

a. Progress Report to June, 1967 - Preliminary results show that the minimum of clay required for gelation is 4 percent. A new osmometer with improved sensitivity has been developed. Biological activity is definitely influenced by differences in water properties of the gel and sol state. Streptococcus faecalis replaced lettuce seeds used in preliminary work since it was desirable that the organism affected by the water be surrounded by it, hence selection of an anaerobic non-gas forming organism. Minimum nutrient found to be 0.1 percent of casamino acid and glucose and 0.01 percent of yeast extract and arginine, based on total weight of clay-water paste. Thermograms using microcalorimetry were obtained from the difference in heat produced by the microorganisms during cell division and metabolism in pastes of varying concentration.

SUPPORTED BY U.S. Natl. Aero. & Space Adm.

6.0218, IMPROVED METHODS FOR ESTIMATING MANPOWER NEEDS FOR WATER RESOURCES DEVELOPMENT

W.L. MILLER, Purdue University, School of Agriculture, *Lafayette - West Lafayette, Indiana* 47907

6. WATER RESOURCES PLANNING

The methods traditionally used to estimate the surplus or shortages in an occupation are inadequate because they fail to explicitly consider the wage rate in the occupation under consideration or the wage rates in closely related occupations.

The general objective of this research project is to develop an improved method to determine more accurately training requirements for an occupational skill level in water resource management. The specific objectives include: (1) to determine supply and demand functions for water resource personnel in the Indianapolis area; and (2) to compare training requirements indicated by these functions with the training requirements suggested by the traditional method of estimation.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Purdue University

6.0219, RECREATIONAL IMPACT OF FEDERAL MULTI-PURPOSE RESERVOIRS

UNKNOWN, Purdue University, Graduate School, *Lafayette - West Lafayette, Indiana* 47907

Necessary data is being acquired which will assist the Indiana State Highway Commission in planning for the future highway requirements of recreational travel to federal multi-purpose reservoirs in the state. The objective of the second phase of this study will be the validation of the models developed for the study and with the estimation of change in characteristics and demand over a period of time.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Indiana State Government

6.0220, EFFECTS OF DOMESTIC POLLUTION ABATEMENT ON A EUTROPHIC LAKE

M.W. TENNEY, Univ. of Notre Dame, School of Engineering, *Notre Dame, Indiana* 46556

The primary objective of this project is to demonstrate changes in a eutrophic lake following complete removal of all domestic pollution. Project results will then be used as a basis for suggesting possible external manipulation of the lake that may accelerate or promote beneficial natural changes. Initial studies will include physical, chemical and biological studies of the existing source of pollution and lake conditions. After removal of the source of pollution the same studies will continue on the lake basin.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
University of Notre Dame

6.0221, FACTORS AFFECTING FISH PRODUCTION PONDS

R.W. BACHMANN, Iowa State University, Iowa Coop Fishery Unit, *Ames, Iowa* 50010

Serum protein fractions of bluegill sunfish. Total serum protein levels of bluegill sunfish in experimental tanks were reduced 30% after 36 days of starvation. Cellulose acetate electrophoresis identified four major serum protein fractions. Serum protein patterns of bluegill from study ponds indicated differences in percentage protein fraction within ponds, sexes and collection dates as well as statistical interactions. Electrophoretic analysis of serum proteins must consider environmental and physiological factors causing variation.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Iowa State Government
Iowa State University

6.0222, PHYSICAL AND ECONOMIC ANALYSIS OF WATERSHEDS AS RELATED TO SOIL AND WATER CONSERVATION

C.E. BEER, Iowa State University, Agricultural Experiment Sta., *Ames, Iowa* 50010

This is a cooperative venture between physical and social scientists and is concerned with the continuing updating and refining of physical inputs which are needed for the solution of various economic problems of soil water and land use on a watershed basis. Economics methodology studies include use of linear programming and computer techniques and various adaptions of cost-benefit analyses.

Physical studies in progress or planned include studies of the effect of plant cover and cultural practices on defined segments of the hydrologic cycle on water sheds which range in size from about 2 to 500 acres.

SUPPORTED BY U.S. Dept. of Agriculture
Iowa State Government

6.0223, STREAM BIOLOGY AND ITS RELATION TO FISH PRODUCTION

K.D. CARLANDER, Iowa State University, Iowa Coop. Wildlife Res. Unit, *Ames, Iowa* 50010

1. Biochemical indicators of fish growth. F. Bulow, Grad. Asst. Ribonucleic acid (RNA) and desoxyribonucleic acid (DNA) ratios were lowest in starved golden shiners and increased with higher feeding levels and faster growth rates. Samples of various organs and tissues are being prepared for analyses. Initiated in 1966 and anticipated completion date is 1969.

2. Distribution of bottom fauna and its utilization by fish in the Fort Madison section of Pool 19, Mississippi River. Jude and R. Ranthum. Grad Assist. Seasonal changes in the bottom fauna and fishes of Pool 19, Mississippi River were determined throughout 1967. Special emphasis was placed upon the ecology of the fingernail clam. Laboratory studies indicate its rapid growth and reproduction. Seasonal and environmental differences in fish distribution were indicated by the yearly sampling program. Master of Science theses will be written on fish distribution in 1968 and the data on the bottom fauna will be completed in 1969.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Iowa State Government
Iowa State University

6.0224, DYNAMICS OF FISH POPULATIONS IN NATURAL LAKES

K.D. CARLANDER, Iowa State University, Iowa Coop. Wildlife Res. Unit, *Ames, Iowa* 50010

1. Life history of yellow bass in Clear Lake, Iowa. M. S. thesis completed by Gary Atchinson in May 1967 reported little change in growth rates of yellow bass following mass mortalities in 1965 and 1966. Sexual development and spawning study of yellow bass initiated in 1966 will be completed by R. Bulkley in 1969.

2. Food preferences and feeding of black bulhead, carp and walleye in Clear Lake. R. Baur, I. Effendie, and F. Jernefcic. Examination of captured free-ranging fish as well as controlled feeding experiments were initiated in 1967 and will be completed in 1969.

3. Water temperature dynamics of Clear Lake. water temperature relationships for the period 1950 to 1965 during ice-free periods were computed by 10-day rolling sums of maximum plus minimum air temperatures. Project was completed with submission of M.S. thesis in May, 1968.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Iowa State Government
Iowa State University

6.0225, IOWA ECONOMETRIC MODEL

K.A. FOX, Iowa State University, School of Agriculture, *Ames, Iowa* 50010

This study focuses on the preparation of a 117-sector input-output model of the Iowa economy and the adaptation of the model for use in water resources planning in Iowa. In addition, a series of economic and population projections for the water resource regions of Iowa for the period 1960 to 2020 will be prepared. Procedures for correlating these projections with similar estimates for the Missouri River and Upper Mississippi River Basins will be formulated.

SUPPORTED BY Iowa State Government

6.0226, AN ANALYSIS OF THE ECONOMIC IMPLICATIONS OF THE PERMIT SYSTEM OF WATER ALLOCATION

N.E. HARL, Iowa State University, Graduate School, *Ames, Iowa* 50010

The proposed research project involves both theoretical and empirical analysis of the economic implications of the permit system of water allocation with particular emphasis upon the effects of the permit system on economic growth, income distribution, and economic stability. The study would examine the economic efficacy of the permit system as an administrative, nonmarket method of resource allocation.

The theoretical analysis phase would involve construction of an appropriate economic model for testing and analysis of the economic operation of the permit system.

The empirical phase would entail gathering of data relating to Iowa on regulated water use, non-regulated water use, and nonapproved requests for water use; projection of water supplies and demands to a future date, and an identification and quantification of inefficiencies in resource allocation resulting and likely to result from continued operation of the permit system.

The final phase would be concerned with articulation of alternative means to improve water allocation from an economic standpoint.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Iowa State University

6.0227, WATERFOWL POPULATIONS AND RECREATIONAL USE PATTERNS IN THE PROPOSED SAYLORVILLE RESERVOIR AREA AS RELATED TO PRE-IMPOUNDMENT CONDITIONS

A.D. HAUGEN, Iowa State University, School of Agriculture, *Ames, Iowa* 50010

Summary of Proposed Work: This study comprises the first phase of what should be considered a two-phase study to determine the impact of the alteration of an environment on waterfowl populations and recreational use patterns at the Saylorville impoundment now under construction on the Des Moines River in central Iowa. The impoundment is expected to dramatically affect wildlife habitat in the area. A measure of these changes and subsequent changes in wildlife recreational use pattern of the areas are major goals of this study.

Use of the area as it now exists, its accessibility, major recreational values and use patterns, and the origin and other characteristics of users will be obtained through field checks, time- lapse cameras, pnuematic car counters, and through questionnaire and interview techniques. The Iowa State University Statistical Laboratory will aid in setting up a sampling system.

Automatic recording devices will record data on daily, weekly and seasonal cycles and fluctuations in recreational activities. Data secured should be of use for planning zoning or other regulations needed to minimize friction between different types of users on similar impoundments elsewhere.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Iowa State University

6.0228, PHYSICAL, LEGAL AND ECONOMIC ASPECTS OF ASSESSMENT OF COSTS AMONG DRAINAGE DISTRICTS

H.P. JOHNSON, Iowa State University, School of Engineering, *Ames, Iowa* 50010

The primary objectives of the proposed research project are (1) to investigate the effects of stream modifications on flood flow characteristics and backwater curves as related to drainage districts contiguous to a common waterway, (2) to correlate the flood flow characteristics and backwater with property benefits and damages such that a procedure or guideline can be developed to assist in the assessment of construction and maintenance costs of drainage districts and (3) to study the existing laws of Iowa and other states in order to determine the optimum framework for evaluating the economic and engineering results.

The courts in the state of Iowa are presently involved in litigation dealing with the problem of equitable assessments among drainage districts which often lasts for long periods of time and does not arrive at a solution to the problem. Recent testimony presented to an Iowa Drainage Laws Study Committee by persons concerned with drainage problems and Iowa's drainage law conveyed the need for more work and legislation in this area.

Field situations involving drainage districts common to a natural stream and a constructed drainage ditch will be utilized in the study. Pertinent field data will be gathered and the computer will be used for all laborious computations involved in determining the effects of stream modification on flood flows and stages.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Iowa State University

6.0229, ECONOMIC AND LEGAL FACTORS IN PROVIDING, USING AND MANAGING WATER RESOURCES IN AGRICULTURE

J.F. TIMMONS, Iowa State University, Agricultural Experiment Sta. , *Ames, Iowa* 50010

Project Objectives - (a) To develop an economic basis for allocating water among competing uses and users, considering both quality and quantity of water; (b) To investigate possibilities of structural means for developing water resources and sharing costs and benefits in the allocation process with quality and quantity of water by uses considered.

Work Proposed - Uses of water from particular supply sources, i.e., aquifers or impoundments, with be identified. Productivities of water in various uses will be determined. Competitive and complementary ranges of uses will be identified. Effects on water quality by uses will be investigated with the costs of maintaining quality of water for re-use.

SUPPORTED BY U.S. Dept. of Agriculture
Iowa State Government

6.0230, POST CONSTRUCTION AUDITS OF THE ECONOMIC PERFORMANCE OF PUBLIC WATER RESOURCES INVESTMENT

R.H. HAVEMAN, Grinnell College, Undergraduate School, *Grinnell, Iowa* 50112

Objective: To develop a methodology for checking the actual economic performance of public water investments against that projected when the investment was analyzed by benefit-cost analysis in the original planning. The principal problems dealt with are the uncertainties concerning the original basis of evaluation and the stochastic nature of the events against which many projects are built, especially storage and flood structures.

SUPPORTED BY Resources For The Future Incorporated

6.0231, ECONOMIC ANALYSIS OF ALTERNATIVE WATER POLLUTION CONTROL MEASURES

J.R. BARNARD, Univ. of Iowa, Graduate School, *Iowa City, Iowa* 52240

The purpose of this study is: (1) to develop methodological procedures for translating economic projections of population and industrial output into future water pollution abatement needs, (2) the formulation of an economic model for determining the most eficient means of meeting and maintaing specified stream quality standards, (3) the empirical implementation of cost models to determine the optimum combination of treatment facilities. Phase I of this project will be concerned with items 1 and 2 above and will be completed during the 1967-1963 fiscal year. Phase II, the empirical implementation of the model will be undertaken in fiscal year 1968-1969.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Iowa

6.0232, TRACE ELEMENT CHEMISTRY OF A SMALL POND IN RELATION TO PRODUCTIVITY

K.B. ARMITAGE, Univ. of Kansas, Water Resources Institute, *Lawrence, Kansas* 66045

6. WATER RESOURCES PLANNING

The relation of oxygen conductivity, temperature, alkalinity, nitrogen, phosphate and selected trace elements (Ca, Mg, Sr, Zn, Co, Fe, Mn, Mo, B, HCO3, Na and K) to abundance of chlorophyll A and seasonal cycles of zooplankter polulations will be investigated in a pond in northeastern Kansas. These relations between the physicochemical and biotic parameters will be analysed by the use of multivarate statistics. It is hoped that we can determine how much, if any of a change in population can be attributed to temperature, conductivity, trace elements, etc. Additionally correlations among the chemical factors may be determined to ascertain if any patterns of occurrence and distribution occur among the different elements under study. Each species of zooplankter will be analysed to determine size, age, sex structure, and reproductive capacity of the population. Community structure of the zooplankters will be analysed.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Kansas

6.0233, ECONOMIC AND LEGAL FACTORS IN PROVIDING, USING, AND MANAGING WATER RESOURCES IN AGRICULTURE

E.S. BAGLEY, Kansas State University, Agricultural Experiment Sta., *Manhattan, Kansas* 66504

Objectives of the Regional Project are: 1. To determine the economic considerations that affect use and management of water in agriculture and competing uses. 2. To identify and describe rights in water and the administrative arrangements that regulate water use in the several states. 3. To analyze the economic consequences of different systems of water law with particular emphasis on the laws of the states in the North Central Region but including comparisons with legal systems in use in other regions. 4. To develop principles which will serve as guidelines in efforts to bring about optimum management and use of water resources.

The Kansas phase of the project is concerned with the appropriation doctrine of water rights and currently under way is an investigation of the feasibility of ground water districts under the appropriation doctrine for regions where ground water stock is large but recharge is negligible.

SUPPORTED BY U.S. Dept. of Agriculture
Kansas State Government

6.0234, MODELING AND OPTIMIZATION OF WATER RESOURCES SYSTEMS

E.S. LEE, Kansas State University, School of Engineering, *Manhattan, Kansas* 66504

This proposal is for the mathematical modeling and optimal management of water resources systems. The primary purposes of the investigation are to establish realistic mathematical models for these sytems and to develop best management policies over a period of time for complex water resources systems based on the models.

It is proposed that the dynamic modeling and optimization of the management of large water resources systems be approached; considering all available model building and optimization techniques but with special emphasis on linear filtering and prediction, quasilinearization, invariant imbedding, dynamic programming, maximum principle, and the function gradient techniques.

The following three basic water resources models will be studied: (1) a single reservoir with multiple purposes, (2) multiple reservoirs, each reservoir with a single purpose, and (3) multiple reservoirs with multiple purposes. Results for the modeling and optimization of the first two models and a fairly realistic model for the third model will be obtained.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Kansas State University

6.0235, THE ECONOMICS OF LAND UTILIZATION

R.D. MCKINNEY, Kansas State University, Agricultural Experiment Sta., *Manhattan, Kansas* 66504

To make economic analyses of present and possible land uses and practices from the viewpoints of individual farmers and society. These analyses would include the economic effect of: (1) Conservation and watershed practices and programs; (2) changes in land uses in areas of the state (such as Great Plains); (3) Soil Bank and similar programs on the profitable uses of land; (4) irrigation on costs and returns and land utilization; (5) converting land from intensive to extensive use (cropland to grassland) or vice versa. These studies will be made in terms of cost and returns over time and their effects upon rural institutions and the individual in light of the goals of people.

Description of Work: A study of the economics of soil conservation is being made within the boundaries of three watersheds located in east central and northeast Kansas. Data are being gathered each year on the cultural practices of crops, conservation measures applied and crop yields within these watersheds and analyzed for measurable economic benefits to the resource holder on a farm firm basis. Data are obtained yearly on all the fields in one watershed and on a random sample in two watersheds. The data are obtained from the same sample each year.

A study of sediment and runoff in association with the economic study is being conducted on the Sabetha Lake watershed. Budgeting and linear programming will be used in analysis of data.

SUPPORTED BY Kansas State Government

6.0236, VALUE OF WATER FOR IRRIGATION IN THE KANSAS RIVER VALLEY

W.H. PINE, Kansas State University, Graduate School, *Manhattan, Kansas* 66504

Irrigation is the most highly consumptive use of water in Kansas. Irrigation is increasing rapidly in Kansas where water supply (and precipitation) is limited. This project will estimate the value of water for irrigation along the Kansas River in eastern Kansas with precipitation ranging from 31 to 35 inches and with much of the land suitable for irrigation. Urban and industrial development are growing in the valley providing an expanded need for water. Competition for water is increasing. The estimated value of water for irrigation, costs for land preparation, installation and equipment costs, and operations costs. From this information the net returns from irrigation under different conditions will be estimated and used to determine the value of water for irrigation.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Kansas State University

6.0237, IMPLICATIONS OF IRRIGATION TO THE MARKETING OF SPECIALTY CROPS

O. SORENSON, Kansas State University, Agricultural Experiment Sta., *Manhattan, Kansas* 66504

1. To provide farmers with information on the opportunities which exist in the marketing of specialty crops. 2. To determine the availability of market outlets for expanded specialty crop production and needed changes in market structure to handle increased output of these crops in Southwest Kansas.

DESCRIPTION OF WORK PROPOSED -- The procedure envisaged for this study is as follows: 1. To determine the extent to which specialty crops are now being produced under irrigation in Southwest Kansas and the availability of markets and marketing facilities for present crops. 2. To determine the extent to which the supply of alternative specialty crops is likely to be expanded in the future. This would consist of determining the competitive advantage of specialty crop production within the area specified, and the extent to which market demand will absorb potential increases in supply. 3. To study needed changes in the marketing structure for specialty crops in S.W. Kansas and make recommendations which will improve the efficiency of marketing specialty crops.

SUPPORTED BY U.S. Dept. of Agriculture
Kansas State Government

6.0238, A SYSTEMATIC STUDY OF RESPONSES TO IMPENDING INUNDATIONS AND THE DIRECTIONS OF IMPELLED POPULATION MOVEMENT

R.J. BURDGE, Univ. of Kentucky, Graduate School, *Lexington, Kentucky* 40506

The proposed research investigates the problems of social adjustment of a group of persons faced with forced migration due to impending inundation of their residences and community. Factors inherent with social change are investigated from the standpoint of community and family decision making. Finally, the study will investigate individual attitudes and responses to the forced migration from the standpoint of anticipated adjustment after migration.

To obtain information for the objectives of the study the following procedures will be employed. 1) A series of personal interviews will be administered to persons directly affected by the inundation 2) Participant observer techniques will be used to investigate the processes of community decision making

Data obtained from interviews will be analyzed to obtain information on factors involved in forced migration and recommendations regarding forced migration will be provided.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Kentucky

6.0239, ANTHROPOLOGICAL ANALYSIS OF SOCIAL AND CULTURAL BENEFITS AND COSTS FROM STREAM-CONTROL MEASURES

H.F. DOBYNS, Univ. of Kentucky, Graduate School, *Lexington, Kentucky* 40506

The proposed research would initiate policy science type anthropological baseline studies of three river watershed study units in central Kentucky where stream-control measures are anticipated within a few years.

Field research will focus on river watersheds, highway routes and roadsides, settlements and counties as units for data collection and analysis. A photographic record of man-made structures and their contents, settlement patterns, tools and machinery, vehicles, styles of clothing and occasions for their use, interpersonal interaction patterns, etc., will be emphasized. Data will also be systematically obtained by interviewing residents, by participant-observation of their activities, search for archival and newspaper documentation of social indicators supplemented by special records of local activities compiled by resident research aides.

Preliminary analysis will focus upon institutional differentiation of settlements, but will seek to identify ethnic group, social class, voluntary association and age distributions, and to begin to describe their characteristics, activities, and goal values.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Kentucky

6.0240, TAXONOMY AND PHYSIOLOGY OF PROTOZOA IN CAVE STREAMS AND POOLS

S.M. GITTLESON, Univ. of Kentucky, Graduate School, *Lexington, Kentucky* 40506

The proposed research involves laboratory and field investigations of taxonomy and physiology of protozoa in cave streams and pools. Preliminary studies in Pine Hill Cave Kentucky indicate that: 1) numerous species of protozoa do occur in significant forms in streams and pools that sink into the cave; 3) many of these protozoa have never been described.

This data suggests that knowledge of the role of protozoa in the ecosystem is important for understanding problems concerning the ecological impact of water development, ground water purity and effects of pollution on groundwater.

Investigations primarily at the Mammoth Cave National Park, Kentucky, will include study of samples from cave streams, pools and surface water related to: 1) identification of protozoa; 2) distribution of protozoa; 3) chemical analysis (ions, gases, total inorganic and organic carbon) and physical analysis (temperature, conductivity, viscosity; specific gravity) of the water; and 4) study of how peculiar conditions of caves - low temperature and absence of light effects type, number, survival, growth and motile behavior of protozoa.

SUPPORTED BY University of Kentucky

6.0241, THE ECONOMIC IMPACT OF FLOOD CONTROL RESERVOIRS

L.D. JAMES, Univ. of Kentucky, Water Resources Institute, *Lexington, Kentucky* 40506

The consequences of four flood control projects in Kentucky will be examined in detail on a post audit basis in order to determine whether costs and benefits actually realized correspond to those predicted during project planning. Specific topics to be studied include: 1. Deviations between planning and historical costs, 2. Effect of project construction on local employment, 3. Historical operation and maintenance, 4. Right-of-way costs and cost incidence, 5. Project build-up period, 6. Project effect on local economic activity and local economic structure, 7. Project effect on public facilities and community services, 8. Local public attitude concerning project, 9. Non-flood-control benefits, 10. Project effect on local tax revenues.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Kentucky

6.0242, A PRELIMINARY RECONNAISSANCE OF AREAS TO BE IMPOUNDED IN THE SALT RIVER BASIN OF KENTUCKY

L.A. KRUMHOLZ, Univ. of Louisville, Graduate School, *Louisville, Kentucky* 40208

A preliminary reconnaissance of the three areas to be impounded in the Salt River Basin will be made during the early spring of 1968. The three areas concerned are the proposed sites for Taylorsville Reservoir, Camp Ground Reservoir, and Howardstown Reservoir as outlined by the U. S. Army Corps of Engineers.

Particular emphasis will be placed on the reconnaissance of the Taylorsville site since it is the first to be built. The entire length of the main stem of the Salt River in the area to be impounded will be cruised on foot, and preliminary selection of sites for permanent collecting stations made. The stream beds of the principal tributaries will also be cruised on foot and sites for collecting stations recommended.

The entire main stem of the Salt River above the proposed flood pool will be inspected to determine characteristics of the stream bed as compared with the areas to be impounded. Sites for the other proposed impoundments will be inspected in as much detail as time permits.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Louisville

6.0243, A PRELIMINARY RECONNAISSANCE OF AREAS TO BE IMPOUNDED IN THE SALT RIVER BASIN OF KENTUCKY

L.A. KRUMHOLZ, Univ. of Louisville, Graduate School, *Louisville, Kentucky* 40208

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SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Louisville

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6.0244, A PRELIMINARY ECOLOGICAL STUDY OF AREAS TO BE IMPOUNDED IN THE SALT RIVER BASIN OF KENTUCKY

L.A. KRUMHOLZ, Univ. of Louisville, Water Resources Laboratory, *Louisville, Kentucky* 40208

Three flood control reservoirs are proposed for the Salt River Basin of Kentucky. The first of these, Taylorsville Reservoir, has been authorized, and construction of the dam will begin in 1971. Construction on the second and third will begin at about three-year intervals. These reservoirs will be within an hour and a half driving time from Louisville and its metropolitan population of about a million people.

The overall project will include detailed studies of the impact of the impoundments on the biological, sociological, agricultural, and economic characteristics of the areas under the immediate influence of a large urban population. The biological phases of the study will include limnological and ecological studies of the aquatic environment and the contiguous terrestrial areas. Sampling and collection of data will commence in July 1968 and will continue at biweekly intervals at about 25 stations throughout construction of the dam and clearing of the Taylorsville Reservoir site and for at least five years after impoundment. Changes in water quality will be documented as they occur.

This project covers only the initial year of the biological phase of the study. Other phases of the study will begin no later than 1970.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Louisville

6.0245, MANAGEMENT OF FOREST AND FARM GAME HABITAT - FISH POND MANAGEMENT

B.A. BATEMAN, Louisiana State University, Agricultural Experiment Sta., *Baton Rouge, Louisiana* 70803

Proposed work will center on: 1. Changes in habitat conditions caused by various cultural practices in the forest and on the farm; effects of shifts in crop production; effects of herbicides. 2. The recovery of heavily browsed forest in the Tensac Delta following a deer population reduction. 3. The effects of controlled fire on the food available for quail, turkey and deer. 4. The control of undesirable aquatic weeds in farm ponds.

SUPPORTED BY Louisiana State Government

6.0246, AN ECONOMIC EVALUATION OF THE TOLEDO BEND RESERVOIR PROJECT

W.J. STOBER, Louisiana State University, Graduate School, *Baton Rouge, Louisiana* 70803

The Toledo Bend Reservoir is a project that is unique in that it has been jointly undertaken by the States of Louisiana and Texas without the assistance of Federal funds. The principal purpose of the reservoir is to store water for hydropower generation; and, consequently, construction has been financed by the sale of revenue bonds which are secured by long-term contracts with three electric utility companies. Recreational benefits as well as flood control benefits are also supposed to result from the project.

The proposed study would: (1) examine the political, legal, and financial arragements that were necessary to bring the project to fruition; and (2), investigate the value of the benefits relative to the costs of the project, giving due consideration to the available alternatives. Because of its political and financial arrangements, the project represents an interesting case for study. Benefits and costs that enter into a decision of state governments do not necessarily coincide with the total social benefits and social costs, as state governments may be able to transfer part of the costs to nonresidents. The primary purpose of this study is to measure the total benefits relative to total costs and to examine their distribution between residents and nonresidents.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Louisiana State University

6.0247, THE MANAGEMENT OF SHALLOW-WATER IMPOUNDMENTS FOR WATERFOWL

T. JOANEN, Rockefeller Wildlife Refuge, *Grand Chenier, Louisiana* 70643

In 1954 an intensive waterfowl habitat development program was begun on the 86,000-acre Rockefeller Refuge in Southwestern Louisiana. Since that time 13 impoundments or management units have been constructed with areas totaling 27,000 acres.

In order to devise methods of managing the impoundments for maximum waterfowl food production a study was begun in 1958. The purposes of the study were to determine the factors affecting the establishment of natural stands of vegetation and to develope methods of establishing certain species while controlling others.

The study involved monthly checks of the water level and salinity in the impoundments and control areas and annual sampling of the vegetation in the areas.

No termination date has been set for this study.

SUPPORTED BY Louisiana State Government

6.0248, EXPANDED AQUATIC PLANT CONTROL PROJECT

F.W. ZURBURG, Univ. of Southwestern La., School of Engineering, *Lafayette, Louisiana* 70506

A comprehensive study of a means for destroying alligatorweed through the use of chemicals. Biological study of the vegetation to determine what factors prevent translocation of herbicides. Development of a non-toxic spray which will destroy alligatorweed either by foliage applications or underwater attack on the submerged portions of the weed. Develop means of increasing the translocation of herbicides throughout the entire plant to include the buds located at the nodes of the plant from which secondary growth springs. Evaluation of water conditions as they apply to the plant. Examination of various products with respect to their possible use as a means for destroying the pest growth. Conduct of field tests under actual growing conditions to determine effects of various materials on the vegetation.

To date, the research workers at the University of Southwestern Louisiana have found that there is translocation throughout the plant from the leaf to the root; that the buds located at the nodes of the plant appear to be protected from the chemical which otherwise moves through the plant and are the source of regrowth under certain favorable conditions; discovery that certain materials when added to known herbicides appear to provide a means of penetrating into the buds and lead to their ultimate destruction. This latter development is under intensive study at the present time and will be reported on in the future as data is assembled.

Based on success of early experiments, studies now include use of some food acids as stimulants to action of 2,4-D.

Examination of herbicides for control of submersed vegetation is now in progress with early tests showing good promise on certain aquatic plants.

SUPPORTED BY U.S. Dept. of Defense - Army
University of Southwestern Louisiana

6.0249, OYSTER LEASE CONTROL MONUMENTS - BAY ADAM, BASTIAN BAY AND SANDY POINT BAY AREAS

J.W. LAY, State Wildlife & Fish Comm., *New Orleans, Louisiana*

Objectives: The overall objective is to establish control monuments throughout the oyster growing areas of coastal Louisiana at 1/2 mile spacings on the land from which surveys of waterbottoms for oyster leases could be coordinated as a specific reference point. This work will be performed on a compartmental basis, working in each particular area until the job is completed as permitted by weather and tidal conditions. Each area will be selected on the basis of the greatest need; however, proximity of such areas will be carefully coordinated insofar as possible.

Procedure and Work Schedule - 1. Monuments are to be set in place around the bays at approximately 1/2 mile spacings. 2. A Traverse Line will then be run, beginning from a known location of a U. S. C. G. Triangulation Station and joining all monuments together, and then tied into another U.S.C.G.S. Triangulation Station. 3. All oyster leases will then be tied into the designated base line monument.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.
Louisiana State Government

6.0250, DISPOSAL OF PAPER MILL EFFLUENT THROUGH IRRIGATION OF BOTTOMLAND HARDWOOD UNDER LOUISIANA CONDITIONS

C.W. WILSON, **Louisiana Polytechnic Inst. , School of Agriculture, *Ruston, Louisiana* 71270**

The objective of the proposed research is to determine the economic and technical feasibility of disposing of paper mill waste water through irrigation of hardwood forests under Louisiana conditions.

A system for delivery of the waste water to the forest area to be irrigated will be designed. The probable increase in timber yield from irrigation will be determined. The waste water, stream conditions, and forest conditions will be studied. From this information, economic and technical feasibility will be determined. The effect of diverting paper mill waste water on water quality of Dugdemona River will be predicted.

The results of this study should be applicable to other waste water supplies in Louisiana.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Louisiana Polytechnic Institute

6.0251, BIOLOGIC AND ENVIRONMENTAL CONTROL OF EURASIAN MILFOIL (MYRIOPHYLLUM SPICATUM L.) IN CHESAPEAKE BAY

J.H. MANNING, **State Dept. of Ches. Bay Afrs. , *Annapolis, Maryland***

Objectives: (1) To determine the abundance and distribution of Eurasian milfoil and other rooted aquatic plants in Middle River, Back River, Rhode River and adjacent creeks in Chesapeake Bay; (2) To analyse environmental conditions in these rivers, and to study factors now excluding milfoil from Back River; (3) To begin the study of milfoil disease and pathology.

Procedures: Distribution and abundance surveys will be done at regular intervals throughout the year; environmental analyses will involve routine measurements of temperature, salinity, pH, light penetration, plankton conditions, nutrient supplies, and trace elements, and other relevant parameters; studies of milfoil pathology will involve histology, pathogen culture, and laboratory transmission studies.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.
Maryland State Government

6.0252, DEVELOPMENT OF COMPUTER MODELS & METHODOLOGY FOR FORECASTING & EVALUATING MUNICIPAL & INDUSTRIAL WATER REQUIREMENTS

W.S. CLARK, **Hittman Associates Inc. , *Baltimore, Maryland***

The proposed research will develop a digital computer program that will calculate present and projected water requirements for residential, commercial, and industrial areas. This will be accomplished largely by utilizing existing water usage data and a mathematical model of a generalized water system and its water resources requirements. Certification of the program will be achieved by testing it against known urban water usage histories in several geographic areas. The projected water requirements of the new 'planned city' of Columbia, Maryland, will also be established and checked. A 'Library of Water Requirements Parameters' will be prepared on magnetic tape suitable for use with the computer program. Other uses for similar tools will be defined.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0253, DEVELOPMENT OF A REFINED PREDICTIVE SYSTEM FOR USE IN FORECASTING MUNICIPAL WATER NEEDS

N. GREENBERG, **Hittman Associates Inc. , *Baltimore, Maryland***

The proposed research will result in a digital computer program that will calculate present and projected water requirements for urban areas containing residential, commercial, and industrial water users. This will be accomplished by adding empirically determined growth variables to a computerized model now being developed for computing current values of municipal water consumption. Certification of the complete system will be achieved by testing it against the growth of water requirements in the new planned city of Columbia, Maryland in future years. Other uses for similar tools will be defined.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Columbia City Government - Maryland

6.0254, A RECONNAISSANCE STUDY OF THE CHEAPEAKE BAY

P.R. FARRAGUT, **Regional Planning Council, *Baltimore, Maryland* 21202**

The report discusses present and future problems confronting the region's shoreline. It synthesizes many of the narrowly focused technical studies completed in the past and presents them in a form which should be of interest to decision makers.

The study recognizes the many important relationships that exist along the bay shoreline at the interface of the land and water resource. The focus in this report is the water resource while a future publication will examine the land resource.

The report discusses physical problems associated with the regional shoreline such as erosion, sedimentation, tidal flooding and water characteristics such as excessive nutrients, polluted shellfish areas, thermal pollution, plant and animal nuisances, the importance of wetlands, and the Susquehanna River.

A separate chapter on water quality contrasts present conditions with the standards called for by the State's Water Quality Standards.

Finally, a functional listing of agency responsibilities and studies that may be of interest is listed under the various problem areas discussed in the text as well as certain economic indicators of the bay fishery, hunting activities, and the sport fishery.

SUPPORTED BY U.S. Dept. of Housing & Urban
Development

6.0255, RELATIONSHIP OF WATER AND LAND MANAGEMENT TO MOSQUITO BREEDING IN WATER IMPOUNDMENTS AND IRRIGATED FARM AREAS

C.H. SCHMIDT, **U.S. Dept. of Agriculture, *Beltsville, Maryland***

Object: To study the bionomics and control of mosquitoes in relation to land and water management practices, with special reference to irrigated areas in the western States.

Plan of work: Biological, ecological, and control studies will be made of different species of mosquitoes found associated with mosquito breeding in irrigated lands, impoundments, mountain pools or swamps in order to relate mosquito production to specific soil and water management, and to develop ways to manipulate conditions or practices to inhibit mosquito production. Where this is not practical of feasible, insecticides, biological agents, etc. will be explored. Information will be developed on the taxonomy, distribution, seasonal succession, flight range, overwintering sites, egg laying sites, and autogeny of different species in relation to moisture, temperature, etc. This information will be used as a guide in developing soil and water management procedures that will create unfavorable breeding environments. Attention will be given to finding, evaluating and rearing parasites and pathogenic organisms that might be used in control. New insecticides will be evaluated as larvicides or adulticides, with particular attention to situations where resistance has rendered currently available insecticides ineffective.

6. WATER RESOURCES PLANNING

SUPPORTED BY U.S. Dept. of Agriculture

6.0256, ENHANCEMENT OF RECREATIONAL USES OF ESTUARINE WATERS THROUGH STUDY OF POTENTIAL CONTROL METHODS FOR STINGING SEA NETTLES

D.G. CARGO, Univ. of Maryland, Natural Resources Institute, *College Park, Maryland*

Sea nettles, with trailing tentacles heavily armed with stinging cells, seriously interfere with swimming, diving and boating in the Chesapeake Bay and other esturaries. In years of abundance, they are seriously detrimental to the economy of the resort areas and to the recreational activities of the public.

Research will be undertaken by the Chesapeake Biological Laboratory to complete the imperfect knowledge of the principal species, evaluate the role of these organisms in the ecology of the estuaries, examine the relationships which appear to exist between water quality and nettle abundance, and develop and test potential chemical and biological methods for reducing their abundance and the damage they inflict on individuals and the economy of affected areas.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Maryland

6.0257, DESIGN CRITERIA FOR LIVESTOCK FARMSTEAD WATER SYSTEMS

E.E. JONES, Univ. of Maryland, Agricultural Experiment Sta. , *College Park, Maryland*

Object: To determine engineering design criteria for livestock farmstead water systems.

Plan of Work: Determination will be made of the amounts and rates at which water is required at various points on the farmstead by each type of livestock enterprise, production processing area, and also to some extent in the farm home. The amount and rate of water use will be measured automatically by electronic equipment using remote recording meters installed in the water lines as sensing devices. Usage data for all branches of the water system will be simultaneously recorded on tape. Data on the hydraulic characteristics of existing farmstead water distribution systems will be analyzed to determine the effect of corrosion, scaling and other water quality factors on the pressures and flow rates in the distribution system, as well as on the service life and materials of the system. Where need is indicated, design criteria will be developed to allow for or correct these effects. Water demand patterns and rates will be analyzed for their effect on labor efficiency and design criteria studied to maximize this factor. Intermediate storage will be studied as a means of enabling low yielding sources to satisfactorily meet high peak requirements. Design criteria established in this study will be made available to manufacturers of water systems equipment.

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SUPPORTED BY U.S. Dept. of Agriculture

6.0258, THE EFFECTS OF THERMAL LOADING AND WATER QUALITY ON ESTUARINE PRIMARY PRODUCTION

J.A. MIHURSKY, Univ. of Maryland, Natural Resources Institute, *College Park, Maryland*

The proposed research plan involves field and laboratory investigations directed towards determining the effects on estuarine primary production and standing crops by a) steam electric station operation, and b) nutrient additions. In addition, field studies will also examine the ecological role of fresh tidal marshes with regard to the utilization of nutrients from domestic sources.

Field investigations will include routine determinations of: (1) primary production by carbon-14 uptake (2) chlorophyll a (3) temperature (4) conductivity (5) salinity (6) methyl orange alkalinity (7) pH (8) inorganic PO4 (9) total PO4 (10) NH3 (11) NO2 (12) NO3 (13) dissolved organic nitrogen (14) particulate nitrogen (15) particulate carbon (16) dissolved carbon (17) particulate carbohydrate. The above determinations will be made on a tidal system ranging from fresh water to about 15 parts per thousand salinity.

Laboratory investigations will examine (1) the effects of temperature temperature changes on natural estuarine and uni-algal populations held in specially designed incubation chambers and thermal gradient blocks and (2) the effects of nutrients viz. NO3, PO4 etc. on primary activity of natural estuarine and uni-algal populations. Measurements of photosynthetic activity under laboratory conditions will be made by the carbon-14 technique, chlorophyll a content and density estimates by packed cell volume.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Maryland

6.0259, DEMAND FOR AND AVAILABILITY OF LAND AND WATER ORIENTED RECREATION FACILITIES IN MARYLAND - ECONOMIC ANALYSIS

D.F. TUTHILL, Univ. of Maryland, Agricultural Experiment Sta. , *College Park, Maryland*

1. To assess the existing facilities in Maryland for land and water recreation purposes. 2. To evaluate the present and future need for recreation facilities in Maryland, based on land and water resources, and analyze the economic potential for the state. 3. To collect cost data for construction and operation of recreation enterprises, particularly those suitable for the farmer or small businessman.

For Objective 1 - Available material on recreation facilities and use will be used and supplemented as necessary to provide the resource base information for recreation development. For Objective 2 - National information on population and income trends, expected increase in leisure time, and changing preference for recreation activities will be interpreted for Maryland conditions to help predict future need for and use of recreation facilities in Maryland. For Objective 3 - Costs and returns for recreation enterprises will be determined from existing data, or collected in field surveys of operating units. These costs and returns will help in decision-making of farms and business units, or for programming procedures in selecting optimum enterprise combinations.

SUPPORTED BY Maryland State Government

6.0260, AN INVESTIGATION OF FACTORS AFFECTING THE INTENSITY OF USE OF WATER RECREATION FACILITIES

D.J. VOLK, Univ. of Maryland, Graduate School, *College Park, Maryland*

The construction of new recreation facilities during the coming decades will require that careful attention be paid to their location if they are to be of maximum usefulness. Surprisingly little is known, however, about locational preferences of recreationists as reflected in their willingness to travel the distances necessary to make use of various types of recreation areas. This study is proposed to try to determine how far people are willing to travel to various types of recreation facilities, and to assess the importance of factors other than distance.

Data will be gathered on the place of residence of vistors to various recreation areas. Analysis of the data by multiple regression techniques will be undertaken to determine the effect not only of distance, but also of other social and economic factors such as income, urbanization, mobility, and the availability of competing facilities at comparable distances.

The study should be of value not only in estimating the potential demand for various proposed recreation areas, but also as a necessary preliminary step in some techniques for estimating recreation benefits.

The study is essentially complete and report is to be published in fall 1967.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Maryland

6.0261, THE POTOMAC RIVER BASIN DEMONSTRATION PROJECT IN GEORGES CREEK

R.W. WIRGAU, Frostburg State College, Graduate School, *Frostburg, Maryland* 21533 (67-014-005)

Objective NO. demonstrate how people in the Potomac Basin can be effectively involved in solving the problems and achieving multirfaceted and interrelated objectives of the Potomac River Basin.

Objective No. or state plans for the Potomac to be ultimately effective must be based on a more precise and thorough knowledge of the critical resources at the local level, i.e., Georges Creek.

Objective No. authorities and local citizenry alternative solutions and proposals.

Objective No. how major problems and opportunities confronting George Creek can begin to be solved by action or implementing programs.

Objective No. to identify the sources of technical and finacial assistance for the conduct of this demonstration project.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Frostburg State Teachers College

6.0262, RELATIONSHIP BETWEEN MOURNING DOVE PRODUCTION AND WATER DISTRIBUTION IN THE SONORAN DESERT

L.H. BLANKENSHIP, U.S. Dept. of Interior, Mig. Bird Population Station, *Laurel, Maryland* 20810

Objectives: 1. To determine the possible effect of changes in water availability to dove production in the Sonoran Desert. 2. To determine if the present distribution of water impoundments is sufficient to provide for mourning dove water requirements during the entire breeding season. 3. To determine the relative success of doves nesting near temporary and permanent water impoundments. 4. To determine if doves nesting near temporary impoundments (that dry up during the summer) will either cease to nest or move to more favorable water areas. 5. To determine how far doves may move to renest if local impoundments go dry.

Procedures: 1. Locate four permanent and four temporary impoundments in southern Arizona and establish these areas as study plots. 2. Visit each study plot at regular intervals to locate and maintain records on all nests. 3. Establish census routes at each study plot and also on an area devoid of water to help determine local nesting densities. 4. Mark nesting doves around temporary impoundments to determine movement and distances moved when impoundments go dry. 5. Count numbers of doves visiting each impoundment during specific daily time periods at regular intervals throughout the nesting season. 6. Keep records on general condition of impoundments, such as depth of water, livestock use, etc.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0263, DISTRIBUTION, LIFE HISTORY, AND ECOLOGY OF EURASIAN WATERMILFOIL

J.H. STEENIS, U.S. Dept. of Interior, Patuxent Wlife. Res. Ctr., *Laurel, Maryland*

Eurasian watermilfoil, an introduced submerged aquatic plant, is being found to be spreading rapidly throughout North America.

Studies on distribution, life history, and ecology of Eurasian watermilfoil are being intensified on the Chesapeake Bay area.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0264, SHELLFISH MORTALITY - CHESAPEAKE BAY

C.A. FARLEY, U.S. Dept. of Interior, Biological Laboratory, *Oxford, Maryland*

An investigation into the possible causes of shellfish (oyster) mortality in Chesapeake Bay has been initiated.

Intensive sampling of several areas in the Maryland portion of Chesapeake Bay indicated that relatively high mortality levels and MSX (multinucleate sphere of unknown taxonomic position) incidence occurred with regularity in the higher saline waters of Chesapeake Bay near the Virginia-Maryland boundary. Consequently, biweekly monitoring of this area for oyster mortality levels and disease incidence in sampled oysters, as well as to record ecological conditions was begun in April 1961, and continues to present.

Laboratory projects include histological comparisons between the normal and pathological conditions of sampled oysters; isolation and culture of protistan parasites, transmission experiments, identification and life cycle studies of heretofore unrecognized or unidentified pathogens, and histochemical studies aimed toward the elucidation of the biochemical changes that occur in both the parasite and host tissues during infection, and to discover possible rapid and differential diagnostic techniques for parasites in shellfish tissue.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0265, COMPARATIVE BIOCHEMICAL AND MORPHOLOGICAL CHARACTERISTICS OF MARINE FUNGI FROM SHELLFISH

S. GOLDSTEIN, U.S. Dept. of Interior, Biological Laboratory, *Oxford, Maryland*

Appropriate histological, histochemical, and cultural methods are used to determine the presence of fungal parasites in shellfish. With the use of conventional and laboratory prepared and modified media, isolations and clones are made of the fungi present in tissues. Physical and physiological parameters necessary for the growth and reproduction of the organisms isolated are established. Morphological properties and nutritional requirements of the isolates grown in vitro are described. Appropriate chemical and biochemical analyses are carried out on the isolates and supporting media so as to permit adequate characterization, possible identification, and to establish the taxonomic position of the isolates. The work is being undertaken at Brooklyn College.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0266, PACIFIC OYSTER MORTALITY STUDIES

A. ROSENFIELD, U.S. Dept. of Interior, Biological Laboratory, *Oxford, Maryland*

Efforts are being made to identify or discover those factors, particularly disease agents, responsible for shellfish mortalities on the west coast of the United States and Canada. Epizootiologic and pathologic studies are being conducted to determine timing, patterns, and possible causes of mortalities, and to determine pathogenicity of disease agents. Shellfish from exotic and domestic 'seed' supply areas are screened for micropathogens or disease organisms before introduction or importation of these shellfish into west coast growing areas.

Shellfish from several Far East potential 'seed' sources have been and are being examined microscopically for the presence of microparasites, micropathogens, and disease conditions. Many previously unobserved or unreported microparasites and disease conditions have been seen in these specimens. Reports and appropriate recommendations are sent to pertinent Pacific Coast state agencies, and when deemed necessary, recommendations for quarantines or embargoes on shipments are given.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0267, CULTURE OF SHELLFISH IN ARTIFICIAL AND NATURAL SALT PONDS

W.N. SHAW, U.S. Dept. of Interior, Biological Laboratory, *Oxford, Maryland*

Early in 1964, four one-quarter acre artificial ponds were completed near the laboratory at Oxford, Maryland. Studies are being conducted on the growth and survival of oysters in these ponds. Studies are being conducted in one of the ponds for catching oyster set and fattening oysters. Atempts to fertilize the ponds to increase productivity are underway.

Studies are planned on the growth and survival of oysters suspended from a rigid structure in the Tred Avon River adjacent to the laboratory. Preliminary studies indicate that the river is favorable for good oyster growth. Strings of oysters will be suspended and their growth and survival studied.

6. WATER RESOURCES PLANNING

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0268, ECOLOGY AND DISTRIBUTION OF OYSTERS AND CLAMS

W.N. SHAW, U.S. Dept. of Interior, Biological Laboratory, *Oxford, Maryland*

The natural populations of commercial shellfish in local areas have been delimited. Zooplankton and phytoplankton levels in shellfish producing areas are being determined and the organisms involved are being identified. The effects of physical and chemical factors on plankton, and on larval, juvenile, and adult stages of commercial shellfish are being determined. Qualitative and quantitative observations are being made on the invertebrate animals in local areas, and numbers and living habits related to effects on commercial species. Food webs, within the small estuarine tributaries of Chesapeake Bay, are being established. Ecological studies in large man-made salt water ponds have been undertaken, and all information, from natural and artificial situations, will be related to maintenance of shellfish in these ponds.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0269, GROWTH, CONDITION, AND SURVIVAL OF SHELLFISH

W.N. SHAW, U.S. Dept. of Interior, Biological Laboratory, *Oxford, Maryland*

In recent years the oyster industry in Chincoteague Bay has been importing oysters from other regions into the bay to hold for future marketing. At present, studies are being conducted to see if these oysters adapt to this new environment. Oysters from low salinity waters are suspended in trays in Chincoteague Bay. Their growth, condition, and survival are monitored.

Monthly, a comparative analysis is made on the conditions, percentage of solids, of oysters on two natural bars--one in broad Creek and one in the Tred Avon River. At each locality the effects of crowding and fouling are being studied.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0270, SURFACE TEMPERATURE STUDIES USING RADIOMETRY TECHNIQUES

C.C. BATES, U.S. Navy, Oceanographic Institute, *Suitland, Maryland*

Objective: To investigate large and small scale temperature variations in the apparent surface temperature of the world ocean using passive radiometric sensing techniques covering the IR and microwave bands. To analyze and correlate radiometric data from aircraft, spacecraft, and ground observations, for delineating major water masses, currents, river discharge patterns, ice distribution and movement, and rate of heat flow from ocean surface for air/sea interaction studies.

Approach: Use known relationships to design radiometer experiments over the water surface. Conduct aircraft flights with NASA, MW and IR sensors and correlate records with ground data. Conduct data analyses to identify and discriminate oceanographic phenomena which contribute to sea surface temperature.

SUPPORTED BY U.S. Natl. Aero. & Space Adm.

6.0271, TEST SITE INSTRUMENTATION

UNKNOWN, U.S. Navy, Oceanographic Institute, *Suitland, Maryland*

OBJECTIVE: To utilize results of IITRI test site study by initiating a surface observational system at key test sites. To acquire the appropriate instrumentation for the near surface observations at oceanographic calibration test sites;

Approach: To compile a work statement for soliciting assistance of industry via request for proposals.

Status: Work statement partially prepared.

SUPPORTED BY U.S. Natl. Aero. & Space Adm.

6.0272, APPLICATIONS STUDIES RELATED TO SEA SURFACE TEMPERATURE

UNKNOWN, U.S. Navy, Oceanographic Institute, *Suitland, Maryland*

Objective: To evaluate Nimbus IR data for ocean sea surface temperature distributions. To develop techniques to utilize satellite data for observing and predicting sea surface thermal gradients, cloud cover and ocean surface relationships, and the physical principles involved. To write a computer controlled program for full automatic utilization of integrated IR equipment in Apollo and future Earth Resources Spacecraft.

Approach: Utilize Nimbus, Tiros, NASA aircraft, and surface ship data for detailed thermal correlations. Perform calibration analysis between satellite data, ship data, and meteorological soundings to relate cloud data to ocean surface parameters.

SUPPORTED BY U.S. Natl. Aero. & Space Adm.

6.0273, OCEANOGRAPHIC USES OF RADAR

UNKNOWN, U.S. Navy, Oceanographic Institute, *Suitland, Maryland*

Objectives: To investigate the accuracy attainable for measuring displacements of sea surface by radar altimetry and scatterometry for oceanographic applications (currents, storm surges, slide levels, and wave heights. To develop computer programs and procedures for improving wind field and wave forecasts from spaceborne radar data.

Approach: Analyze all radar data forwarded from the NASA and Navy remote sensing aircraft. Conduct theoretical studies based on nationwide capabilities in altimetry and scatterometry. Develop computer programs for spaceborne radar data input to already developed wave prediction programs.

SUPPORTED BY U.S. Natl. Aero. & Space Adm.

6.0274, RADAR DATA ACQUISITION OVER OCEANOGRAPHIC TEST SITES

UNKNOWN, U.S. Navy, Oceanographic Institute, *Suitland, Maryland*

Objective: To obtain, process and analyze radar backscatter data over a variety of sea states and multifrequency, multipolarization radar imagery over the North Atlantic iceberg regions and over the Arctic test site at Pt, Barrow, Alaska with controlled surface data conditions. To obtain ocean sea state information from photographic records of the sea surface and develop statistical techniques to describe the sea surface in terms of its optical luminance.

Approach: To utilize the experience and expertise of the Wave Preparation Branch, Electronics Division, Naval Research Laboratory to determine the optimum frequencies, optimum polarizations, data processing, techniques, power and antenna requirements and optimum orbit characteristics for most effective identification and discrimination of oceanographic phenomena. To utilize the variation of sea luminance cause by sea state (waves and white caps) to obtain and establish the functional description of various surface conditions and the corresponding luminance modulators.

SUPPORTED BY U.S. Natl. Aero. & Space Adm.

6.0275, OIL SLICK ANALYSES

UNKNOWN, U.S. Navy, Oceanographic Institute, *Suitland, Maryland*

Objectives: To obtain reflectivity signatures by spectroscopy for various fish oils and vapors in laboratory, to extend spectroscopy technique to airborne instrumentation and investigate feasibility of oil slick and vapor detection from spacecraft.

Approach: Identify various fish and mineral oils and vapors with lab spectro-correlator, extend techniques to airborne sensor and finally to spaceborne sensors.

SUPPORTED BY U.S. Natl. Aero. & Space Adm.

6.0276, DEPTH CONTOURING BY COLOR SEPARATION

UNKNOWN, U.S. Navy, Oceanographic Institute, *Suitland, Maryland*

Objective: To develop photographic masking techniques to provide photographic film density contours.

Approach: Utilize available spacecraft photographs taken over ocean areas of known depths, adapt the 'unsharp: photographic masking techniques to separate, and display areas of constant color tone (or photographic density). Evaluate the techniques and develop operations techniques to develop a rapid system to display water depth contours when they can be realted to water 'colors'.

SUPPORTED BY U.S. Natl. Aero. & Space Adm.

6.0277, SATELLITE SEA ICE STUDIES

UNKNOWN, U.S. Navy, Oceanographic Institute, *Suitland, Maryland*

Objective: The determination of rates of change of ice cover/water ratio, the relative distribution and rate of movement of ice for data usable by meteorological, shipping, and fishing organizations.

Approach: Utilization of presently available ESSA and Nimbus arctic imagery showing ice pack units, pack fringe widths, ice cover, areas of melt, ice pack movement, turbulent eddy cells, meandering, size, curl, and net ice transport, etc.

SUPPORTED BY U.S. Natl. Aero. & Space Adm.

6.0278, DOUBTFUL HYDROGRAPHIC DATA

UNKNOWN, U.S. Navy, Oceanographic Institute, *Suitland, Maryland*

Objectives: (1) Identify features and conditions detectable from aircraft and spacecraft.)2) Determine electromagnetic frequency of sensor(s) which will provide results desired. (3) Substantiate theroetical approach with some field data. (4) Provide sufficient aircraft ground truth data to qualify techniques arrived at in first phase.

Approach: Develop theoretical approach to factors required to detect hydrographic features from spacecraft and test theory with surface and aircraft data.

SUPPORTED BY U.S. Natl. Aero. & Space Adm.

6.0279, ANALYSIS OF MANAGERIAL, FINANCIAL, AND REGULATORY FUNCTIONS OF REGIONAL WATER RESOURCES AUTHORITIES AND OTHER INSTITUTIONAL ARRANGEMENTS

H.D. MESSER, Booz Allen Applied Res. Inc. , *Washington - Bethesda, Maryland*

The purpose of this study is to analyze the managerial, financial, and regulatory functions of regional water resources authorities and other institutional arrangements and to analyze the impact of water rights doctrines on the practice of water management. The results of this analysis will provide a basis for the establishment of mechanisms for water resources management. Research results will be useful in improving management effectiveness through lessening of conflicts, uncertainties, and confusion among claimants to the resource. The major steps in this program will be: 1. Identification, collection, and organization of an appropriate information base 2. Analysis of functions of water resources authorities 3. Development of functional standards for regional water resources authorities 4. Analysis of functions of existing water resources authorities using standards developed 5. Development of alternative functional patterns of regional water resources authorities.

The study will be carried out by requesting information from water resources authorities by letters of inquiry, indexing this information, and using the resultant classification to accomplish the stated objectives.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0280, A METHODOLOGY FOR PLANNING OPTIMAL REGIONAL WASTE MANAGEMENT SYSTEMS

D.D. ADRIAN, Univ. of Massachusetts, School of Engineering, *Amherst, Massachusetts* 01003

A regional system of waste management encompasses several communities lying on the watershed of a stream which is used for effluent disposal. These communities may at present have various types of treatment plants. Regional planning is an attempt to maintain or to upgrade stream quality by expanding or adding new facilities while considering the region as whole rather than on a piecemeal, community by community basis. The expected outcome of this type of planning is the pooling or sharing of some facilities thereby significantly lowering the cost of meeting stream standards.

The overall objective of this research is to develop a practicable methodology for regional waste water management planning employing economic optimization techniques. It is proposed that this be done as follows:

A. Form a research team drawing personnel from several disciplines. B. Develop for each sub-system of the regional plan quantitative expressions defining and describing: 1. Physical relationships among variables. 2. Significant constraints on the subsystems. 3. Cost functions. C. Construct over-all mathematical model integrating the above relationships. D. Adapt and develop techniques for model analysis and optimization. Code these techniques for a computer. E. Devise methods for testing the model in the absence of existing regional waste management plans and test the model in accordance with these methods.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Massachusetts

6.0281, PROGRAMMED SELECTION OF OPTIMUM USES OF A SMALL WATER RESOURCE SUBJECTED TO COMPLEX SIMULTANEOUS DEMAND STRESSES

C.A. CARLOZZI, Univ. of Massachusetts, School of Agriculture, *Amherst, Massachusetts* 01003

The objectives of the total study are as follows: l. To develop methods for relating the demand-supply information to determine present or anticipated stress on the water resource; 2. To simulate alternative use schedules and management inputs and test for optimum economic choices under various theoretical management and use schemes; 3. To develop methods for the graphic interpretation on watershed maps of probable sequential changes in the supply-demand relationships among the major water users by public and private economic sectors, geographic location, demographic features, and management inputs to 1977; 4. To develop methods for expressing the graphic information derived as a series of alternatives for choice in integrated watershed planning; 5. To develop a computer graphics program that has applicability to integrated watershed planning generally and that can present complex multivariate economic and statistical data in form easily assimilable and meaningful to planners and decision makers in public and private roles.

The purpose of the project is to develop an improved method for attaining optimum use of a small water resource by analyzing and synthesizing diverse data on water demand and related supply through the tools of computer graphics and multivariate systems simulation. This integrated project will draw information on water use and management from several disciplines: forestry, fisheries, wildlife ecology, resource planning, economics, engineering, business management and recreation.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Massachusetts

6.0282, ENHANCEMENT OF ECOLOGIC AND AESTHETIC VALUES OF WETLANDS ASSOCIATED WITH INTERSTATE HIGHWAYS

C.A. CARLOZZI, Univ. of Massachusetts, School of Agriculture, *Amherst, Massachusetts* 01003

The objectives of the study are as follows: (1) To develop design and management criteria for protecting coastal wetlands and developing small water impoundments in conjunction with Federal Interstate Highway Construction in relation to wildlife and fish habitat improvement in Massachusetts and Southern New England. (2) To develop visual-aesthetic design and management criteria for such impoundments and wetlands in relation to highway beautification. (3) To examine existing statutory, institutional and administrative provisions and their application and improvement in order to create a procedure for implementing the design and management proposals in the interstate Highway program.

The purpose of this study is to examine the ecological and aesthetic characteristics of water resources formed or altered during the construction of major highways in order to derive approaches for purposefully using such water bodies to enhance wildlife and fisheries potentials and landscape beautification.

This will require research in two distinct but intimately related parts. Part one will involve the nature of the biological and physical changes consequent and subsequent to highway construction. Part two will examine the legal, institutional bases relating to the implementation of highway construction plans and the administration of resources resulting for multiple purpose higway development.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Massachusetts

6.0283, A COMPENDIUM OF WATER LAW AND ECONOMICS IN NEW HAMPSHIRE

R.H. FORSTE, Univ. of Massachusetts, School of Agriculture, *Amherst, Massachusetts* 01003

The considerable body of statutory and common law relating to water rights in New Hampshire exists in a diffused form throughout state statutes and in court decisions over a period of more than 150 years. Some of these statutes and decisions have relevance to water law and use today; other statutes and laws that have been in effect for over a century may impose adverse effects on the economic efficiency of water use and the distribution of income associated with particular water users. The objectives of this study, therefore, are: (1) to describe relevant existing statutory and common law as it relates to water resources in New Hampshire; and (2) to assess the economic effects of these laws on water users and use patterns in qualitative terms, in areas of water quality, diversion, accessibility, multiple -use, and so forth.

Legal research is being performed mainly at the law offices of Alexander J. Kalinski, 51 High Street, Manchester, New Hampshire.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of New Hampshire

6.0284, INSTITUTIONAL PATTERNS FOR EVOLVING REGIONAL PROGRAMS FOR WATER RESOURCE MANAGEMENT

I. HOWARDS, Univ. of Massachusetts, Bureau of Government Research, *Amherst, Massachusetts* 01003

Greater research emphasis on the institutional aspects of water resources planning and development is considered necessary if we are to maximize on the potential contribution of the various public and private interests involved, and at the same time minimize the conflicts among them. Such conflicts, arising frequently after detailed planning has taken place and alternative solutions proposed, constitute a real and recognized barrier to more rational and efficient planning and administration. This research project proposed is designed to overcome such barriers.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Massachusetts

6.0285, THE USE OF AERIAL PHOTOGRAPHS TO EVALUATE THE RECREATIONAL RESOURCES OF A RIVER

W.P. MACCONNELL, Univ. of Massachusetts, Agricultural Experiment Sta., *Amherst, Massachusetts* 01003

Objectives: (a) To develop and test the use of aerial photogrammetric techniwues as a tool for identifying and classifying river-based recreation sites, (b) to examine and map a large river by these methods and make recommendations for its recreational use, and (c) to determine the land use changes which have taken place along a portion of the river since it was last photographed in 1952.

The river to be studied is the Connecticut River. Refinement of analytical techniques will be based on a study of the River in Massachusetts; later the entire river will be studied from its source in northern N. H. to its mouth in Connecticut. The entire length of the river will be photographed in a swath at least 500 inches wide on either side. These photographs will be examined photogrammetrically with frequent ground checks to determine what can be detected with respect to (a) the land bordering the river -- accessibility, locations for parking, camping, and picnic areas, scenic overlooks and other picturesque sites, soil drainage, and characteristics of vegetation, (b) the shoreline-- beach sites, dock sites, shoreline fishing and hiking, and (c) the river itself -- water depth, flood level, currents, nature of the bottom, physical obstacles, navigational landmarks, aquatic vegetation.

A classification system for recreational use of a river will be developed and the entire river will be analyzed, mapped, and classified.

SUPPORTED BY U.S. Dept. of Agriculture
Massachusetts State Government

6.0286, THE ECONOMICS OF WATER SUPPLY AND QUALITY

R. DORFMAN, Harvard University, Graduate School, *Cambridge, Massachusetts* 02138

The objective of this research is to develop improved methods of planning water resource developments in situations where municipal and industrial water supply and pollution problems are significant.

This work is comprised of three essential parts. First is the study of the economics of water pollution abatement at the waste source and the construction of functions which reflect the losses and benefits associated with alternative abatement measures such as low flow augmentation, long-distance waste transport and instream treatment. Second is the study of the economics of municipal and industrial water supply and the development of improved benefit and loss functions for water system performance. Finally these economic functions will be incorporated into simulation models of the Delaware River basin and estuary with the objective of developing improved methods for planning water supply and pollution abatement policy.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

6.0287, OPTIMUM LINEAR SYNTHESIS IN URBAN HYDROLOGY

P.S. EAGLESON, Mass. Inst. of Technology, School of Engineering, *Cambridge, Massachusetts* 02139

The goal of this research is to develop and evaluate a new method for the prediction of the entire hydrograph of surface runoff given the time-distribution of rainfall excess. The method is to have an accuracy and to involve a computational effort which are compatible with its incorporation into algorithms for the optimal design of urban drainage systems.

Development of the method will involve systematic investigation of the errors introduced into analytical models of surface runoff systems by linearization and by lumping of systems which are inherently distributed and non-linear. These aspects of the research results will be of equal value in the development of improved analytical models for forecasting the surface runoff component of streamflow in rural areas also.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0288, SYSTEMS METHODOLOGY FOR WATER-RESOURCE PLANNING IN A REGIONAL DEVELOPMENT CONTEXT

R.T. MCLAUGHLIN, Mass. Inst. of Technology, School of Engineering, *Cambridge, Massachusetts* 02139

Research on the use of mathematical models and systems analysis in planning for comprehensive development of water resources in river basins or other hydrologic units. The relationship of such developments to the social and economic activity of the region in which the unit is located is also being considered. Simplified mathematical models are being investigated for possible use in obtaining approximate answers in the early stages of a planning study. The results of the simplified models are being checked against results of simulation.

SUPPORTED BY Massachusetts Institute of Technology

6.0289, BIOLOGY AND CHEMISTRY OF MARINE PLANKTON POPULATIONS

B.H. KETCHUM, Woods Hole Oceanographic Inst., *Woods Hole, Massachusetts* 02543

The short term changes which proceed during the growth of plankton populations are to be studied in the Gulf of Maine. A parachute drogue attached to a radio buoy is used to identify a particular patch of water and observations are made close to the buoy. The objectives of this program are to evaluate quantitatively the turnover rates of the nutrients and to study rates of decomposition in situ. It has been postulated that in situ recycling of elements maintains the level of productivity in parts of the world throughout much of the year, but no useful estimates of recycling rates have been available. Additional studies include the changes in the vertical distribution of chlorophyll and the rate of sinking of particles, the changes in the ratio of elements in particles as they sink and decompose in the water column, and diurnal variations in the rate of photosynthesis as a function of the chlorophyll content of the water. Studies of the vertical distribtuion of the zooplankton are included since a substantial part of the regeneration of elements may result from the phytoplankton respiration and zooplankton consumption and digestion of particulate matter in the sea.

SUPPORTED BY U.S. Atomic Energy Commission

6.0290, PHYSIOLOGY AND BEHAVIOR

T.A. EDSALL, U.S. Dept. of Interior, Biological Laboratory, *Ann Arbor, Michigan*

Laboratory and field studies are underway to determine the potential productivity of Lake Michigan for intermediate and top carnivores. Recent biological changes in Lake Michigan that have altered the lake's trophic structure are under investigation. Analysis of food chains and energy flow within and between trophic levels will include studies of food preference, food competition, and the efficiency of utilization. The effects of the chemical and physical factors of the environment on the physiology and behavior of native and exotic species are being investigated. Special emphasis will be placed on determining the role of these factors as controlling mechanisms in energy flow and productivity in the ecosystem.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0291, ECOLOGY OF C. BOTULINUM IN THE COMMERCIAL FISHERIES ENVIRONMENT

J.T. GRAIKOSKI, U.S. Dept. of Interior, Technological Laboratory, *Ann Arbor, Michigan*

In studies concerning the ecology of C. botulinum in the fisheries environment, the distribution, types and relative numbers in fish, bottom sediments, water, contiguous soils, and in the cycle of handling and processing of fish and fishery products is being determined. Areas of interest are the Great Lakes Region and commercial fishing areas of the North and South Atlantic fisheries not being surveyed by other groups under similar programs. Organisms obtained in these studies are being identified and classified according to classical methods and immunoserological techniques. Field studies, specifically in the Great Lakes region, are being directed towards looking for reservoirs of botulinum spores and the preformed toxin, including the possibility of a cycle of transfer of the organism and the preformed toxin from elements of the fishery food chain to fish and to waterfowl.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0292, RESEARCH ON THE MACROBENTHOS OF THE GREAT LAKES

J.K. HILTUNEN, U.S. Dept. of Interior, Biological Laboratory, *Ann Arbor, Michigan*

The objective of this project is to determine the kinds of bottom dwelling invertebrates and their ecology in offshore areas of the Great Lakes.

Research on freshwater macrobenthos can yield data on the availability of fish food organisms and provide insights into the relationships between species and water quality. Studies of bottom fauna currently undertaken include Lakes Ontario and St. Clair and the Apostle Islands region of Lake Superior. In Lakes Michigan and Erie benthological research is confined mostly to taxonomy and ecology of microdrile oligochaetes. Among aquatic invertebrates, populations of oligochaetes are generally the best indicators of pollution.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0293, LAKE SUPERIOR EXPLORATIONS

N.J. REIGLE, U.S. Dept. of Interior, Exptl. Fish & Gear Res. Base, *Ann Arbor, Michigan*

The decline of high-value, food fish species and increases in populations of low-value fish stocks have left the Lake Superior fishermen with little chance to earn satisfactory incomes with traditional gill nets, trap nets and pounds nets. Systematic exploratory fishing operations are being conducted for locating and assessing the potential commercial yield of additional or alternate fish stocks; introducing existing gear from other areas or improved or new methods and equipment to allow efficient and economical harvest of these populations; surveying the physical characteristics of Lake Superior to ascertain suitability for various types of fishing gear; and determining the seasonal availability of various species in order to stabilize production and counteract the effects of seasonal gluts.

Otter trawls are being evaluated to determine the effectiveness of this gear for more economical exploitation of the abundant species such as chubs, smelt and suckers. Continuing studies will provide the basis for sound management of the available resource and permit economical, year-round utilization of underutilized species.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0294, DISTRIBUTION AND ABUNDANCE OF ZOOPLANKTON IN LAKE ERIE

J. REYNOLDS, U.S. Dept. of Interior, Biological Laboratory, *Ann Arbor, Michigan*

This project is aimed at obtaining good estimates of relative abundance and standing crop of common species of zooplankton in Lake Erie, Such estimates require a knowledge of the variation in catch contributed by factors causing other than real changes in biomass (i.e., apparent changes due to sampling). Initially, a restricted area in Lake Erie will be sampled to determine the extent of sampling error. Subsequent experiments will attempt to quantify those ecological relationships which significantly mask the real changes in zooplankton abundance. Considering present knowledge of zooplankton ecology, some of the factors studied will be light, oxygen, temperature, diurnal movement, and horizontal distribution. Proper treatment of the data will require multiple regression analysis and multiple analysis of variance using the high-speed computer. Inclusion of any significant ecological factors as an adjustment in estimation would increase the precision involved in detecting real changes in zooplankton abundance. Hopefully, these improved estimates may give additional meaning to the relation between density of zooplankton and survival of certain species of fishes in Lake Erie, particularly young-of-the-year. The project will begin during May 1967.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0295, EARLY LIFE HISTORY OF COREGONIDS

L. WELLS, U.S. Dept. of Interior, Biological Laboratory, *Ann Arbor, Michigan*

Little or nothing is known about the early life history of coregonids, and of related ecological events and requirements. This study is exploring means of locating and collecting juvenile coregonids from hatching through their second year. Only recently has it been possible to collect larvae and fry in limited numbers, but methods to locate and catch young from the middle of their first year until the start of their third year have not been found. Once satisfactory means of collection have been developed, studies will be directed to their distribution, growth, and mortality in relation to the physical, chemical, and biological characteristics of the environment. The results of this study will be used in making estimates of recruitment and early mortality in population studies.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0296, DECISION MAKING UNDER UNCERTAINTY - ECONOMIC EVALUATION OF STREAMFLOW FORECASTS

A. BRINSER, Univ. of Michigan, Graduate School, *Ann Arbor, Michigan*

Research is intended to develop a model of estimating the net benefits to selected classes of users of water services from successive increments of improvement in the reliability of water supply forecasts; to develop improved criteria for comparing the value of incremental increases in the reliability of water supply forecasts with that of incremental increases in total usable supply obtainable from weather modification or watershed treatment, as these values are assessed by several classes of users; and to suggest an appropriate level of intensified operational activity and research effort directed toward technologically feasible improvements in streamflow forecasting techniques.

A product of the research will be a model for estimating the value of increased certainty of streamflow, together with empirical tests of the model, based on data gathered in the field in selected basins.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0297, COMPUTER SIMULATION OF EFFECTS OF LAND MANAGEMENT AND WEATHER MODIFICATION ON WATERSHED ECOSYSTEMS

C.F. COOPER, Univ. of Michigan, Graduate School, *Ann Arbor, Michigan*

Objective: To develop improved computer simulation models for preliminary evaluation of the effects of land use and weather modification on watershed ecosystems and on the quantity, quality, and timing of water yields.

Procedures: (1) Review existing simulation models. (2) Test multivariate statistical techniques for mathematical description of ecosystem structure. (3) Develop preliminary simulation model of a small forested catchment. (4) Test and refine preliminary model against observed data. (5) Determine response of hypothetical ecosystem to changes in weather inputs. (6) Define gaps in existing data programs and analytical procedures.

SUPPORTED BY U.S. Dept. of Agriculture

6.0298, URBAN WATER POLITICS AND DECISION MAKING IN THE DETROIT METROPOLITAN REGION

W.R. GABLE, Univ. of Michigan, Institute of Public Admin., *Ann Arbor, Michigan*

The proposed research program involves both literature and field investigations designed to understand and develop a conceptual structure for the decision making process relating to water resources in The Detroit Metropolitan Region.

Institutional relations as they affect water resource actions provide the central focus for investigation. The main approach is to study the political process as it provides the interlinkages among institutions, and thus motivate and condition decisions that will be made by each.

Literature investigations will include that relating: (1) decision making with respect to water management and/or metropolitan government, and (2) conditions and actions regarding water resources in the study region.

Field investigations will rely primarily upon interviews with principal actors and other 'water influentials' in the metropolitan area. Interviewing strategies will be adapted to different needs. It is anticipated that questionnaires will be employed in surveying differences of perceptions of the various interests in water resources.

An information-political 'model' will be developed for one river basin in the metropolitan fringe to illustrate political interactions between water interests in the fringe area and the water interest in the metropolitan core.

Political decisions and arrangements in water affairs will be identified and evaluated in terms of criteria for optimal water use.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0299, INFRARED IMAGER STUDIES

D. LOWE, Univ. of Michigan, Institute of Sci. & Technology, *Ann Arbor, Michigan*

Objectives: Develop experiment techniques for interpretation of infrared data. To provide instrument and interpretation support to various users of infrared data returns. Determine experimental goals that can be achieved with Infrared Imaging instrumentation as applied to discovery of minerals, water resources, oceanographic features, etc.

Approach: Conduct studies for instrumentation covering the emitted and reflected IR spectral band. Define instrument parameters required to accomplish various user discipline objectives. Conduct an investigation to determine optimum signal processing techniques.

Status: Completed evaluation if IR scanner for an early Earth Resources mission. Conducting conceptual design studies for space instrumentation. Evaluating signal studies for space instrumentation. Defining experimental goals that can be achieved with imaging instrumentation.

SUPPORTED BY U.S. Natl. Aero. & Space Adm.

6.0300, FARM FISH POND MANAGEMENT

R.C. BALL, Michigan State University, Agricultural Experiment Sta., *East Lansing, Michigan* 48824

Estimate production of plants and animals per unit area or volume of water in farm type ponds, and natural ponds. Determine to what extent fertilization of ponds will increase production of fish food (plankton, insects) and fish. Devise practical management programs for farm ponds; this includes the number of fish to plant and harvest. Detect and measure possible detrimental effects of use of fertilizers in fish ponds.

Description of Work: Measurement of release of stored nutrients in the subaqueous soils by addition of chelating (EDTA, etc.) materials to the waters will be made by chemical methods.

Evaluation and tracing of the paths of nutrients added to the waters will be possible through the tagging of the nutrients with radioactive tracers (p32), and the fate of these in bottom deposits.

The rates of fixation of nutrients and accumulation of organic material (basic productivity) will be measured by the C-14 light-and- dark bottle technic. This will be correlated by light-and-dark bottle methods of determining of production of oxygen and pond-biota respiration. Input of solar radiation will be measured by Eppley pyrheliometer and submarine photometer.

SUPPORTED BY U.S. Dept. of Agriculture
Michigan State Government

6.0301, DYNAMIC SYSTEM MODELING AND SIMULATION OF A RIVER BASIN

G.A. COULMAN, Michigan State University, School of Engineering, *East Lansing, Michigan* 48824

The dynamic phenomenological characteristics of a segment of a river basin are to be mathematically described. The system will provide a detailed hybrid computer simulation for study fo the variation in time of the significant variables of the river. Once firmly proven to accurately represent the system, the simulation will provide a facility for deterministic and stochastic response studies of projected regional changes and natural occurrences.

During the initial period of this work, it is expected that a major portion of the model will be developed and justified.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Michigan State University

6.0302, WATERSHED ANALYSIS RELATING TO EUTROPHICATION OF LAKE MICHIGAN

M.E. STEPHENSON, Michigan State University, School of Engineering, *East Lansing, Michigan* 48824

The objectives of the project are to (1) establish a storage and retrieval system of data on water quality and quantity within the surface system of lakes and streams of a major watershed of Lake Michigan, the Grand River, and (2) collect and collate existing data pertaining to the physical, chemical, biological, and socio-economic aspects of the water resources of the basin, (3) incorporate a current evaluation of material transport (phosphorus, nitrogen, total carbon, pesticides, etc.) within the river system, (4) determine the qualitative and quantitative relationships between waste discharge and receiving stream water quality on the Grand River system and Lake Michigan, and (5) carry out a compilation and analysis of land use practices and socio-economic developments as related to each of the water resource parameters considered above.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Michigan State University

6.0303, STUDIES ON PLANTED BROOK TROUT IN RELATION TO NUMBERS PLANTED, LIMNOLOGICAL CONDITIONS AND FOOD SUPPLIES IN UNFISHED LAKES

H. GOWING, State Res. & Dev. Division, *Lansing, Michigan* 48926

Objectives: To investigate the population of stocked brook trout in lakes closed to angling when stocked at various numerical levels; to determine the extent that these fish utilize or ignore sources of available food; to learn if methods can be devised to increase the growth and/or survival rates of the planted fish.

Procedures: In the fall of 1965, six lakes on the Pigeon River Fisheries Research Area were stocked with fin-clipped 5 to 6 inch brook trout at levels of 50, 100, and 500 fish per acre. The mortality rates of these fish in the absence of angling has been followed, and will be followed, by spring and fall population estimates. From 10-20 fish collected monthly, growth is measured, and stomach samples are obtained for food habits analysis.

Detailed bottom food sampling is done 4 times yearly in West Lost Lake to estimate the types of bottom food available, and the crayfish population of this lake is estimated to measure the abundance of this food form. Tests of correlation between the above data and the growth records and food studies should provide some measure of the amount of use of the available trout foods. Water chemistry and temperature data on all experimental lakes are recorded at regular intervals.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Michigan State Government

6.0304, HYDROLOGY OF RIVER-BASED RECREATION

G.E. HENDRICKSON, U.S. Dept. of Interior, Geological Survey, *Lansing, Michigan*

Purpose: To analyze the hydrologic factors related to use of cold-water rivers in a glacial terrain, to provide guidelines for assessing the potential recreational value of such rivers, and to determine how development by man in the watersheds affects the recreational value of the streams.

Methods: On the basis of streamflow and water quality records, geology, topography, and amount of development, select representative rivers in northern Michigan. Assemble information regarding streamflow characteristics, stream morphology, water temperature, ground-water levels, and areas of ground-water discharge. Obtain information on recreational potential of rivers, including fish populations and present and future use for fishing, boating, and camping. Interpret relationships of recreational uses to hydrology of the watershed. In developed watersheds obtain information on surface and ground water withdrawals, disposal of sewage and other wastes, regulation by dams, and indirect controls by timber-cutting and other changes in land use in the watersheds. Report on relationships of characteristics of streamflow, water quality, and stream morphology to river-based recreation.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Michigan State Government

6.0305, ECONOMICS OF FLOOD CONTROL STRUCTURES IN THE LOWER MINNESOTA RIVER WATERSHED DISTRICT

L.E. SAMSTAD, Lower Minn. Rivr. Wat. Dist. , *Burnsville, Minnesota*

The purpose of this study is to provide (a) a survey of existing flood control structures, (permanent and temporary), protecting towns and industries in the Lower Minnesota River Valley; (b) a tabulation of costs of these structures; (c) a tabulation of the savings which accrue from these structures; (d) a study of the indirect benefits of flood proofing; (e) an objective economic appraisal of these flood control structures based on existing conditions.

The Lower Minnesota River Watershed District encomasses several towns (Carver, Chaska, Shakopee, Savage, Burnsville, Bloomington, Mendota Heights and Mendota, Minnesota) all lying along the banks of the Minnesota River at its terminus or confluence with the Mississippi River. Many flood control structures have been erected to protect these towns as well as large industries such as Cargill, Inc.; Northern States Power; and American Crystal Sugar, Inc.

These flood control measures in the lower reaches of this river valley have not been evaluated as to effectiveness in harnessing the ravages of severe floods.

This study would detail the existing flood control measures. Costs of this flood protection measures (permanent and temporary) would be tabulated. A determination would be made of all direct savings from these structures based on past floods. The investigators would evaluate the economic advantages and disadvantages of all types of flood proofing encountered.

An analysis of existing methods would lead other investigators to help evaluate their success, from engineering and economic stand points, and hopefully lead these investigators to new and improved methods of flood proofing in similar river valleys.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0306, HYDROLOGIC ASPECTS OF WATER LAWS IN MINNESOTA

W.C. WALTON, Univ. of Minnesota, Water Resources Research Ctr. , *Minneapolis, Minnesota* 55455

Perhaps the greatest concern felt by water users in Minnesota is the apparent uncertainly and variability of their water rights. Our entire system of water is based on uncertain tensure arrangement subject to administrative water permits and regulations and judicial determination of reasonable and beneficial public use. Both surface and groundwater property rights are incident to the owership of land. To operate effectively the water right must be capable of coping with the physical uncertainty of water resources, the fugititve and fleeting nature of water resources which creates problems of commonality or spillover effects of use, technical aspects of the hydrologic cycle, and diversions of water resources form one basin to another. This research is directed toward fully understanding water laws in Minnesota and their relation to hydrologic cycle events and improving water laws to make them hydrologically sound.

Office investigations will include: 1) collection of data on all direct and indirect water laws in Minnesota; 2) Collection of available data pertaining to the hydrologic cycle and water use in Minnesota; 3) collection or data on water resources institutional environment in Minnesota; 4) study data to identify advantages and disadvantages of current water laws with respect to hydrologic cycle events; and 5) formulation of hydrologically sound water laws.

6. WATER RESOURCES PLANNING

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Minnesota

6.0307, HYDROLOGIC PARAMETERS CONTROLLING RECREATIONAL USE OF MINNESOTA RIVERS

R.F. BROWN, U.S. Dept. of Interior, Geological Survey, *Saint Paul, Minnesota*

Purpose - To determine the effect of hydrologic parameters - streamflow, water quality, geology, stream morphology - on recreational use of selected rivers in Minnesota.

Methods - Selected Minnesota rivers have been designated by the State as 'Wild Rivers' and knowledge of the geologic and hydrologic environment of these streams is required by conservationists and recreation managers and planners to evaluate their recreational use. Available records of streamflow, water quality and geology will be evaluated in terms of the controlling influence of these parameters on the present and future recreational value of the rivers. Longitudinal profiles of streams will be made, channel morphology will be studied, and additional measurements of streamflow and water quality parameters will be made and their relation to recreational use will be evaluated.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Minnesota State Government

6.0308, VALUE PRODUCTIVITY OF WATER IN AGRICULTURE

J. BURNS, Univ. of Minnesota, Agricultural Experiment Sta. , *Saint Paul, Minnesota*

Objectives: To estimate the value productivity of water in agricultural uses, and analyze the economic effects of technological improvements in the efficiency of water use in agriculture.

Approach: Data describing water use for irrigation and other agricultural uses will be collected and analyzed to determine value productivity. The analyses will devote special attention to the effects on water use efficiency from improvements in water supply and use technology. Estimates will be made of marginal value products of resources used in irrigated and nonirrigated farming in Minnesota and other North Central States. Existing techniques for estimating demand for irrigated acreage in the United States will be examined and modified on the basis of the estimates of value productivity of water and other resources used in irrigation farming.

SUPPORTED BY U.S. Dept. of Agriculture

6.0309, ECOLOGY AND MANAGEMENT OF BOUNDARY WATERS CANOE AREA CAMPSITES

S.S. FRISSELL, Univ. of Minnesota, Graduate School, *Saint Paul, Minnesota*

This project is designed to provide the basic data necessary for the development of a program of wilderness campsite management in the Boundary Waters Canoe Area of the Superior National Forest, Minnesota. The study is divided into five sub-projects to investigate the following: 1. The supply of currently used campsites, their physical characteristics, location with respect to potential campsite areas, and the possibility of shifting use from over-used sites to new sites; 2. The form and severity of changes in the wilderness environment on campsites in areas with different geology, soil type, and vegetative cover; 3. The rate of change which takes place with use; 4. The effectiveness and acceptibility of techniques for closing over-used campsites; and 5. The effectiveness and acceptibility of various techniques for rehabilitating over-used wilderness campsites.

SUPPORTED BY U.S. Dept. of Agriculture
University of Minnesota

6.0310, ECONOMIC PROBLEMS IN THE USE, ALLOCATION, REGULATION AND PRICING OF WATER

P.M. RAUP, Univ. of Minnesota, Agricultural Experiment Sta. , *Saint Paul, Minnesota*

To estimate supply and demand for water for agriculture and competing uses, currently, and for years to come; explore economic consequences of existing laws and doctrine; examine economic issues involved in competition for water among agricultural, recreational, municipal, and industrial uses; appraise alternative forms of organization for conservation, use, and regulation of water resources; and study data bearing on conflicts between public and private rights in control over water resources.

Description of work: Supply and demand for water in Minnesota will be determined; and adequacy of current legislation regulating permits by Division of Waters and Department of Conservation will be tested, and method evaluated. Conflict between public and private interests, and ownership rights will be studied and economic issues examined. Cost of development; division of costs and benefits among users, and delineation of public and private interests will be determined. Detailed research procedures will be developed through joint investigations by economists and law students and professors, and actual research will also be conducted by them. After two years, research will be coordinated with neighboring states making similar investigations to obtain maximum value.

SUPPORTED BY U.S. Dept. of Agriculture
Minnesota State Government

6.0311, ECONOMICS OF WATER QUALITY CONTROL IN THE UPPER MISSISSIPPI RIVER (MINNESOTA)

J.J. WAELTI, Univ. of Minnesota, School of Agriculture, *Saint Paul, Minnesota*

Objectives: The overall objective of the project is to formulate an economic optimizing model for water quality control and sewage disposal on selected stretches of the upper Mississippi River. The model will be designed to serve as a useful basis for public policy decisions in Minnseota with respect to both the water quality standards adopted on particular segments of the River and for least-cost-methods of attaining given standards. The methodology developed would be expected to be adaptable to water quality problems elsewhere.

Specifically, the model would be useful in answering such questions as: 1. What is the least-cost strategy of attaining given water quality parameters, taking into account-a. Natural assimilative capacity of the river; b. Variations in flow; c. Alternative levels of treatment; d. Alternative locations of treatment; 2. What are the economic benefits associated with alternative standards? Taking into account the above, 3. What are the costs and benefits associated with raising or lowering water quality standards on particular stretches of the River? 4. What are the policy implications for stream standards versus uniform effluent standards for all waste dischargers?

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Minnesota

6.0312, UNDERGRADUATE TRAINING FOR CAREERS IN WATER SUPPLY AND POLLUTION CONTROL

C.D. MCNABB, Saint Marys College, Graduate School, *Winona, Minnesota* 55987

The project objective is to evaluate the effectiveness of a subsidized undergraduate program in competing for promising young students who will prepare for graduate work and eventual careers in water supply and pollution control. Two students will be supported for one calendar year beginning in the second semester of their junior year. In the winter term they will learn techniques and design a program for sampling a pool of the Mississippi River to evaluate water quality parameters. The following spring, they will write a technical report on their field work which will satisfy their thesis requirements. They will be placed in graduate school and their careers will be followed with feedback information.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Saint Marys College

6.0313, THE IMPACT OF RESERVOIRS ON LAND VALUES - A CASE STUDY

D.C. WILLIAMS, Univ. of Southern Mississippi, Graduate School, *Hattiesburg, Mississippi* 39401

This project studies the effect of reservoir construction on land values. Land values in the area around the reservoirs and determined for periods before and after construction and compared with settlement values where land was taken as part of the reservoir.

The case study method is employed and the Ross Barnett Reservoir in central Mississippi was selected for study. Land values will be determined from records of land sales and personal interview with buyers and sellers. These data are to be collected on a sample basis. An analysis of results is included.

Although this is a case study of only one reservoir, it is felt that some general conclusion may be drawn because of the size and location of the reservoir. Similar studies at other reservoir sites may be undertaken after completion of this study.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Southern Mississippi

6.0314, FOOD HABITS STUDY

UNKNOWN, State Game & Fish Commission, *Jackson, Mississippi*

An electric shocker will be used to collect the fish used in this study. Collection will be made on a monthly basis as near the stations for the other two jobs as possible.

The fish will be grouped in inch classess and the stomachs combined for analysis. Qualitative and quantitative determinations will be made of the contents of the stomachs. The findings will be compared with the findings of Job I to determine utilization of bottom organisms and plankton.

Attempts will be made to collect at least 20 per month of each of the following species: Largemough bass, crappie, bluegill, shad, orange spotted sunfish and catfish.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Mississippi State Government

6.0315, AN ECOLOGICAL AND RECREATIONAL USE SURVEY OF A SMALL MISSISSIPPI RIVER JUST BEFORE CHANNELIZATION

D.H. ARNER, Mississippi St. University, Graduate School, *State College, Mississippi* 39762

An ecological and recreational use study of a small Mississippi river just before channelization. Littoral Benthos macrofauna and fish populations will be sampled. Water and soil chemistry data will be collected. Water table levels will be measured along lines perpendicular to the river. Data concerning hunting and fishing use of the river will be collected. It is anticipated that a follow-up study will be made after channelization.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Mississippi State University

6.0316, POLITICAL PROCESSES IN THE PROMOTION OF WATER RESOURCE DEVELOPMENT PROGRAMS

A.R. JONES, Mississippi St. University, Social Science Research Center, *State College, Mississippi* 39762

This study will analyze the administrative network of federal state, state-state, and intrastate relations characteristic of three major water resource agencies in Mississippi, one of which involves a cooperative compact with two adjacent states. Historical and legal records will be utilized to reconstruct the pattern of political influences which led to the origin of and furthered the early and recent development of each program. Interviews will be taken with leaders of each program in order to collect information on the correct political and administrative setting of each program. Modes of support (appropriation, taxation, grant, etc.) will be explored and related to program implementation. The total analysis will be comparative with emphasis on the processes, cooperative and coordinative, and problems related to each agency.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Mississippi State University

6.0317, AN ANALYSIS OF PRICING PRACTICES AND POLICIES OF WATER SERVICE UTILITIES IN SMALL COMMUNITIES IN MISSISSIPPI

G.T. PEDEN, Mississippi St. University, Graduate School, *State College, Mississippi* 39762

During the first three to six months, the members of the Bureau staff assigned to the project will collect data on water rates from municipalities having populations of between 2,500 people and 10,000 people. It is felt that the water service utilities in these towns will be small enough to be subject to inadequate price policies, but large enough so that a good price policy could have a marked effect on the financial structure of the water service utilities.

After all the information is collected, an analysis will be made of each community's pricing practices using economic and financial principles as criteria. Then the most widely accepted practices among the communities will be selected to formulate the representative pricing practices of the communities.

The final step will be to develop a set of pricing procedures or practices commensurate with the average plant size and general community objectives with the aim or goal being a generally applicable pricing model that the communities could apply in determining their water rate structure.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Mississippi State University

6.0318, COMMUNITY INVOLVEMENT OF PARTICIPANTS IN WATERSHED PLANNING

K.P. WILKINSON, Mississippi St. University, Social Science Research Center, *State College, Mississippi* 39762

This study will examine the nature, extent and consequences of generalized community involvement of those persons who play the leading roles in watershed development programs in Mississippi, the assumption being that community involvement of participants has significant implications for program effectiveness. Local participants in watershed development programs in the state will be identified from secondary sources and through contacts with key informants. A questionnaire survey will be used to identify community involvement patterns and watershed program roles of leading participants and to collect background information on participants. Community differences will be identified and related to data collected earlier and available from secondary sources on accomplishment of watershed program goals.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Mississippi State University

6.0319, ACUTE TOXICITY OF PESTICIDES TO FRESHWATER INVERTEBRATES - DEVELOPMENT OF A LABORATORY STREAM FOR REARING AND TESTING AQUATIC INVERTEBRATES

H. SANDERS, U.S. Dept. of Interior, Fish Pesticide Res. Lab. , *Columbia, Missouri* 65201

The objective of this work is to design, build and test for efficiency a laboratory stream for rearing, holding and testing aquatic invertebrates normally found in flowing water situations. Rearing and testing facilities will be tested with several species of animals involving control of water temperature, water quality, and water flow conditions.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0320, ECONOMIC ASPECTS OF SUPPLEMENTAL IRRIGATION IN MISSOURI

O.R. BURT, Univ. of Missouri, Water Resources Research Ctr. , *Columbia, Missouri* 65202

This research focuses on the problems of irrigation under sub-- humid climate. It is quite long range in its requirements and will involve irrigation experiments as well as utilization of currently available data. Present research is limited to irrigation of corn.

6. WATER RESOURCES PLANNING

The general method of approach to supplemental irrigation is: (1) estimate a physical production relationship with moisture and temperature as the primary explanatory variables (other variables such as fertility must be included but are of only secondary interest); (2) estimate an optimal intraseasonal irrigation policy taking cognizance of the stochastic climatic variables, optimality being measured by an expected value criterion function; (3) using the irrigation policy, the physical production function, and an estimated probability distribution for the climatic variables, evaluate returns to investment in irrigation facilities by using both expected value and dispersion of returns as criteria.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Missouri
Missouri State Government

6.0321, AN EVALUATION OF ALTERNATIVES FOR WATER RESOURCES REGULATION IN MISSOURI

T.E. LAUER, Univ. of Missouri, Water Resources Research Ctr., *Columbia, Missouri* 65202

This project involves critical examination of existing Missouri decisional and statutory water law followed by determination and evaluation of prospective legislative systems of water resources regulation for the state, in light of existing legal and non-legal conditions. The purpose of the research is to develop feasible alternatives for comprehensive water resources regulation, and to ascertain the strengths and weaknesses of each. These alternatives will be submitted to consultants in non-legal fields for evaluation, re-evaluated from a legal standpoint and, as may prove practicable, legislative alternatives drafted for inclusion in a final project report.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Missouri

6.0322, AN ECONOMIC ANALYSIS OF THE PUBLIC WATER SUPPLY DISTRICT

C.G. MCNABB, Univ. of Missouri, School of Agriculture, *Columbia, Missouri* 65202

The overall purpose of this project is to describe and analyze certain economic and social aspects relating to the growth, development and operation of the public water supply district. Data will be secured from records of the supervising agency, records of local districts and from interviews with members of local organizations.

The specific objectives will be (1) to develop concepts and provide information about the growth and development of the public water supply district, (2) to identify problems associated with their development and operation and (3) to identify and analyze economic and social factors associated with sound planning, financing and management of the public water supply district.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Missouri

6.0323, ECONOMIC AND LEGAL FACTORS IN PROVIDING, USING, AND MANAGING WATER RESOURCES IN AGRICULTURE

F. MILLER, Univ. of Missouri, Agricultural Experiment Sta., *Columbia, Missouri* 65202

Objectives: The objectives of the regional project relate to both qualitative and quantitative aspects of water use problems in the North Central Region. The objective of the Missouri contributing project is to determine the economic considerations that affect use and management of water in agriculture and competing uses.

Description of work proposed: Economic returns to investments in supplemental irrigation in Missouri will be estimated. Results from this analysis will permit estimation of the value that can be imputed to water used for irrigation. This value can then be compared with that in competing uses.

SUPPORTED BY U.S. Dept. of Agriculture
Missouri State Government

6.0324, COLORADO COMPREHENSIVE PLAN FOR OUTDOOR RECREATION

W.R. CHENEY, Midwest Research Institute, *Kansas City, Missouri*

Objectives of this project are to develop local participation data from primary sources to be used in updating the Demand, Supply, Needs. amd Action portions of the Comprehensive Outdoor Recreation Plan for Colorado. Data from a study of the Economic Impact of Hunting and Fishing Activities by resident population are also being collected for use in a separate study as well as inclusion in the plan. The study is proceeding approximately on schedule. The data produced will provide a statewide mapping system on transparent overlays: county boundaries; highways, cities and towns and water courses, base map coding system with recreation inventory plotted, and topography at a scale of 1:250,000. This information is to be made available at the cost of reproduction to all agencies requesting data.

Procedure: Personal household interviews are being conducted on a statewide basis. Households are selected on the basis of a random sampling plan stratified by county, region, and S.M.S.A. Data will be projected on the basis of current population studies to the years 1970, 75, 80, 90, 2000, 2010 and 2020, for the Recreation Study. These projections when compared with measures of existing and potential supply will be used as the basis for needs statements now and in the future. The project was started in fiscal year 1967-68.

SUPPORTED BY U.S. Dept. of Interior - Bu. Outdoor Rec.
Colorado State Government

6.0325, DEVELOPMENT OF A STATE WATER PLANNING MODEL

D.W. BOYD, Montana State University, School of Engineering, *Bozeman, Montana* 59715

The State of Montana Water Resources Board has been charged by the State Legislature with developing a State Water Plan. In fulfilling its mission, the Water Board inevitably will have to cope with and evaluate innumerable proposals and requests from all quarters. The Water Board, therefore, urgently needs a specially structured simulation model which will permit the rapid evaluation of a proposed river basin treatment and determination of the probability of achieving the desired goals.

The systems approach will be applied to the design of a State Water Planning Model, by implementing orderly systems engineering methodology based on the thesis that the dominating factor in the complex system is the large quantity of information involved. The Model will incorporate such Operations Research techniques as simulation and input-output analysis. A Sigma 7 digital computer will be utilized in the simulation of various management policies.

Development of a single watershed model for the Yellowstone River basin will proceed concurrently with the decomposition, analysis and structuring of the state-wide system. The Yellowstone model will then be interacted with other aspects of the system, and will form a unit of the State Water Planning Model.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Montana State University

6.0326, A STUDY OF WATER RESOURCES RESEARCH NEEDS IN MONTANA

C.C. BRADLEY, Montana State University, Graduate School, *Bozeman, Montana* 59715

This is a one-year project (July 1, 1968 - June 30, 1969) with the objective of identifying the major water problems of Montana as a basis of establishing goals, directions, and priorities for the Montana Joint Water Resources Research Center.

The procedure envisions the creation of several task forces envolving about five faculty members each, coordinated by a council composed by task force chairmen under the leadership of the principle investigator.

The mission of the task forces will be to identify the major water related problems of the state, and to break these down into an integrated group of research-size packages, which in turn become specific attainable goals for faculty members and other research personnel working directly or indirectly with the Montana WRRC.

The project will start at Montana State University and later will be expanded to include the University of Montana and Montana College of Mineral Sciences and Technology.

The work of the task forces and coordinating council will be organized into a report at the end of the project period.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Montana State University

6.0327, THE ECONOMICS OF WATER TRANSFER - AN APPRAISAL OF INSTITUTIONS

H.C. HOLJE, Montana State University, Agricultural Experiment Sta., *Bozeman, Montana* 59715

(1) To appraise the legal-institutional-administrative devices and processes through which transfers of water between uses and users take place and (2) To assess the consequences of these devices and processes on the economic efficiency and equity of water use and (3) To suggest desirable modifications in these devices and processes that might enhance economic efficiency or equity in the use of water resources.

To describe the functional structure of the selected water right complex vis-a-vis the marginal value product of water use in each category of use. Appraise the results from such alternative modifications against the criterion of maximized marginal value product to water use. To conclude as to the hypothetical ideal of efficiency and the political ideal of attainability relative to each of the programmed modifications. Regional synthesis of the findings will be undertaken in one or more regional publications.

SUPPORTED BY U.S. Dept. of Agriculture
Montana State Government

6.0328, PROBLEMS AND OPPORTUNITIES OF WATER RESOURCE UTILIZATION IN THE UPPER COLUMBIA AND MISSOURI RIVER BASINS

R.J. MCCONNEN, Montana State University, School of Agriculture, *Bozeman, Montana* 59715

This research project has as its major objectives the following: (1) A comprehensive inventory of available data and research reports related to the water resources of the upper Columbia and Missouri River Basins, (2) identification of problem areas and trends in water use, (3) consideration of the multiple uses of water and identification of competitive and complimentary uses, (4) demonstration of investiment opportunities in water resource development, and (5) assistance in the preparation of a plan for the future development of water resources of the upper Columbia and Missouri River Basins.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Montana State University

6.0329, SOCIAL CHANGE IN A WATER RESOURCE DEVELOPMENT AREA - SOCIAL ASPECTS OF THE CONSTRUCTION PHASE OF LIBBY DAM

H.J. TURECK, Montana State University, Graduate School, *Bozeman, Montana* 59715

The small town of Libby, Montana (population in 1965 was slightly over 4,000) is the site of the construction of Libby Dam. This project is to take five years and will bring about 15,000 newcomers into the area during construction. The objectives of this research are concerned with establishing 'benchmark' attitudes regarding the construction, displacement of some residents, present recreational patterns, recreational potentials represented by the reservoir, and social changes brought about by increased population and economic development. Longitudinal study will then catalogue changes in these attitudes during the construction period. The impact of the rapidly changing problems of community development will also be studied during the construction period. The overall objectives of the research are: (1) to gather information about changing attitudes, values, and social interactions in a small community undergoing high social impact, and (2) ultimately to provide useful information to decision-makers in the area of water resource development.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0330, EFFECTS OF DEWATERING ON A TROUT POPULATION

A.H. WIPPERMAN, State Fish & Game Department, *Helena, Montana*

The purpose of this project is to determine if reduced stream flows affect a trout population, and if so, what flows are required to sustain a trout population of value to recreational fishing. A second objective is to determine how dewatering affects the physical features of the stream.

An artificial dewatering system was constructed on Blacktail Creek in Southwestern Montana in the spring of 1965. A diversion canal and diversion structures were constructed so that various reductions in flow could be made in three consecutive stream sections.

The study plan for 1967 will involve dewatering the entire study area 90 percent below low normal summer flow. Dewatering will begin in early June and terminate in early September. The fish population will be inventoried with the aid of shocking gear prior to and at the conclusion of the dewatering period. Fish traps will be maintained at each end of the dewatered area to determine fish movements in or out of the area.

Physical features of the stream channel will be measured at low normal flow and at the dewatered flow. Measurements will include widths, depths, volume, cover, and velocities. These physical features will be correlated with the fish population at normal flows and at dewatered flows.

Work and data collection will be conducted during the summer of 1967. Report writing will follow completion of data collection.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Montana State Government

6.0331, ECONOMIC SURVEY OF BEAVERHEAD COUNTY, MONTANA

M.C. JOHNSON, Univ. of Montana, Graduate School, *Missoula, Montana* 59801

An economic study of Beaverhead County, Montana, in 1964 prior to utilization of water from the Bureau of Reclamation's East Bench Unit project. This project will provide full irrigation services for 21,800 acres of land not previously irrigated and supplemental water for 28,000 acres that were under irrigation before construction of the project.

An interim study of secondary data will be performed in 1971 following the availability of 1969 Census of Agriculture and 1970 population census. A final study and evaluation to measure the effects of the irrigation project on Beaverhead County and surrounding trade centers will be conducted in 1975 and 1976. This will represent a 10-year time span essentially coinciding with the end of the development period and will also permit the full utilization of 1974 census of agriculture data.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

6.0332, WATER AND RECREATION USE, BLACKFOOT RIVER DRAINAGE, WESTERN MONTANA

C. MALOUF, Univ. of Montana, Graduate School, *Missoula, Montana* 59801

This study will concentrate on the recreational uses of the Blackfoot River system, in western Montana. The objectives are three-fold: 1) Use of portions of the river course for recreation by local residents, and by visitors. Visitors come from three large communities on three sides of the drainage area. 2) To study the extent of seasonal uses for recreation through summer and winter, fall and spring. 3) To establish new uses for the area and to determine its recreational potential.

The communities nearby which make wide use of the river system are Great Falls on the east, Missoula on the west, and Helena on the south. To the northward are primitive areas and Glacier National Park. Use by people from outside the regions mentioned will also be determined. The drainage includes high mountain ranges, many lakes capable of supporting boating facilities and fishing, forest and parklands, and some sizeable rivers. There are at present no ski reports here.

Data will be collected which can be tabulated. The investigators will make samplings during various seasons by contacting people who are making current use of the recreation offerings in this region.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Montana

6.0333, LEGAL RESEARCH, WRITING AND DRAFTING TOWARD IMPROVING MONTANA WATER LAWS

A.W. STONE, Univ. of Montana, Joint Water Resour. Res. Ctr., *Missoula, Montana* 59801

Previous allotments resulted in an initial draft of a comprehensive surface and groundwater code for Montana which was completed in time to be used during the 1967 legislature. It needs further work on its organization and on some of the drafting, as well as revision of parts of that draft.

There is a need for legal research on the background at common law and in Montana law of the public interest in the use of waters, hopefully leading to a clarification of that interest as well as a basis to support legislation on the subject.

Water Conservancy District Legislation has been considered by state agencies, the legislature and private organizations. No such law has been enacted. Legal work on this is needed, and will be pursued with the Montana Conservation Council.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Montana State University

6.0334, SAUGER AND WALLEYE INVESTIGATIONS IN THE MISSOURI RIVER

L. MORRIS, State Game & Parks Commission, *Lincoln, Nebraska* 68509

The objectives of this job are to determine the daily and seasonal activity patterns of sauger and walleye adults which congregate during the spring immediately below Gavins Point Dam. Their population sizes will be determined also.

When these fish congregate immediately below Gavins Point Dam in the spring they constitute an important sport fishery; however, their movements and habits during the remainder of the year are largely unknown. This segment, as in the two previous segments, we will tag a large number of adults when they are congregated below the dam. The movement information gained from sport fishermen's return of tags will be added to that already gathered in order to discern movement patterns. The determination of movement patterns by returned tags has been slow but each year's information improves our understanding of both distance and time of movements. Fish tracking transmitters, if they are available, may be used to facilitate this determination.

In addition, we will estimate the population size (modified Schnabel Method) in the stilling basin in order to determine the size of the resource.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Nebraska State Government

6.0335, FLATHEAD CATFISH INVESTIGATIONS IN THE MISSOURI RIVER

L. MORRIS, State Game & Parks Commission, *Lincoln, Nebraska* 68509

The objective of this study is to improve our understanding of recent flathead catfish population changes in the Missouri River.

Previous work done under this job suggests that the flathead catfish populatiion has declined since 1964 expressed primarily as a sharp decline in numbers of fish over 13 inches. During this segment we will attempt to pinpoint the year of life and size at which flathead catfish numbers decline. To accomplish our objective we will study flathead catfish environmental requirements through the use of radio transmitters, and their age, rate of growth, and food habits. We will also investigate the amount and availability of food organisms of the flathead catfish.

The data to be collected during this segment will be analyzed and compared with the flathead catfish life history information from earlier segments. In this manner we hope to determine precisely both the reasons for and the time of life at which flathead numbers decline.

It is expected that the collection and analysis of data will be largely the responsibility of a graduate student, Mr. Delmar Holz, of the University of Missourii.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Nebraska State Government

6.0336, INPUT-OUTPUT ANALYSIS OF WATER USE FOR NEBRASKA INDUSTRIES - WATER RESOURCE PLANNING - WATER DEMAND

A.W. EPP, Univ. of Nebraska, School of Agriculture, *Lincoln, Nebraska* 68508

We plan to determine the input-output relationship for water for each major segment of industry in Nebraska including agriculture. We will study the water use interrelationships among industries and the possibilities for multiple use of water. Further studies will be made to determine the opportunities for locating industries to obtain maximum benefits from the available water. It appears possible to develop a programming model that will permit electronic computation of optimal allocation of the available water resources to the various uses. This project will be started in fiscal 1966 and should be completed in fiscal 1968.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Nebraska

6.0337, THE OPTIMUM RELEASE POLICY FOR A MULTIPURPOSE RESERVOIR USING STOCHASTIC HYDROLOGY

W.S. BUTCHER, Univ. of Nevada, Desert Research Institute, *Reno, Nevada* 89507

For a multipurpose reservoir with realistic constraints, and using the historical streamflow record this project will develop an optimum release policy to give maximum expected annual benefits and will determine the risk and uncertainty associated with these returns.

The method will be developed using one or more particular projects as examples. Monthly streamflow will be regarded as a non-stationary Markov Chain and will use dynamic programming to determine the optimal release policy.

Using synthetic hydrology, Monte Carlo methods will be used to determine the risk associated with the annual returns when the optimal policy is used as an operating policy.

The method to be developed on this project will be able to be used in planning studies to determine direct benefits possible from a multi-purpose facility. In addition the method will produce a release policy capable at being used in real time operation of a reservoir.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Nevada

6.0338, ECOLOGY OF SCHISTOSOME DERMATITIS IN WESTERN AND NORTHERN NEVADA WATERS

R.L. CHURCH, Univ. of Nevada, Graduate School, *Reno, Nevada* 89507

Survey for occurrence of causative schistosomes of human dermatitis and the distribution and abundance of their molluscan hosts in selected lentic waters.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Nevada

6.0339, RESEARCH AND ANALYSIS TO PLAN, DEVELOP, AND MANAGE A GROUND AND SURFACE WATER SUPPLY

P.A. DOMENICO, Univ. of Nevada, Water Resources Research Ctr., *Reno, Nevada* 89507

This research has four objectives: 1) to analyze sources of ground and surface water supplies and determine the optimal methods of integrating these supplies, 2) to determine the optimal institutional arrangements for planning, implementing, and managing selected alternative supply integrations, 3) to determine values of water for alternative uses, and 4) to analyze pricing policies and their effects for various uses.

The area of Las Vegas Valley, southern Nevada, was chosen because its problems apply to other arid and semi-arid regions. The problems are acute in that ground-water recently has been over-developed, which has precipitated surface-water importation from Lake Mead. The area is the fastest growing urban region in the United States. Thus, how a new and rapidly growing population plans and organizes for optimal water management is crucial to all arid and semi-arid regions.

Minimizing total annual costs is the objectives function, and mathematical programming will be used to determine optimal water supply integrations. Present and proposed institutional arrangements and water laws will be analyzed through legal research and field interviews. Economic and statistical models will measure values of water in alternative uses, and selected pricing schemes will be investigated to determine water use effects.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Nevada

6.0340, APPLICATION OF SIMULATION THEORY TO WATER RESOURCES PLANNING AND MANAGEMENT

G.B. MAXEY, Univ. of Nevada, Water Resources Research Ctr., *Reno, Nevada* 89507

This research is directed toward development of criteria whereby manifestations of various types of management decisions affecting the optimization of a complex river system may be analyzed and evaluated. Secondly this research is directed toward a detailed study of a) the feasibility of applying a recently developed hydrological simulation technique on a large and very complex hydrological system, and b) the effectiveness of such a technique as a guide in water resources planning.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0341, STATE WATER LAW ORIENTATION TOWARD SCIENTIFIC AND TECHNOLOGICAL BASES FOR EFFECTIVE PLANNING AND MANAGEMENT

J.C. OHRENSCHALL, Univ. of Nevada, Desert Research Institute, *Reno, Nevada* 89507

This research has four objectives: (1) analysis of one or more systems of Western state water laws to determine the historical and socio-political bases for legal classifications and doctrines; (2) determination of the extent to which decision-makers must ascertain common sources of supply; (3) investigation and resolution of conflicts in Western water legislation with the desirability for planning and management purposes of treating all water resources and rights uniformly on a scientific basis; and (4) preparation of recommendations for the water law systems selected for study.

Comprehensive river basin planning and management depend upon allocation of water rights; these depend upon state laws. A model state system of water law should encourage maximum development and security of water rights. The first step is to accommodate state water laws to scientific and technological reality. How to accomplish this step is crucial to all regions of the nation, particularly to the West where water is a regional scarcity and has already become an over developed resource.

Present and proposed institutional arrangements and water laws, including allocations of water among states, will be analyzed through legal research, field interviews, and hydrologic applications in Nevada and similarly-situated neighboring states.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Nevada

6.0342, FERTILIZER-WATER-CULTURAL PRACTICES

R.A. YOUNG, Univ. of Nevada, Agricultural Experiment Sta., *Reno, Nevada* 89507

1. To determine the effects of various combinations of fertilizer, water management regimes and cultural practices on performance of annual crops on 'new lands'. 2. To determine the effects of various combinations of fertilizer, water management regimes and cultural practices on performance of perennial grasses and legumes (emphasis on seed production). 3. To determine the efficiencies of resource use and economic returns from the various combinations.

Field experiments will be conducted with cereal grains and perennial grasses and legumes in which variables of fertilizer, water management regimes and cultural practices will be imposed in various combinations. Performance of crops and efficiency of water use will be determined. Economic returns from the various combinations will be determined.

SUPPORTED BY U.S. Dept. of Agriculture
Nevada State Government

6.0343, ESTIMATION OF HOUSEHOLD CONSUMPTION OF WATER

R.A. ANDREWS, Univ. of New Hampshire, School of Agriculture, *Durham, New Hampshire* 03824

The objective of this study is to quantify the influence of income, family composition, vacation patterns, use of water using appliances, number of bathrooms and household outdoor uses on per capita and per family consumption of water.

The determinants of water demand will be estimated from cross sectional data obtained from families on metered and municipal water systems by mail questionnaire. Traditional cross sectional analysis using single equation least squares and 0-1 techniques will be employed to measure the influence of family characteristics on the families' consumption of water.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of New Hampshire

6.0344, TEMPERATURE TOLERANCE OF MARINE ANIMALS THROUGH BEHAVORIAL RESPONSES

D.W. BRIDGES, U.S. Dept. of Interior, Sandy Hook Marine Lab., *Highlands, New Jersey*

Introduce acclimated and non-acclimated marine organisms into waters of various temperature regimes; observe and measure behavioral patterns such as rate of feeding of fishes, cirral activity of barnacles and pumping rate of bivalves. Diagnose range of temperature in which experimental animals are able to maintain normal behavior as well as determine the thermal death point(s) for these organisms.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0345, DISTRIBUTION OF YOUNG STAGES OF COASTAL FISHES

J. CLARK, U.S. Dept. of Interior, Sandy Hook Marine Lab., *Highlands, New Jersey*

A survey is to be made of the continetal shelf from Cape Cod, Mass. to Cape Lookout, N.C., utilizing the research vessel Dolphin. The goal is to determine relative abundance of young of the major game species in the open estuaries, along the coast, and seaward onto the continental shelf. A series of 14 transects will be established; each extending from the shore to at least the 50-fathom contour. Eight cruises will be made at approximate 1-1/2 month intervals throughout one year. Collecting stations will be spaced along the lines at approximate 10 mile intervals; somewhat closer near shore. At each station along the survey transects a 30-minute oblique tow will be made with 1) a modified Gulf III sampler for larvae and 2) a special 20 foot mid-water trawl for juvenile fish. All fishes taken will be identified to species and isometric charts of abundance of eggs, larvae, and juveniles will be drawn.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0346, INFLUENCE OF THE PHYSICAL ENVIRONMENT ON DISTRIBUTION OF YOUNG STAGES OF COASTAL GAME FISH

R. STONE, U.S. Dept. of Interior, Sandy Hook Marine Lab. , *Highlands, New Jersey*

The fate of critical young stages of coastal migratory fish is governed largely by conditions of the physical environment. Physical measurements of the continental shelf waters will be concurrent with the collection of ichthyoplankton (see 2541-01-in an attempt to relate the distribution of young stages of fish to physical conditions in the environment. Hydrographic stations will be made on each of eight cruises from Cape Cod, Mass., to Cape Lookout, N.C., along 14 transects. Observations will include temperature, salinity, oxygen content and turbidity. Drift bottles and bottom drifters will be released at each station.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0347, AN ENGINEERING-ECONOMIC STUDY OF THE INDUSTRIAL GROWTH POTENTIAL OF THE UPPER PASSAIC RIVER BASIN

A.H. SPINNER, Stevens Institute of Technol, Graduate School, *Hoboken, New Jersey* 07030

New Jersey's eminence as an industrial state has been due in part to industry's settling and growing along its waterways, such as the Passaic River. The complexion of industry has changed as water requirements, river characteristics, and social, political and legal constraints have altered. Further changes in the complexion of industry along the Passaic River can be expected as a result of the promulgation of new water quality standards. It is hoped that the guidelines developed in this study will assist in an orderly industrial growth. Of perhaps equal importance are the methodology and simulation model which will be available for other similar river studies.

The objective of this study is to develop a plan to attain preferential growth patterns for industrial development in the Upper Passaic River Basin given multi-purpose use of the river.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Stevens Institute of Technology

6.0348, EFFECT OF WATER QUALITY ON RESIDENTIAL LOCATION DECISIONS

J.L. BEYER, Rutgers The State University, School of Agriculture, *New Brunswick, New Jersey* 08903

An exploratory project to investigate the probability of finding enough information to warrant an intensive study of the economic effects of water quality--or changes in water quality--on residential location decisions. with deterioration in the quality of surface waters, as this deterioration affects the aesthetics of the environment, seems a reasonable one to make. There are few data, however, from field studies to support the assumption. It would be useful to explore the perception of those engaged in buying, renting, selling, or taxing land and homes with respect to the values they attach to pleasant water environments. The hope here is that a measure can eventually be made of the costs of not maintaining such an environment and their willingness and/or ability to pay is also part of the study.

The Raritan River Basin is suggested as the locus of such a preliminary study. It is a well-defined physical unit with a range of occupance patterns from rural to heavily industrial. Studies of pollution have progressed to the point where adequate information is now available about the actual quality problem for the Raritan and many of its tributaries. Access to developers, real estate dealers, residents, potential buyers, farmers, tax assessors, and conservation workers (watershed association members, etc.) is possible and anticipated.

This preliminary study will be useful primarily in determining the need for more intensive research in an area of decision making which has many implications for planning and future development in a rapidly urbanizing area of New Jersey.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Rutgers The State University

6.0349, THE EFFECTIVENESS OF GOVERNMENTAL ACTION FOR WATER POLLUTION CONTROL IN NEW JERSEY

P.H. BURCH, Rutgers The State University, Graduate School, *New Brunswick, New Jersey* 08903

The objective of this research is to determine the factors which contribute to the effectiveness of governmental action for the control of water pollution. The factors in a given watershed which lead to the development of a pollution problem will be analyzed; the pertinent aspects of government in the watershed will be assessed; and both will be correlated with measurements of the effectiveness of pollution control activities. The study will proceed from an initial phase involving a survey of the literature and interviews with experienced water pollution control personnel, through the development of hypotheses, the testing of the hypotheses in a number of case studies of New Jersey watersheds, and the development of generalized conclusions and recommendations for public policy.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Rutgers The State University

6.0350, A STUDY OF THE DEMAND FOR OUTDOOR RECREATION BASED ON THE ANALYSES OF THE NATIONAL RECREATION SURVEYS OF 1960 AND 1965

P. DAVIDSON, Rutgers The State University, Graduate School, *New Brunswick, New Jersey* 08903

The Bureau of Outdoor Recreation initiated a supply inventory for public recreation facilities throughout the United States. In 1960 the Outdoor Recreation Resources Review Commission sponsored a National Recreation Survey for each quarter of 1950; this was followed up by a similar Survey of Outdoor Recreation Participation by the Bureau of Outdoor Recreation in 1965.

The purpose of this project is to analyze the interactions of demand and supply variables which jointly determine participation patterns of different cross section segments of the population for different activities. A theoretical as well as an empirical model will be used to test different economic hypotheses for different factors, which determine participation in Outdoor Recreation.

The water based outdoor recreation activities have been considered primary activities in this study. This is true because they are important from the demand side because of the vast numbers of participants and from the supply side because of the extensive data that the B.O.R. has inventoried disaggregating recreation water by quantity and quality.

SUPPORTED BY U.S. Dept. of Interior - Bu. Outdoor Rec.

6.0351, URBANIZATION AND ITS EFFECT ON WATER RESOURCES

M. MARCUS, Rutgers The State University, Graduate School, *New Brunswick, New Jersey* 08903

The proposed research is intended to identify, describe, and project major processes of urbanization in relation to land use and water pollution aspects of water resource development. The study will define urbanization in terms of industry and households as the two major urban water user groups.

Dr. Marcus proposes to analyze the aggregate area (New Jersey) economy as a set of industries in which urbanization characteristics can be examined and for which projections can be attempted. Existing industry, employment and population data will be used. The analysis will be organized to describe anticipated changes in the economic dimensions of newly urbanized areas and project industrial growth into the future.

Dr. Newlling proposes to analyze the spatial structure of urban population and areal growth on the basis of a simple urban growth model which uses a density-distance relationship. The technique will be applied to selected test areas using parameters developed from available census and residential land use data. Test projections of increased population and densities will be made for periods of 10 to 20 years in duration.

Dr. Genetilli proposes to study the development of the raw organic pollution load over a period of years in three key watersheds, i.e., the Millstone-Stony Brook, the Raritan, and the Passaic. Following this, a statistical analysis and correlation will be carried out to determine the relationship between growth of pollution load on one hand and growth of population and of specific types of industry on the other. These parameters will then be applied to economic and demographic projections to determine what growth of raw organic pollution load may be expected in key river basins of the state up to the year 2000.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Rutgers The State University

6.0352, THE IMPACT OF SUBURBAN DEVELOPMENT ON THE WATER RESOURCES OF NEW JERSEY.

B. NATHAN, Rutgers The State University, Agricultural Experiment Sta., *New Brunswick, New Jersey* 08903

OBJECTIVES: To compare the water balances of small watersheds occupied by properly managed farms and/or woods to those of matched watersheds occupied by suburban developments.

To determine the practices which will best contribute to proper conservation of existing water and soil resources in agricultural areas undergoing suburban development.

WORK PROPOSED: Rainfall will be measured in a network of standard gauges. Evaporation will be determined with standard pans. Elevations of the water table will be recorded with observation wells and stage recorders. Runoff will be determined in appropriate locations by standard flumes. Stream flow will be determined and recorded by electric velocity probes and current meters and standard hydraulic procedures. Soils will be sampled and moisture contents determined periodically by standard methods. Records of temperature and relative humidity will be kept.

SUPPORTED BY New Jersey State Government

6.0353, IMPROVEMENTS TO THE BOROUGH OF NEW PROVIDENCE SEWAGE PUMPING STATION AND TREATMENT FACILITIES

J.T. MCCANN, New Providence Government, *New Providence, New Jersey* 07974

It is proposed to install two high rate trickling fiters designed to accommodate the extreme range of flows which occur during periods of rainfall, one trickling filter would be constructed with a plastic filter medium; the other would be provided with conventional trap rock or stone filter medium. Following the filters, facilities will be provided to add polyelectrolytes and other chemicals to improve sedimentation efficiency in the final settling tank, also a part of this project. Cholorination facilities will be provided to disinfect the final effluent.

This project will also include the necessary evaluation required to meet the demonstration program objectives. A monitoring program will be pursued, designed to thoroughly evaluate the operation and effectiveness of the separate treatment units as well as the overall effectiveness of the entire installation. The system operation shall be varied so as to develop the most effective and economical plant operation to achieve the desired results.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
New Providence City Government - N. J.

6.0354, ESTUARINE DREDGE HOLE INVESTIGATIONS

W.S. MURAWSKI, State Div. of Fish & Game, *Trenton, New Jersey*

Objectives: To summarize our studies on the ecology of submarine estuarine dredge holes, especially in regard to finfish habitation.

Procedure: Information relative to the location of estuarine dredge holes, their area, depth and other physical characters gained during the course of four years of field work will be analyzed and brought together in a final report.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
New Jersey State Government

6.0355, DETERMINE ECOLOGICAL CHANGES RESULTING FROM IMPOUNDMENT

W.E. SHOEMAKER, State Div. of Fish & Game, *Trenton, New Jersey*

Objectives: To determine ecological changes resulting from impoundment and record the appearance of new vegetation on the dikes with special reference to undesirable vegetation.

Procedures: Prepare cover type maps of the impoundments and establish permanent transects to determine changes in major vegetative types. Record species of vegetation within the impoundments, both submerged and emergent; their densities by estimated percentages; and their heights. Make note of any undesirable vegetation which becomes established on the dikes or within the impoundments. In addition, cost figures will be recorded for maintaining desired water levels.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
New Jersey State Government

6.0356, PATTERNS OF POLICY MAKING IN WATER RESOURCES DEVELOPMENT

H. INGRAM, Univ. of New Mexico, Graduate School, *Albuquerque, New Mexico* 87106

This study aims to set up a model of how the political system in an arid Western State responds to the problems raised by water being a scarce natural resource. The model is to represent the process through which consensus is constructed and maintained on a water policy, and how disagreement which threatens consensus building is handled in the decision making process. Propositions are deduced from the model relevant to the behavior which can be expected of certain actors under certain circumstances. These propositions are tested in a specific instance of water policy making. A case study is made of New Mexico's role in the Colorado River Basin Development controversy. The usefulness of the model is assessed on the basis of the validity of the propositions as tested.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of New Mexico

6.0357, PROJECTING THE DEMAND FOR AND SUPPLY OF WATER

N. WOLLMAN, Univ. of New Mexico, Graduate School, *Albuquerque, New Mexico* 87106

Significance: The nation is faced with numerous problems associated with meeting current and prospective demands for water use. One of the most difficult tasks that has been faced by policy makers and the public generally in dealing with these problems is that of securing a reasonably accurate picture of the water demand-supply outlook. Over the past several years Resources for the Future has supported a series of studies aimed at providing a foundation for a better assessment of the national water situation. The first of these efforts was a study conducted by Professor Wollman under the sponsorship of Resources for the Future and with the cooperation of the Senate Select Committee on National Water Resources and the federal agencies. This study was published as a report of the Senate Select Committee on National Water Resources in 1960. Because of the tentative nature of the results, Resources for the Future has made additional grants to the University of New Mexico for continuation of this line of study under Professor Wollman's direction. Although the further work advanced the methodology of this kind of appraisal, it has not been possible in view of the complexities and difficulties encountered to bring the research to a satisfactory conclusion.

Specific Aims and Expected Results: The general purpose of the study would be to further the development of a methodology for appraising from a national point of view the water demand-supply situation in the United States. The specific objectives would be to: 1. Devise, demonstrate and test a methodology for projecting water supply and demand by regios of the United

States. 2. Provide an up- to-date and greatly improved set of waer supply and demand projections for the 22 major river basins of the United States. The major emphasis in the study would be upon the development of analytical models, the appraisal of the suitability of available data for making projections, and the determination of data deficiencies.

SUPPORTED BY Resources For The Future Incorporated

6.0358, CULTURAL AND MANAGEMENT STUDIES FOR GRAIN SORGHUM ON THE HIGH PLAINS OF EASTERN NEW MEXICO

N.R. MALM, New Mexico State University, Agricultural Experiment Sta., *Clovis, New Mexico* 88101

Objectives: 1. To determine the effects of plant spacing in single and double rows on yield of grain, plant height, test weight, tillering, grams of seed per head, and other agronomic characters under irrigated conditions. 2. To determine the effects of iron and zinc applied as a foliar treatment on the production of grain sorghum. 3. To determine the effects of several micro-nutrients on the production of grain sorghum. 4. To determine the production of grain sorghum as affected by various water management practices.

Description of Work Proposed: Four experiments will be conducted to determine the effect of: 1) various plant populations; 2) foliar treatment with iron and zinc; 3) micro-nutrients; and 4) irrigation treatment on grain production and other agronomic characteristics of grain sorghum. Other agronomic characteristics noted in addition to yield will be flowering date, plant height, exsertion and test weight. For the micro-nutrients experiments, iron, zinc, boron, copper, and manganese and molybdenum will be applied to plots receiving near-optimum nitrogen and phosphorus. All experiments will be irrigated.

SUPPORTED BY New Mexico State Government

6.0359, DECISION MODELS FOR MINIMIZING COST OF INFORMATION OR ERROR IN ESTIMATING BENEFIT-WATER RELATIONSHIPS IN IRRIGATION. (ABBREV)

R. DARGE, New Mexico State University, Water Resources Research Inst., *Las Cruces - University Park, New Mexico* 88001

One of the most critical elements required for the application of mathematical models to water resource systems is the estimation of the relationships between quantity and/or quality allocations, and the resulting net benefits generated. The application of incremental benefit measurements to allocation problems has not been explored to determine their reliability and the cost of gaining the necessary information as compared with the present means of developing models. It is contemplated that existing systems methods can be utilized with some alterations to develop alternative sets of decision rules. Net benefit functions will be developed and tested.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
New Mexico State University

6.0360, IRRIGABLE ACREAGE IN NEW MEXICO AND PROJECTED DEMANDS FOR IRRIGATION WATER

M.L. HANSON, New Mexico State University, Water Resources Research Inst., *Las Cruces - University Park, New Mexico* 88001

Irrigated and potentially irrigable land areas of New Mexico will be classified according to physical and economic feasibility of irrigation. Crop enterprise budgets will indicate production alternatives for potential irrigation development. Projections of irrigable acreage will proceed assuming unlimited availability of capital, labor and water.

Productivities of additional water supplies to maintain or increase irrigation development in all areas of the state will be estimated when allocated to highest agricultural uses based on projected production coefficients, price relationships, and discount rates. The demands for irrigation water will be estimated in the context of economic development or growth.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
New Mexico State University

6.0361, LAND AND WATER VALUES IN EASTERN NEW MEXICO

D.C. HENDERSON, New Mexico State University, Agricultural Experiment Sta., *Las Cruces - University Park, New Mexico* 88001

The objective of this study is to calculate guidelines for determining depletable irrigation water costs in Lea, Roosevelt, Curry and Quay counties. Data will be collected on land sales from a date of about 1948 to present in the study area to determine: (1) at what point in time a price differential began between land with underground water supplies suitable for irrigation and land without such supplies. (2) an allocation of the original purchase price between the land including all improvements and the depletable ground water supply. Any value attributable to non-farm uses must be excluded. Guidelines will be constructed by homogeneous areas for percent of irrigated land value attributed to irrigation water, maximum values for the depletable water cost base and minimums for the dryland value. Guidelines will be verified with knowledgeable people in each area.

SUPPORTED BY New Mexico State Government

6.0362, A COMPREHENSIVE WATER RESOURCES ANALYSIS OF A TYPICAL OVERDRAWN BASIN IN AN IRRIGATED SEMIARID AREA - PECOS RIVER BASIN, NEW MEXICO

C.E. JACOB, New Mexico State University, Graduate School, *Las Cruces - University Park, New Mexico* 88001

The objectives of this project are: (1) To develop basic physical and sociological data. (2) Analyze the surface and sub-surface hydrologic system by use of digital and analogue computations using techniques of systems analysis and linear programming. (3) Develop a mathematical decision-model for the design and operation of an overdrawn water supply system. (4) Establish primary land classification and cost and returns information for guiding the present and future agricultural uses of water. (5) Develop a method of economic and legal analysis appropriate for a region with surface and groundwater for the maximization of the region's economic welfare.

This interuniversity-interdisciplinary project is bringing together the many factors into an overall analysis as well as refining the information for each disciplinary segment. The decision model, the gross systems analysis and the economic legal analysis will combine the several factors for analysis on the basis of the whole basin, and its interrelated problems, rather than considering each segment separately.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
New Mexico State University

6.0363, ECONOMICS OF WATER SUPPLY-PORTALES VALLEY, NEW MEXICO

R.B. LONG, New Mexico State University, Agricultural Experiment Sta., *Las Cruces - University Park, New Mexico* 88001

Objectives: 1. Evaluate the past, present and future water supply of the Portales Valley and its current and future influence on the economy of the area. 2. Evaluate the new proposals to bring water to the valley from nearby wells and from the Ute Reservoir, and the impact of these alternatives on the agricultural economy of the area.

Description of Work Proposed: The work to be conducted will be separated into two parts. First, secondary historical data will be secured from the State Engineer, County, A.S.C. office, etc., to determine: water use for agriculture, municipalities, and industry; precipitation; water levels in observation wells; thickness of the water bearing strata; and population. Secondly, data will be collected to determine the cost of water from sources outside the valley, farm size and crop structure, and budgets for the major crops and livestock enterprises in the valley. These data will then be analyzed, and the proposed publications prepared.

SUPPORTED BY U.S. Dept. of Agriculture
New Mexico State Government

6.0364, EFFECTS OF RESTORATION AND MANAGEMENT OF THE SAN SIMON MARSH ON ITS UTILIZATION BY MEXICAN DUCKS

F.W. MARTIN, New Mexico State University, Agricultural Experiment Sta., *Las Cruces - University Park, New Mexico* 88001

Objective: To assist the Bureau of Land Management in a program to preserve Mixican duck habitat by gathering basic facts concerning effects of restoration and management of the San Simon marsh on the development of a self-sustaining population of Mexican ducks.

Work Proposed: Four impoundments, one acre or less in size and from four to five feet deep will be constructed. Two of these impoundments will be fenced to exclude livestock. These ponds will be interconnected and will contain islands for nest and loaf sites. The aquatic and upland vegetation will be mapped and vegetation important for nesting or food may be introduced if this appears desirable and feasible. Studies will be conducted on species of waterfowl use, distribution, number of broods and effects of normal grazing on utilization of habitat.

SUPPORTED BY U.S. Dept. of Interior - Bu. Land Mgmt.

6.0365, EFFECT OF RATE OF SEEDING AND THE APPLICATION OF AGRICULTURAL CHEMICALS ON YIELD AND QUALITY OF ALFALFA SEED

B.A. MELTON, New Mexico State University, Agricultural Experiment Sta., *Las Cruces - University Park, New Mexico* 88001

1. To determine optimum seeding rates and planting methods for alfalfa seed production. 2. To investigate the effects of rates and frequencies of irrigation on alfalfa seed yields. 3. To evaluate the effects of the number and time of forage harvests on the yields of alfalfa seed. 4. To evaluate new and promising herbicides, growth regulators and desiccants for alfalfa seed production (as they become available through preliminary evaluation tests).

Description of Work Proposed: Selected seeding rates from 1/2 to 20 pounds per acre will be evaluated in 12-inch rows, 24-inch rows, 40-inch beds with 2 rows per bed, and in broadcast plantings. The effects of time and number of forage harvests on yields of alfalfa seed will also be evaluated. The rate and frequency of irrigation will be evaluated for efficiency of water utilization and effects on seed yields. Promising herbicides, growth regulators and desiccants will be evaluated for possible use for seed production as indicated by preliminary screening conducted within other projects.

SUPPORTED BY New Mexico State Government

6.0366, A COMPREHENSIVE WATER RESOURCES ANALYSIS OF A TYPICAL OVERDRAWN BASIN IN AN IRRIGATED SEMIARID AREA - PECOS RIVER BASIN, NEW MEXICO

H.R. STUCKY, New Mexico State University, Water Resources Research Inst., *Las Cruces - University Park, New Mexico* 88001
WOLLMAN

An interdisciplinary-interuniversity research project, which includes a unified approach on the part of the University of New Mexico, Albuquerque; New Mexico Institute of Mining and Technology, Socorro; and New Mexico State University, University Park, New Mexico, in a water basin which has problems, the solution of which have local, state, regional and national significance.

The Pecos River Basin in New Mexico is a typical river basin in the irrigated West. This project includes a gross-systems analysis by Civil engineers, a general economic and economic land classification (as affected by water supplies and as it would effect water use) by economists and agricultural economists; a digital and analog computation based on known facts about the surface and subsurface hydrology, and a legal study. These will assist in bringing together a total resources analysis to the end that the available and exploitable water resources analysis may be put to optimum use. This will be done with proper regard being given to the hydrologic and geologic phases as well as the agronomic, biologic, economic and legal phases.

There are many basic facts available on the numerous and complex problems such as overpumping, saline water encroachment, increasing total water demands, and water laws and regulations.

The hoped for success in sharpening and refining the water balances, based on this research, will be of great assistance to the over-all future economy of the New Mexico portion of the river basin, as well as to the section of the Pecos River in the State of Texas. The Pecos River Compact signed in Santa Fe in December 1948, provides for the regulation and division of the Pecos waters between the two states.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
New Mexico State University

6.0367, TURFGRASS MANAGEMENT

C.E. WATSON, New Mexico State University, Agricultural Experiment Sta., *Las Cruces - University Park, New Mexico* 88001

Objectives: 1. To determine the effect of varying amounts of nitrogen, phosphorus, potassium, and minor elements in turfgrass growth and quality. 2. To determine weed control, residual effects and damage to turf by various herbicides when used against cool or warm season and annual or perennial weeds. 3. To determine the resistance to compaction, percolation or water and water holding capacity of various soil mixtures, and growth of grass with and without soil amendments or conditions. 4. To observe new varieties and strains of cool and warm season turfgrass plants for adaptation to climate, soils, and to determine turf quality under southern New Mexico conditions.

Description of proposed work: The fertilization phase will include 20 treatments with the three major elements of nitrogen, phosphorus and potassium. Iron, zinc and manganese will be the only minor elements considered. Studies will include chemical methods of weed control. testing will include various soil and sand mixtures, and the effect of amendments and conditioners on soils. Observations will be made on new varieties, strains, and species of promising plants for use as turf.

SUPPORTED BY New Mexico State Government

6.0368, EVALUATION OF MARINE AND ALKALI TOLERANT SPECIES INTRODUCTION IN THE LOWER PECOS RIVER

W.J. MCNALL, State Dept. of Game & Fish, *Santa Fe, New Mexico*

Procedures: Orangemouth corvina, sargo, and bairdiella, gifts from California, will be taken from the Salton Sea and introduced into the Pecos River from Malaga Bend southward and the Bottomless Lakes. Sacramento perch, a gift from Nebraska, will be released in alkaline waters of southeastern New Mexico where game fish populations are limited due to the alkalinities. Survival, migration, and reproduction will be determined by standard population sampling. Chemical phenomena will be determined from U.S.G.S. data and field analysis. Harvest, when such occurs, will be determined from conservation officers' creel census records.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
New Mexico State Government

6.0369, EVALUATION OF IRRIGATED PASTURE GRASSES

D.H. WILLIAMS, New Mexico State University, Agricultural Experiment Sta., *Tucumcari, New Mexico* 88401

Objectives: 1. To determine the performance of selected sudangrass-sorghum crosses, hybrid sweet sudangrasses and millets grown under irrigation in northeastern New Mexico. 2. To determine the performance of six selected grass pasture crops grown with three rates of nitrogen fertilization under irrigation in northeastern New Mexico.

Description of work proposed: Sudangrass and millet varieties, crosses, hybrids and/or strains will be fertilized with three applications of nitrogen and their adaptability for possible use in this area as temporary summer pasture crops will be evaluated. Measurements will be made on their green, air-dry yields, recovery after cutting and other related factors.

Six grasses - Midland, Coastal, Common, N.K.37, WS-300 Bermuda grasses and Blackwell Switchgrass - will be grown with three levels of nitrogen fertilization. All plots will be overseeded with Hairy Vetch each fall. Measurements will be recorded on green and air-dry yields, stand, recovery after cutting and other characteristics.

SUPPORTED BY New Mexico State Government

6.0370, REGIONAL COMPREHENSIVE MULTI-PURPOSE WATER RESOURCES PLANNING STUDIES

***F.W. MONTANARI*, State Conservation Department, *Albany, New York* 12226**

Each study involves an inventory of the water resources, quantity and quality, of the basins under investigation; an assessment of present needs (including recreation, irrigation, public water supply, low flow augmentation, fish and wildlife, power, navigation, etc.) in terms of water resources development; and a projection of future needs and identification of means and preparation of plans for meeting them. An economic base study is made to determine present economic make-up of the area, and to make the necessary projections of population growth, industrial change, etc.

Hydrologic and economic information are obtained from analysis of existing data and intensive data collection using field observation, interviews, and mail questionnaires.

At present, regional studies under six water resources planning and development boards are underway. The Erie-Niagara Basin investigation under one board was begun in 1963 and will be completed in 1968. The Upper Seneca portion of the Oswego River Basin is being studied under two boards. This study was initiated in 1964 and will end in 1970. The Eastern portions of both the Susquehanna River Basin and the Oswego River Basin are being studied under two boards created in 1967; an Allegheny Basin board was also created in 1967. During fiscal year 1968-69 studies of several other regions will be started. These include the Western Susquehanna, the Delaware, the Black, the St. Lawrence, and the Genesee Basins.

A non-salaried seven-man Board composed of local leaders appointed by the Water Resources Commission, is responsible for the conduct of the study and for evolving comprehensive plans for development of each region. Office space, equipment, technical, legal, engineering, clerical and other personnel and services are provided by the Commission. The Commission is composed of the heads of seven State Departments--Conservation (Chairman), Agriculture and Markets, Commerce, Health, Law, Transportation and the Office For Local Government.

SUPPORTED BY New York State Government

6.0371, PHYSICAL & CHEMICAL PROPERTIES OF WATER & SOILS OF MARSHES AS THESE PROPERTIES RELATE TO THE SUCCESS OF WATERFOWL FOODS & COVER.

***J.D. LATHWELL*, State Div. of Fish & Game, *Albany, New York* 12226**

Procedure: Procedures under this job may be catalogued under three heads; biological, chemical and physical. 1. Biological a. Throughout the growing season changes in growth and color of established plantings will be noted. At the end of the growing season air-dry weight will be obtained for the growth in each plot, intensity of seed production will be determined, and if possible, seeds will be analyzed for nutrient content. b. Unwanted vegetation will be removed from between the plots by mowing and within the plots by hand weedings. 2. Chemical a. Analyze for dissolved oxygen by the Winkler and Oxygen meter methods of water taken at the surface, and at one foot intervals to and including the bottom. Samples to be obtained in vegetated and non-vegetated areas. b. Using the Tarow indicator, analyze water samples for total alkalinity obtained at the same locations and at the same time water is collected for dissolved oxygen determinations. c. Measure the pH of the surface and bottom water by using a Beckman pH meter. d. Determine the concentrations of carbon dioxide by using a nomograph. e. Using spectrophotometer, analyze water samples from main marsh and from selected 1/10 acre marshes for nutrient content. This will show the nutrient level for 13-15 major components of the water. f. Using techniques defined by Greweling and Peech, soil samples obtained from each one-tenth acre area will be analyzed for nitrogen, phosphorus, potassium, calcium, magnesium, iron, aluminum and manganese. Soil organic matter and soil pH will also be determined. Samples will be obtained quarterly. In addition soil samples will be obtained from selected marshes throughout the growing season to study in detail quantities and forms of iron and manganese present in various layers of the soil. In addition forms of inorganic nitrogen will be determined. Oxygen consumption as a measure of biological activity will be measured on selected soil cores. These data will be used in an attempt to predict the state of oxidation or reduction of the soils as they may be related to vegetative growth. 3. Physical a. Maintenance of proper water levels. b. Maintenance of weather station. c. Measurements of soil temperatures. d. Measurements of surface temperatures of the water. e. Measurements of water transparency. 4. Appraisal -- Preparation of a publication documenting plan, objective and status of studies with recommendations for the future.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
New York State Government

6.0372, EFFECT OF LIMNOLOGICAL CHANGES ON SURVIVAL OF YOUNG FISH IN ONEIDA LAKE

***R.L. NOBLE*, State Div. of Fish & Game, *Albany, New York* 12226**

Objectives: Determine aquatic plant and bottom fauna distribution and abundance and compare with surveys conducted in 1916-1918 to determine if major ecological changes have occurred; monitor annual fluctuations in zooplankton and bottom fauna abundance; develop procedures for measuring zooplankton production and its utilization by young fish.

Procedure: A. Repeat survey of Lower South Bay (Baker, F.C. 1918. The productivity of invertebrate fish food on the bottom of Oneida Lake with special reference to mollusks. N.Y.S. College of Forestry Tech. Pub.9) 1. Complete analysis of 120 bottom samples taken in Lower South Bay during 1967 and summarize data comparing aquatic plant distribution in 1916 and 1967. 2. Review biological and water quality data collected since 1916 by various agencies (4 surveys). 3. Determine extent of changes in limnological parameters which have been measured; their possible relation to rapid urbanization of the watershed, and future effect on the fishery. B. Establish sampling program to monitor annual changes in plankton and bottom fauna. (The U. S. Geological Survey is currently conducting an intensive limnological survey on Oneida Lake and this segment of the project will not be initiated until the USGS program is terminated in 1969.) C. Measurement of zooplankton abundance and utilization by young yellow perch. 1. Estimate zooplankton density from samples taken at weekly intervals with Isaacs-Kidd sampler during May through July. 2. Obtain estimates of zooplankton consumption by rearing young perch on known quantities of plankters. 3. From estimates of young perch density obtained under Job I-b compute portion of zooplankton standing crop utilized by perch production.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
New York State Government

6.0373, THE USE OF SYSTEMS ANALYSIS IN THE DEVELOPMENT OF WATER RESOURCES MANAGEMENT PLANS FOR NEW YORK STATE

***A.C. TEDROW*, State Div. of Water Resources, *Albany, New York* 12226**

The proposed research is intended to develop tools of systems analysis for use in the water resources planning studies undertaken by New York State. The study will provide techniques for use with current information levels in on-going planning surveys as well as pointing the way to more fruitful data collection efforts for providing better inputs to higher levels of analysis.

The research will be conducted concurrently with an on-going planning study. It will start with the development of rudimentary mathematical models and simulation techniques and then will proceed to higher levels as more information becomes available.

At each level of development, an evaluation will be made as to the benefits derived from that particular mode of analysis and the implications on the collection of data.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0374, STOCHASTIC BASIS FOR COMPREHENSIVE RIVER BASIN PLANNING

F.G. HAAG, Union College & University, Graduate School, *Albany, New York* 12208

Systems analysis and stochastic methods will be utilized to identify optimum river basin plans. In particular Monte Carlo probability simulation will be applied. Wherever possible known probability frequency distributions will be used for the physical parameters that are significant to water resources. However, where probability frequency distributions do not exist they will be developed analytically and correlated with available data. The overall mathematical model for the physical variables of a river basin will be developed and programmed for the digital computer. The results obtained when the model is applied to the Hudson River system will be compared against data that is available from New York State and the U.S. Geological Survey.

Economic data will be developed to permit relating the cost of alternate water development plans (e.g. waste treatment plants, water storage, and water transmission facilities) to the relative economic benefits to alternate users (e.g. recreation, industrial, commercial fishing and transportation).

The physical and economic models will be coupled and optimization techniques will be applied to evaluate various performance criteria. The use of stochastic methods will permit more realistic decision making by water resources management because the uncertainty will be described quantitatively in terms of confidence levels.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Union College & University

6.0375, SOCIAL CONSEQUENCES OF VARIATION IN AGRICULTURAL IRRIGATION

B. PASTERNAK, State University of New York, Graduate School, *Buffalo, New York* 14214

This research promises to determine the social and political consequences of modifying an irrigation system in such a way as to equalize or disequalize access to water. Attention will be especially focused upon the relationship between irrigation and local patterns of conflict and cooperation. The general hypothesis which will be tested to achieve this objective is that disequalization of access to irrigation water will result in an intensification of conflict over water; an expansion and formalization of local cooperative networks; and less intensive labor demand peaks. Where access to irrigation water is equalized, on the other hand, the opposite results will ensue.

The methodology will be controlled comparison. New data to be collected in a village on the Chianan Plain of Formosa (a disequalized irrigation setting) will be compared with that collected earlier in a village on the Pingtung Plain (an equalized irrigation setting). The technique of participant-observation, interview, and historical inquiry will be used in the field to collect new data. The proposed project is intended to provide comparative data on relevance to a more general, long-range study of the relationships between local water managerial systems and specific forms of social and political organization. A clearer appreciation of such relationships would be of predictive value to those involved in the alteration or modification of irrigation systems, particularly those concerned with the possible social consequences of such changes.

SUPPORTED BY U.S. National Science Foundation

6.0376, STUDY OF EXCRETORY PATTERNS IN CRAYFISHES

M.L. SHARMA, State University of New York, Graduate School, *Fredonia, New York* 14063

Crayfishes are freshwater crustaceans. On a few occasions, they have been reported from slightly brackish waters. They have also survived for long periods in water of relatively high salt content. The applicant acclimated specimens of Orconectes rusticus to 50% sea water. The environmental osmotic stress brought about a reversible shift toward ureotelism in their mode of nitrogenous excretion. This shift toward ureotelism by the adult ammonotelic crayfishes is neither related to phylogeny nor does it serve as a water-conserving device. In the latter respect, it is at variance with the widely accepted view of Needham. Therefore, it appears that the ureotelism exhibited by Orconectes rusticus differs from those so far reported in the literature. This raises questions about the sources of this increased urea production, its utility, and the mechanism of its synthesis. Further, since it does not act as a water-conserving device, it raises the possibility that the changes in the pattern of nitrogenous excretion under osmotic stress are not necessarily related to the availability of water but may be triggered by some other factor. These questions were partly investigated during the summer of 1967. One paper is in press and another will be submitted very shortly. It is proposed to further the project by undertaking the following studies: (a) the determination of the contribution, if any, of purine degradation to increased urea production; this will involve the estimation of the activity of uricolytic enzymes. To begin with, the estimation of urease and uricase activity will be undertaken. (b) a determination of total nitrogen excreted and its partition into various excretory products.

In view of the interesting results obtained so far, it is proposed to extend the project on a comparative basis. For this purpose, the applicant will apply for a federal grant next year.

SUPPORTED BY State University of New York

6.0377, RHEOTAXIS IN ALGAL METABOLISM AND PHOTOSYNTHESIS

K.G. WOOD, State University of New York, Graduate School, *Fredonia, New York* 14063

Rheotaxis of algae has been a neglected area of study despite the fact that growth of the sessile alga, Cladophora, has become a major problem along the wave-swept shores of Lake Erie and other eutrophic lakes. This alga lives in areas of intense water movement, but breaks away during storms to wash ashore and forms rotting masses of vegetation to the detriment of recreational use of the shore. The proposed study will be part of a continuing investigation of the physiology of this alga.

Two questions are involved in this study: (a) Does rheotaxis augment the rate of respiration and/or photosynthesis? (b) If the results of part (a) are positive, does rheotaxis act through mechanical stimulation per se or does it merely provide a steeper diffusion gradient between the cells and their environment?

The biological parameters to be investigated will be carbon dioxide uptake in the light and carbon dioxide output in the dark. Algae enclosed in full containers of water will be subjected to various shaking procedures. The carbon dioxide content of the water will be determined gasometrically at the beginning and end of the experiments. In addition, the isotope method with carbon-14 will be employed simultaneously to yield an independent estimate of the phytosynthetic rate. This dual approach in the photosynthetic studies will improve greatly the validity of the results as shown by the applicant (Wood, in press). Nutrient levels will be increased in some experiments in an attempt to lessen the diffusion gradient required by the algae. There may be an equivalence between nutrient level and rheotactic effect.

SUPPORTED BY State University of New York

6.0378, FLORA OF THE GENESEE COUNTRY--AQUATIC VASCULAR PLANTS CONESUS LAKE COMMUNITY STUDIES

H.S. FOREST, State University of New York, Graduate School, *Geneseo, New York* 14454

Flora of the Genesee Country (10 county area including Genesee River Basin in New York).

A. Aquatic vascular plants: search and summary of reports, location and verification of herbarium specimens, and collection of specimens to establish identity, distribution, and frequency. B. Conesus Lake (Livingston Co.) Community Studies. 1. Algae: identity, frequency, seasonal distribution. 2. Aquatic vascular plants: identity, distribution, quantitative community composition. 3. E. coli: quantity, distribution, sources. 4. Phosphate budget.

These studies are being coordinated with limnological studies by Dr. K. M. Stewart (SUNY, Buffalo) and with fish management plans of the State Conservation Department.

SUPPORTED BY State University of New York

6.0379, A STUDY OF POTENTIAL INSTITUTIONAL ARRANGEMENTS FOR WATER POLLUTION CONTROL IN THE HUDSON-MOHAWK RIVER BASIN

L.B. DWORSKY, Cornell University, School of Engineering, *Ithaca, New York*

Basin or sub-basin wide solutions to water pollution problems are technologically feasible considering existing technology and are possible conceptually using new and developing technology. Such solutions are expected to result in economies of scale operational efficiency and the establishment of an improved priority basis for scheduling and pollutional control efforts.

A major obstacle to the development of basin or sub-basin wide solutions has been the lack of modernization of governmental institutional arrangements to stimulate and encourage the early and efficient utilization of existing and newly developing technology for the public benefit.

The research proposes to develop alternative institutional arrangements for the Hudson-Mohawk River Basin, or appropriate sub- basin units, to achieve a substantially improved water pollution control program for the study basin.

The plan of research will consider basin history, geography and culture; current water pollution control programs of state, federal, compact and local agencies; government organization affecting water pollution control; water pollution control plans; preliminary type engineering-economic studies of alternative pollution control measures; formulation of criteria to consider in the development of regional institutional arrangements for pollution control; the relation of alternative institutional arrangements for water pollution control to local water and waste water utility services, and to multi-basin and multi-purpose water and related land resources development programs in the northeastern United States. The research will conclude with a synthesis, recommendations and supporting references.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Cornell University

6.0380, WATER RIGHTS & WATER LAW & THE EFFECTS OF THESE ON THE DEVELOPMENT & UTILIZATION OF THE WATER RESOURCES OF NY STATE (ABBREV)

W.H. FARNHAM, Cornell University, Graduate School, *Ithaca, New York*

In general, the scope of the project is concerned with adjusting and improving the legal structure for the more effective use of known or newly developed technology. This will insure an adequate supply of water at the proper time in the proper place and of the right quality in New York State to serve all human requirements. Cornell University Water Resources Center together with the New York Temporary State Commission on Water Resources Planning proposes to study (1) the question as to whether the state of New York has proprietary rights or rights as trustee for the public in the waters of the State, as distinct from its police and navigation powers over such waters, and (2) the question as to whether the state, if it has such rights, is by virtue thereof, authorized to modify riparian rights in furtherance of the public interest. In addition, the investigation will include studies of such questions as the following: What changes should be made in the constituent rules of an administration of the riparian doctrine which in New York and in other eastern states has for many years determined rights and privileges with respect to streams? What changes should be made in the New York law governing the use of an interference with the flow of surface and percolating waters and in the administration of that law?

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Cornell University

6.0381, RESEARCH ON DECISION MAKING AND RELATED MANAGERIAL ASPECTS OF BRITISH WATER RESOURCES PROGRAMS

E.S. FLASH, Cornell University, Graduate School, *Ithaca, New York*

Under the social science aspects of the research program of the Cornell University Water Resources and Marine Sciences Center, this project will investigate and analyze the processes of policy development and implementation operating in British water resources programs carried out under the Water Resources Act of 1963. To determine the impact of relevant substantive, political, and administrative factors, the research will focus on the relationships between political executives and professional experts as they participate in the creation and execution of particular programs related to development in the South East Region of England. By providing a valuable basis for comparative analysis, this research will contribute to the solution of managerial problems associated with American water law and institutions. Research on particular decision-making situations will be accomplished by review of public and available official documents and by interviews with officials of national and local organizations including river authorities, business executives, academicians, and private citizens. The entire project will be conducted by Professor Flash. He will work in England and have access to the facilities of the London School of Economics and Politics, and, on a temporary basis, to those of the University of Glasgow. He will also make such field trips as necessary.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Cornell University

6.0382, MATHEMATICAL MODELS OF HYDROLOGIC SYSTEMS

J.A. LIGGETT, Cornell University, School of Engineering, *Ithaca, New York*

The overall objective of this research is to contribute to the economic design of water resource systems. In particular we are considering systems which require the description of complete flow hydrographs for design purposes such as urban and rural storm drainage systems, river systems involving unsteady discharges from dams, hydro power plants, and sewage outfalls, and estuaries. In each of these cases the water quality aspects may be very important and, in general, a good description of water quality involves knowledge of quantities. A physically sound description of flow in channels or over surfaces is provided by shallow water theory. At present the equations of shallow water theory are of limited use to engineers because their solution is very complex. However, these equations can be solved on the digital computer; many of the solutions can be put in table or chart form for ready use. Thus calculations involving the unsteady flow of water with a free surface can be made accuurate through use of exact physical analysis.

The overall objective must be pursued in a sequential manner. We have selected as the first objective of this project the development of shallow water theory in a manner such that it can provide a practical tool for research and design.

Subsequently we propose to investigate the design process itself and to develop general techniques and procedures for the design of hydraulic structures. These procedures will involve the physical processes investigated under the first objective as well as economic theory and may utilize systems analysis techniques.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

6.0383, STOCHASTIC MODELS FOR WATER RESOURCES MANAGEMENT

D.P. LOUCKS, Cornell University, School of Engineering, *Ithaca, New York*

Analytical methods are to be developed which incorporate the complex stochastic nature of streamflow and runoff into models for defining alternative policies for managing both the quantity and quality of water within a developed river system. The solutions of these stochastic programming models will indicate the daily reservoir releases and the quantities of water that should be allocated to each water use, so as to best achieve some physical or economic management objective and at the same time, satisfy all the requirements that are imposed upon the system. The study will begin in Fiscal Year 1968 and span a two-year period.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0384, IMPACT OF WATER BASED RECREATION

D.J. ALLEE, State University of New York, School of Agriculture, *Ithaca, New York* 14850

The general problem is how to relate the capacity of water and related land resources to provide recreation services with the growing demand for those services in the context of comprehensive water resources planning. Specifically, selected aspects of relevant biological processes and physical features will be studied to describe the production function for recreation services of one of the New York Finger Lakes and two old flood control reservoirs which have just recently been partly converted to recreation use. Included in this will be a specification of substitution relationships with other water uses, and a review of public and private inputs including institutional changes. In turn these production relationships will be related to estimates of the demand for recreation services and its growth in the service areas of these bodies of water. Measurements and projections of both direct and indirect benefits will be attempted. The objective is to develop and test, theoretically sound operational planning procedures while adding to our meagre fund of knowledge about water based recreation, its economics and its technology.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Cornell University

6.0385, SUPPLY AND DEMAND FOR WATER

D.J. ALLEE, State University of New York, Agricultural Experiment Sta., *Ithaca, New York* 14850

This is a part of the C. U. Water Resources Center project of the same title. It will contribute to the technology of projecting of water use by user type and for relevant use regions by 1) developing overall methodology to delineate such regions and make projections, 2) identifying the weak links in such methodology and attempting to devise means of strenghtening them. Water supply projection techniques require the identification of the means of satisfying the use projections. The Northeastern United States is the current focus.

DESCRIPTION OF WORK - A transportation model, one type of linear programming, appears to provide an organizing framework as it envisions a series of supply points and use points (regions), can be adapted for supply and demand schedules, and includes transfer cost relationships. It lends itself to the segmentation of the problem, allowing any one researcher to work on a single part, for example the use of water by a single industry. An examination of water use overtime and space is expected to include the reaction of use to cost (price) as well as population, income, sector output and changes in technology. Agricultural Economics will develop demand relationships for selected water use sectors. Initial emphasis will be on pulp and paper products, livestock, food processing, recreation, and irrigation. Also general assistance will be given to the general handling of demand.

SUPPORTED BY New York State Government

6.0386, WATER RIGHTS AND WATER LAW

D.J. ALLEE, State University of New York, Agricultural Experiment Sta., *Ithaca, New York* 14850

Within the overall Cornell University Water Resources Center project personnel from these two departments will relate findings of law to specific water use situations with special attention to rural areas. They will also identify areas of uncertainty which water users have encountered that relate to the law. Particular aspects of the law which will be studied include, 1) The State's proprietary rights as distinct from police or navigation powers and the relation of these to riparian rights and in turn to allocation powers of the State, 2) changes in administration, eg. permit system, 3) effect of a permit system on existing users, 4) alternatives for adjudication of conflicts, 5) operation of a reasonable use doctrine, 6) implication of the legal distinction between stream, surface and perculating water.

DESCRIPTION OF WORK -- On the one hand the unique circumstances of water use in New York State will be studied and on the other hand the existing law of the state, in other states and experience in other states will be examined. A synthesis of these will be made in order to prepare alternative recommendations and reasons for each. Particular attention will be given by these departments to the application of the current status of the law as it now affects rural water users.

SUPPORTED BY New York State Government

6.0387, EFFECT OF INCUBATION TEMPERATURE ON SURVIVAL OF LARGEMOUTH BASS EMBRYOS

A.W. EIPPER, State University of New York, School of Agriculture, *Ithaca, New York* 14850

Objectives of this project are 1) To determine if egg age, acclimation, or both factors produced mortality differences between acclimated and non-acclimated embryos observed during 1966 at temperatures above 25 C and below 12.5 C, 2) To observe the effects of sudden temperature shifts on bass eggs of various known ages, 3) To determine the developmental stage at which non-acclimated embryos are most critically affected by sharp temperature changes. Water temperature control facilities were expanded to permit precise control of temperature in 20 50-gallon aquaria, and a method for collection of spawning bass with an electric shocker was devised. Experiments were begun in 1967 to determine the effect of temperature on mortality of largemouth bass embryos. Artificially-fertilized eggs were obtained by mixing gametes of a pair of spawning bass caught with the electric shocker. Embryos were divided into lots of 20 per container, and all embryos started at 20 C. At 5 hr. intervals, some embryos were subjected to sudden temperature changes, and others reached final incubation temperatures from 10 C to 30 C via acclimation rates of 0.3 C and 1 C. Total mortality, determined three days after hatching, indicated no evidence of a 'critical' temperature-sensitive period. There was indication of a broad temperature tolerance zone between 15 C and 25 C, within which mortality varied relatively little. Mortalities occurring at the extreme temperatures (10 C and 30 C) decreased slightly with age, regardless of acclimation. The effect of temperature alone seems insufficient explanation of high mortalities observed by earlier workers in nature during the early life of the bass. Experiments were repeated during the bass spawning season in 1968, and analysis of data is in progress. Mr. Swallow's thesis, which reviews literature on the effect of water temperature on survival of fish eggs, is in final stages of preparation. This project was begun in 1965 and will be terminated in 1970.

SUPPORTED BY U:S. Dept. of Interior - Bu. Sport Fish.
New York State Government
Cornell University

6.0388, CONSERVATION AND DEVELOPMENT PLANNING FOR THE ESTUARINE ZONE (A CASE STUDY IN THE TOWN OF SOUTHOLD, LONG ISLAND)

L.S. HAMILTON, State University of New York, School of Agriculture, *Ithaca, New York* 14850

The estuarine zone, where fresh and salt water meet, is probably as rich in situations where one man's actions can inadvertently affect another man's welfare as any in the world of natural resources. Dredging, waste disposal, filling and bulkheading, silt and the like, can lay waste to the spawning grounds for fin fish, shellfish beds and areas of unique ecological significance. Important commercial, recreational and esthetic values can be quickly lost. Planning, controls and public investiment decision processes have been developed to specifically solve these types of problems in other environments, but little has been done here. New institutions and approaches are required.

This project proposes to study the estuarine zone of an important part of Long Island in an attempt to identify the mechanisms by which problems arise, to determine the existing and potential roles of public agencies, and to develop an approach--essentially a planning methodology--suited to the evaluation of the public interest in the estuarine zone in meaninful policy amd program terms. This project will seek positive means whereby local governments can both promote new economic development and still enjoy the fruits of this rich marine resource.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Cornell University

6.0389, A CASE STUDY OF WATER RESOURCES DEVELOPMENT - AN ANALYSIS OF A PROPOSED PROJECT ON THE MISSOURI RIVER

L.S. HAMILTON, State University of New York, School of Agriculture, *Ithaca, New York* 14850

The objective of this study is a detailed analysis of the 'Joint Report on water and related land resources development for the Missouri River, Fort Peck Reservoir to the vicinity of Fort Benton, Montana,' released by the U.S. Department of the Interior and the U.S. Army Corps of Engineers in June, 1963.

The Joint Report proposed eleven alternative plans for development of the 200 mile reach of the Upper Missouri River. The plans ranged from total protection of the reach as a National Wilderness Waterway to total inundation by reservoirs designed almost exclusively to produce hydroelectric power. Of the eleven plans, plan 04 which called for 2 dams was preferred by the Corps of Engineers and the Bureau of Reclamation because it exhibited both the highest benefit-cost ratio and the greatest excess of benefits over costs. The National Park Service felt that plan 04 would be incompatible with their National Wilderness Waterway proposal and thus preferred either plan 06 (one dam) or plan 07 (no dams).

It is intended to analyze the Joint Report from four major aspects: 1) As an example of a comprehensive water and related land resources development plan. 2) To ascertain the sensitivity of the overall economic feasibility of the project when certain variables and adjusted within a range of reasonableness; instead of being accepted as constants. 3) To apply those changes that have occurred over the past five years since the Joint Report was released. These changes include legislation passed by Congress, Executive Directives, changes in construction costs, changes in thermal electric power generation technology. 4) The analysis will also attempt to consider the development schemes from their social/economic impact. What is the current status of the region? How valid is the choice of region? What impact would the projects have on the people and the economy of the area?

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Cornell University

6.0390, MULTIPLE PURPOSE WATER RESOURCE INVESTIGATIONS

L.S. HAMILTON, State University of New York, Agricultural Experiment Sta., *Ithaca, New York* 14850

To investigate critical multiple-use problems with respect to New York's surface waters, so that information is made available on which to base both private and public policy with respect to the use and development of this vital resource.

Description of Work: Water-use conflicts are becoming increasingly severe even in the humid East. New York State already is experiencing conflict between irrigation, navigation, recreation, power production, pollution, municipal water supply, industrial use and flood control. Some of these conflicts will be examined as case studies with the goal of criteria for water allocation and policy formulation. The initial case study will be an analysis of municipal water supply reservoirs in New York, focussing on the degree of multiple use of the water and watershed lands.

SUPPORTED BY U.S. Dept. of Agriculture
New York State Government

6.0391, PLANNING ANALYSIS FOR THE NON-MARKET VALUES OF WATER RESOURCES WITH PARTICULAR EMPHASIS ON RECREATION

R.J. KALTER, State University of New York, School of Agriculture, *Ithaca, New York* 14850

Based upon sample surveys taken both for this specific study and national surveys taken by the Bureau of Outdoor Recreation this project will construct a model of the demand for water based recreation. This model, hopefully, will reflect such factors as the inter-action between supply and demand, the developing preferences of young people, shifts in income and population. It will be carried through to the point of actual projection and will be integrated into the planning programs for the Finger Lakes Region of New York State. The basis for benefit estimates will be included. Both through the development of the model and through ancillary studies the project will attempt to lay the basis for improved management of the lakes and other waters of the region and their environment. Policy guides which relate the network of environmental influences to institutions for management will be developed.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Cornell University

6.0392, SYSTEMATIC STUDY AND DEVELOPMENT OF LONG-RANGE PROGRAMS OF URBAN WATER RESOURCES RESEARCH

M.B. MCPHERSON, Amer. Soc. of Civil Engrs., *New York, New York*

This project is a continuation of a project by ASCE to assist in outlining, developing and initiating a coordinated national program of urban water resources research. The first year of the project had the objective of providing guidelines for initiating and expanding a program of long-range studies on urban water problems. This included; (1) Conduct a prefeasibility study to determine the possible effectiveness, cost, and time requirements for a comprehensive systems engineering analysis of all aspects of urban water. (2) Conduct a prefeasibility study to determine the possible effectiveness, cost, and time requirements for a general economic analysis of costs and pricing parameters of all aspects of urban water. (3) Conduct a state-of the-art study of for analyzing urban rainfall-runoff-quality processes. (4) Study requirements for assessment of drainage damage and explore alternatives to direct storm water runoff, such as the utilization of recharge basins or other storage schemes. (5) Study political, economic, legal and social problems related to urban water management with recommendations for further work. (6) Prepare appropriate reports of the research results of the project suitable for publication in engineering and professional journals.

In addition, this project was conducted along with a parallel project sponsored by the USGS to conduct a study of 'Research and Analysis of National Basic Information needs in Urban Hydrology' with special emphasis on the assessment or definition of data needs, data devices and data networks. Continuation of this parallel project will lead to development of a Metropolitan Water INtelligence System.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0393, BENEFITS FROM INTEGRATED WATER MANAGEMENT IN THE NEW YORK METROPOLITAN REGION

L. ZOBLER, Columbia University, Graduate School, *New York, New York* 10027

The main objective of the research effort is to determine the increase in the effective water supply of the New York Metropolitan Region that can be attained as a result of integrating the management of the separate water systems presently responsible for the procurement, treatment, and distribution of water within the area. The expansion of supply is to be attained without the development of new source areas.

The research plan is to be carried out in the following steps: 1. Assemblage of the basic water facts. 2. Analysis of operations of the region's separate water producing units. 3. Design of a simulation model. 4. Preliminary suggestions for a water authority.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0394, PONSAR REGULATING SIPHON

E.E. HULT, New York City Dept. Pub. Works, *New York, New York*

The project is the installation and evaluation of a unique flow regulating device called the Ponsar Regulator. The function of the regulator is to deliver a predetermined maximum volume of combined sewage to the interceptor sewer from the drainage area collection system. The regulator operates on a siphon principle wherein the flow is proportional to the sum of the hydrostatic and differential pressure heads. The device is so constructed that the total pressure difference will remain constant after a predetermined hydrostatic head has been reached and surpassed. In addition, an adjacent existing regulator will be monitored for direct comparison of performance under like conditions.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
New York City Government - New York

6.0395, ECOLOGY OF YEASTS IN LAKE CHAMPLAIN

W.L. COOK, State University of New York, Graduate School, *Plattsburgh, New York* 12901

The yeast population of Lake Champlain has never been determined. This makes it imperative that the normal yeast population be determined before pollution, which usually follows increasing human utilization, changes the environment. Yeasts could possibly be used as indicators of pollution.

Beginning February 1968, monthly water samples are being taken from two selected sites in Lake Champlain. Yeasts are collected with Cobet Sterile Water Samplers, concentrated with a Millipore filter, isolated and identified by standard biochemical and morphological means. The water samples are further analyzed for temperature, oxygen, carbon dioxide, alkalinity, pH and conductivity.

SUPPORTED BY State University of New York
U.S. National Science Foundation

6.0396, ECOLOGICAL STUDIES OF LARVAL TREMATODES AND THEIR SNAIL-HOSTS IN THE LAKE CHAMPLAIN WATERSHED

R.H. SUDDS, State University of New York, Graduate School, *Plattsburgh, New York* 12901

This project was designed to obtain two types of information. The first phase of the study involves a survey of the aquatic mollusks in the northwestern Lake Champlain watershed to determine what mollusks are present in this area (such a survey has never been done). The second phase of this study is concerned with the relationships which develop between larval digenetic trematodes and the mollusks of this area that serve as intermediate hosts for these parasites. Information being sought concerning host-parasite relationships includes the effect of environment upon both the snail host activities and the activities of the parasite, location of the snail-hosts by free swimming trematode miracidia, and the effect of snail size, age, feeding habits, and species upon the ability of the larval trematodes to utilize the snails as intermediate hosts.

Both field and laboratory experiments are being employed.

SUPPORTED BY State University of New York

6.0397, RESEARCH ON DATA AND ANALYTICAL SYSTEMS FOR PREPARING NATIONAL WATER ASSESSMENTS

J.W. WILKINSON, Rensselaer Polytechnic Inst. , Graduate School, *Troy, New York* 12181

Water-resource data-collection programs and the techniques for development of coordinated and integrated data (information) systems will be examined and evaluated, and computational modeling techniques and analytical systems appropriate for water-resource data interpretation and reporting will be examined and evaluated, both with a view to selecting from among alternative information-analytical systems an approach or approaches to methodology for a national water assessment by water-resource regions.

The elements of a selected model must reflect present and projected water quantity and water quality conditions, including statistical probabilities of excesses and deficiencies in physical terms. These elements will identify present and future water supply and requirements problems, water quality problems, and flood and drought problems.

Subsequently, the development and testing of physical assessment systems from this investigation and selection stage will be coupled with economic analyses for water-resource policy, planning, development, and management decisions at Federal, State and local levels. Therefore, the incorporation of economic variables will be given some consideration in these investigations.

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SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0398, ECOLOGICAL STUDIES AT THE KAINJI LAKE BASIN, BEFORE, DURING AND AFTER INUNDATION

A. IMEVBORE, Univ. of Ife, *Ife, Nigeria*

Firstly, to study in detail the fundamental limnological changes occurring as the river becomes a lake, and secondly to measure the productivity of the water during the initial period of maximum change. The quantitative and qualitative determinations of the changes in chemical composition and physical properties of the water, and the micro-organisms it supports, will provide valuable data to complement the applied pre-investment studies to be undertaken by the UNDP/FAO Kainji Lake Research Project, which deals primarily with lake fisheries.

SUPPORTED BY Rockefeller Foundation

6.0399, COLLECTION AND APPLICATION OF INFORMATION ON THE USE OF FOREST RECREATION FACILITIES AND RELATED RESOURCES

G.A. JAMES, U.S. Dept. of Agriculture, *Asheville, North Carolina*

Object: To develop principles and guides to enhance recreational use benefits from forests and other wild lands of the Southeast.

Plan of work: A major phase of work involves improvement of methods for collecting and processing information on area and site characteristics, and use. Planned work includes the design and testing of a system to compile, store and retrieve facility and use data for all National Forest recreation lands. Maximizing the use of fish and game resources will be explored. This will involve an analysis of the avilability and use of access roads and trails. Means of predicting future facility needs will be sought and the effects of regulatory measures on hunting and fishing evaluated. Study of the cold water fishery resource will involve an assessment of its nature, amount and worth in significant areas. The surveys of resources will be complemented by studies of the relationships between resource availability, fishing pressure, and enjoyment of the sport. Improvement of the selection, design and management of recreation sites will be sought by: (1) development of vegetation, and restoration of problem sites. Measurement of the carrying capacity of sites will be explored, as will the choice of horticultural materials for enhancing and restoring sites. (2 pmy per yr.)

SUPPORTED BY U.S. Dept. of Agriculture

6.0400, EFFECT OF ENVIRONMENTAL CHANGES ON BLUE CRAB ABUNDANCE

M.H. JUDY, U.S. Dept. of Interior, Biological Laboratory, *Beaufort, North Carolina* 28516

Under this project the following studies are planned or are in progress in North Carolina waters:(1) relative abundance and distribution of all life history stages. (2) migratory movements of adult blue crabs. (3) species composition of crab population. (4) development of methods to estimate adult crab population size. (5) relationship between size of spawning population and resulting marketable size progeny.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0401, SURVIVAL REQUIREMENTS OF JUVENILE AND ADULT BLUE CRABS

M.E. TAGATZ, U.S. Dept. of Interior, Biological Laboratory, *Beaufort, North Carolina* 28516

The project has three phases, which will be undertaken in the order in which they are listed.

Phase 1. Determine the nature of, and the capacity for osmotic and ionic regulation in juvenile and adult blue crabs.

Phase 2. Determine factors affecting length of intermolt period and percentage increase in size at time of molt.

Phase 3. Analyze responses of juveniles and adults to environmental stresses such as salinity, temperature, pH, dissolved oxygen, etc., under controlled laboratory conditions, to establish parameters within which survival is possible. Within these parameters, determine optimum conditions for growth and reproduction.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0402, ADAPTING THE WATER RESOURCE PLANNING PROCESS TO PROBLEMS AND NEEDS OF METROPOLITAN AREAS

M.M. HUFSCHMIDT, Univ. of North Carolina, Graduate School, *Chapel Hill, North Carolina* 27514

Investigation of changes required in existing water resource planning theory, process, technique and practice to adapt water resource planning to meet emerging needs and problems of metropolitan areas and their natural resource hinterlands. The approach will be (1) establishment of a conceptual public investment model for water resources in an urban metropolitan context, (2) analysis of applicability of the model to actual cases such as Washington, D.C.- Potomac River basin, and Philadelphia-Delaware River basin, and (3) refinement of model and development of specific, detailed methodology for water resource planning in conjunction with comprehensive metropolitan planning, with associated criteria, standards and techniques.

Conceptual research will involve and interdisciplinary approach and use systems analysis insights.

Testing applicability of models will be done by literature analysis and intensive on-the-spot investigations involving interviews with practitioners and public officials, and participant-observation research.

Research results, in the form of refined conceptual models, statements of planning methodology, techniques and organization and administrative constructs will be published initially as progress reports and finally as a report on the entire research project.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0403, SPECIES AND SUCCESSIONAL CONTROL OF UNDESIRABLE VEGETATION

O. FLORSCHUTZ, State Wildlife Resources Comm. , *Raleigh, North Carolina*

Procedure: 1. Experimental plots for chemical herbicides with control plots will be established on a limited basis.

2. Plots will be mapped, numbered and complete data will be kept for each plot including chemical and concentration, carrier and wetting agent, when and how applied, physical condition of marsh, degree of growth of species being tested, initial and final results, and cost per acre.

3. On the Orton Development, and/or other areas where practicable, experimental plots will be established for each of the following methods:

(a) Mowing (b) Burning (c) Disking (d) Crushing (e) Flooding (f) Plowing (g) Combinations of above

4. In order listed the following species are considered undesirable and will be given special attention: Alternanthera philoxeroides, Juncus roemerianus, Typha spp. (on waterfowl areas), Cladium jamaicense, Castalia odorata, Decadon verticillata, and sesbania.

5. After successful elimination of undesirable species, the growth of desirable vegetation will be encouraged to prevent or retard return of the original growth.

6. In cooperation with biologists of the U. S. Fish and Wildlife Service, a series of herbicide experiments will be initiated to determine a practical control method for Alternanthera philoxeroides.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
North Carolina State Government

6.0404, A PRELIMINARY STUDY OF THE ECOLOGY, PRESENT AND ALTERNATIVE FUTURE LAND USE PATTERNS IN THE DISMAL SWAMP AREA OF NORTH CAROLINA

A.W. COOPER, Univ. of North Carolina, School of Agriculture, *Raleigh, North Carolina* 27600

Wetlands in the United States are subject to numerous pressures for alteration and development. Clearing, drainage, stream channelization, and real estate development are several of the pressures facing our wetlands. North Carolina is confronted with a major wetland problem in the Dismal Swamp in the northeastern part of the state. Here lumbering has been the major past commercial use. Now, real estate development and strong pressure for conversion of organic soils to agriculture threaten the area. In addition, conservation and wildlife interests wish extensive portions of the swamp preserved. This research project is a preliminary evaluation of the effects and relative values of the various proposed land use practices in the Dismal Swamp. Existing data on the ecology of the area, augmented by field studies, will be synthesized. The present land use pattern will be determined. The various future land use proposals for the Dismal Swamp will be evaluated and, insofar as data permit, judgments as to effects on the ecology of the region will be made. If the data warrant, a full-scale project will be developed for an intensive study. The work will be coordinated with the Virginia Water Resources Research Institute.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
North Carolina State University

6.0405, EXPLORATORY STUDY OF SOCIOLOGICAL ASPECTS OF WATER RESOURCES RESEARCH

A.C. DAVIS, Univ. of North Carolina, Graduate School, *Raleigh, North Carolina* 27600

The current phase of the project is exploratory in nature, designed to develop a theory and methodology for investigation of a processual model of adjustment to alterations which might occur in the social psychological composition and social structure of a community as a consequence of imposed sociocultural changes. Adjustment will be conceived as an interplay of internal response to external force, resulting in a patterned sequence of events moving essentially from opposition to accommodation. Developed theory in fields such as community structure, power and influence, identification, value systems, and response to frustration and conflict should be productive but not limiting. Information from related studies catalogued in the Science Information Exchange should be useful when received.

The anticipated investigative research proposal is perceived as one incorporating a sequence of stages, each adapted to a unit in the model of adjustment to be involved. Each stage will constitute a distinct research project which will in turn integrate into a wholistic investigative interpretation of the model.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
North Carolina State University
North Carolina State Government

6.0406, DEVELOPMENT OF A SYSTEM OF DETERMINING THE CAPACITY OF WATER RESOURCES TO SUP-

PORT VARIOUS TYPES AND COMBINATIONS OF RECREATION USE

G.A. HAMMON, Univ. of North Carolina, Graduate School, *Raleigh, North Carolina* 27600

The general purpose of the proposed research is to formulate concepts and practical methodology for estimating or predicting the volume of recreation use which can be properly supported by various types of waterbodies in the state of North Carolina. More specifically, it is proposed to:

1. Define the statistical population and develop parametric descriptions of component elements and groups. 2. Establish criteria based on observable or predictable characteristics of typical population elements, or groups of elements, as a basis for recognizing the degree to which significant characteristics and attributes are present. a. Minimize the effect of subjective reasoning through a dichotomous sequence of alternative/consequence decisions. b. Express the effect of decisions in numerical terms to facilitate comparison of typical sets of circumstances and combinations of characteristics. 3. Develop a simple appraisal technique which will yield a quantified estimate of the capacity of any individual waterbody under a specified set of conditions and management assumptions. Validate methodology in typical situations. Express capacity in meaningful units of time, area, and patron presence.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
North Carolina State University
North Carolina State Government

6.0407, A FIELD AND LABORATORY STUDY OF FLUORIDE UPTAKE BY OYSTERS

J.E. HOBBIE, Univ. of North Carolina, School of Agriculture, *Raleigh, North Carolina* 27600

The project is designed to answer the following questions about fluoride in North Carolina estuaries: l. Is there evidence for an increase in levels of fluoride in oysters due to effluents from phosphate mines? 2. What is the effect of the phosphate effluents on growth and fluoride levels of oysters? 3. Are these levels potentially dangerous to humans?

Techniques used will be linear growth and meat-shell ratio measurements as well as a spectrophotometric determination for fluoride in soft tissues following oxidation and diffusion of HF.

The project will involve measurements of the fluoride levels in natural populations, transplant of oysters into effluent areas to see if fluoride is concentraed, and laboratory studies in high fluoride environments to follow growth and concentration effects.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
North Carolina State University

6.0408, ECONOMIC EVALUATION OF CHANGES IN LAND USE OF A MUNICIPAL WATERSHED AS A GUIDE TO DECISION-MAKING

T.E. MAKI, Univ. of North Carolina, Graduate School, *Raleigh, North Carolina* 27600

The proposed research involves two major phases, the first of which consists mainly of photogrammetric analysis of six sets of photos taken at varying intervals over a 30-year-period, supplemented by field investigations, to delineate the nature and extent of changes in land use over the past forty years on the 168-square mile Lake Michie municipal watershed near Durham, North Carolina. Concomitantly, the Lake Michie reservoir records would be examined and compiled to provide data on variation in yield, quality, and treatment costs of the water over the same 40-year period. The data on land use changes and on weather factors would comprise the variables against which the reservoir water records would be assessed and correlated by appropriate statistical techniques.

The second major phase consists of an appraisal of research results at several hydrologic stations where vegetative cover manipulation has been studied in relation to streamflow. Relevant treatments would be selected and applied hypothetically in kind and degree to cover types on the Lake Michie watershed after a detailed field investigation of the composition and condition of the existing vegetative cover of the watershed to determine what increases in streamflow might be effected through alternative treatments and what the net benefits from such treatments would be.

Finally, an attempt would be made to develop guides that would be helpful to managers of municipal watersheds in decision-making.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
North Carolina State University

6.0409, NORTH DAKOTA STATE COMPREHENSIVE OUTDOOR RECREATION PLAN

J.E. WALTERSON, State Outdoor Rec. Agcy. , *Bismarck, North Dakota*

The Regional Setting - Comparisons with surrounding states and provinces. Resources - Emphasis on outdoor recreation. Land Use - General land suitability. Participation and Preferences in Outdoor Recreation (Demand) Present recreation opportunities. Standards of Capacity and Seasonal Use. Outdoor Recreation Needs - A mathematical comparison of demand and supply Responsitilities for Outdoor Recreation in North Dakota - Legal implications of recreation programs. Plans of Others - Inventory of proposed and potential development projects, governmental and private. The Impact of Garrison Diversion Outdoor Recreation in North Dakota - A two million acre irrigation project's impact on recreation. Recreation for North Dakota's Disadvantaged Persons. Tourism and Outdoor Recreation in North Dakota. Plan for State Parks in North Dakota. Historic Sites in North Dakota - Development and acquisition of historic sites. Land Suitability Study - An analyses and mapping of the best or highest use for all lands in North Dakota.

SUPPORTED BY U.S. Dept. of Housing & Urban Development
U.S. Dept. of Housing & Urban Development
North Dakota State Government

6.0410, BROOD PRODUCTION AND POND PREFERENCE OF DIVING DUCKS IN THE TURTLE MOUNTAINS OF NORTH DAKOTA

J.F. CASSEL, North Dakota State University, Graduate School, *Fargo, North Dakota* 58102

Approximately 175 selected lakes and ponds in the Turtle Mountains of North Dakota are being analysed for the following data: a. Utilization by adult waterfowl. b. Utilization by duck broods. c. Aquatic vegetation. d. Use of surrounding land. e. Water chemistry. 1. pH. 2. Total dissolved solids. 3. Conductivity. 4. Alkalinity.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
North Dakota State University

6.0411, EFFECTS OF IRRIGATION DEVELOPMENT ON TRADE PATTERNS AND INCOME GENERATION

A. HERTSGAARD, North Dakota State University, Agricultural Experiment Sta. , *Fargo, North Dakota* 58102

Objectives: 1. To identify business expenditure patterns in the New Rockford and Warwick-McVille irrigation areas in North Dakota. 2. To project changes in the levels of income, by economic sector, that result from irrigation development in the New Rockford and Warwick- McVille irrigation areas. 3. To provide primary data that will describe existing and changing patterns of economic activity in an area during the initial stages of irrigation development.

Description of work proposed: 1. Delineate a study area including the proposed irrigation areas and assemble data on expenditures of economic units within the area. 2. Apply income multipliers (obtained in this and previous research) to the expenditures associated with irrigation development to obtain projections of the changes in income that will result within the area. 3. Collect and compile auxiliary economic data that will be useful for the research and for planning resource development programs.

This project (OWRR number B-003-NDak and N.D. Agr. Expt. Sta. number S-3-16, entitled 'Effects of Irrigation Development on Trade Patterns and Income Generation') is funded under the matching grant program of the Office of Water Resources Research and will constitute the initial research effort of the North Dakota Agricultural Experiment Station toward Objective 2 of NC-88, 'Economic Development in Rural Communities'.

SUPPORTED BY North Dakota State Government

6.0412, EFFECTS OF IRRIGATION DEVELOPMENT ON TRADE PATTERNS AND INCOME GENERATION

T.A. HERTSGAARD, North Dakota State University, State Water Resources Inst, *Fargo, North Dakota* 58102

This study will measure the level of economic activity in each of the economic sectors in an area prior to the initiation of an irrigation development project in that area. Gross receipts multipliers obtained from previous research will be applied to the changes in income that result directly from irrigation development in order to estimate the indirect changes in income that are likely to result from irrigation development.

An input-output model will be employed as the analytical framework in this study. The interdependence coefficients to be used in the projection of indirect income changes will be those which are associated with marginal rates of income change in each sector rather than those based upon average expenditure patterns.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
North Dakota State University

6.0413, ECONOMIC IMPACTS OF WATER RESOURCE DEVELOPMENT

T.A. HERTSGAARD, North Dakota State University, Agricultural Experiment Sta., *Fargo, North Dakota* 58102

Objectives: To test the hypothesis that secondary income generated by water resource development can be explained and predicted on the basis of measurable characteristics of the community.

A multi-county functional economic area will be selected for study and classes of similar economic activity will be delineated as economic sectors. Data will be collected on the expenditures of economic units in each sector to each of the other sectors. These data will be aggregated to obtain a total expenditures matrix for each of several subareas within the area studied. A set of trade coefficients will be computed for each of the subareas and these coefficients will be compared for differences.

SUPPORTED BY North Dakota State Government

6.0414, PRIMARY PRODUCTIVITY, AND STANDING CROPS IN RELATION TO WATER QUALITY IN LAKE ASHTABULA RESERVOIR, NORTH DAKOTA

J.J. PETERKA, North Dakota State University, Graduate School, *Fargo, North Dakota* 58102

The relationships of productivity of phytoplankton and standing crops of zooplankton and bottom fauna to water quality will be studied in Lake Ashtabula reservoir in southeastern North Dakota.

Field studies will involve measurements of 1. phytoplankton production measured by the light- and dark- bottle oxygen change technique and phytoplankton standing crops measured by chlorophyll 'A', total numbers, dry weights; 2. zooplankton standing crops. 3. bottom fauna standing crops; and 4. measurements of temperature, total alkalinity, 02, SO4, NO3, NO2, NH4, pH, and total dissolved salts. Measurements will be taken throughout the year at a permanent station established a short distance above the dam.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
North Dakota State University

6.0415, A PHYSICAL AND ECONOMIC ANALYSIS OF ALTERNATIVE IRRIGATION METHODS IN A SUB-HUMID CLIMATE

E.C. STEGMAN, North Dakota State University, School of Agriculture, *Fargo, North Dakota* 58102

The objective of this project is to evaluate alternative methods of irrigation for the purpose of identifying the design or designs which maximize returns to resources in a sub-humid climate. The results of this study will provide information needed by irrigators to make decisions regarding the method and size of irrigation system needed to realize the optimum economic potential or irrigation in the new irrigation districts in North Dakota.

Description of Work Proposed: A. Available crop water use data will be analyzed to develop suitable soil moisture accounting model. B. Available crop yield and associated climatic data will be anlayzed by means of the soil mositure accounting model to develop production functions for potentially irrigible crops. C. Artificial irrigation programs will be synthesized for significant periods of climatic record to estimate the yield response distributions attainable with discrete irrigation system design capacities as applied to a range of farm unit sites, soil moisture storage capacities, and crop rotations. D. Linear programming techniques will be utilized to identify the system designs which maximize irrigation returns to selected resources given specific combinations of the factors considered.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
North Dakota State University

6.0416, DISTRIBUTION AND ECOLOGY OF RIVER MOLLUSKS IN CENTRAL AND WESTERN NORTH DAKOTA

A.M. CVANCARA, Univ. of North Dakota, School of Engineering, *Grand Forks, North Dakota* 58202

This investigation has two objectives, 1) to determine the distribution and ecology of mollusks in the rivers of central and western North Dakota, and 2) to determine the effects of water pollution in the rivers of this area as indicated by these mollusks.

This study is to be initiated and completed before natural drainages are altered by the Garrison Diversion Unit of the Missouri River Basin Project. The diversion project will effectively mix the waters of the Missouri River and Hudson Bay Drainage basins.

Ecologic factors affecting mollusk distribution, once known, can be further evaluated by ecologic impact studies after the natural drainages are altered physically of by possible water pollution. Also, present ecologic data can be related to paleoecological conditions of Pleistocene mollusks. Distribution data of the mussels may be applied to tracing former stream confluence in central and western North Dakota.

Numerous sampling stations will be established on each river system, with at least five stations on each minor tributary. At each station, all species of mollusks will be collected and their relative abundance estimated. Light penetration, turbidity, water temperature, dissolved oxygen, alkalinity, hardness, chloride content, nitrate and nitrite content, pH, and other factors will also be analyzed.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of North Dakota

6.0417, THE LIMNOBIOCHEMISTRY OF DEVILS LAKE, NORTH DAKOTA

J.K. NEEL, Univ. of North Dakota, Graduate School, *Grand Forks, North Dakota* 58202

This proposed study is aimed at determination of the physical, chemical, and biological nature of the highly saline Devils Lake environment and energy exchanges between the water, bottom sediments, and atmosphere as brought about through the life processes of plankton, benthos, nekton, and outside predators.

Investigations will involve the following: 1. Analyses of water, plankton, seston, and bottom sediments to show annual patterns of productivity and nutrient exchanges and energy among these divisions. 2. Determination of benthos composition and concentration and how it and energy conservation are affected by insect emergences and repopulations. 3. The role of vertebrates (nekton) in energy cycles as related to their utilization of plankton and benthos and their removal by predation and migration (salamanders).

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of North Dakota

6.0418, THE IMPORTANCE OF THE FOOD CHAIN IN BOTULISM INTOXICATION AMONG WATERFOWL LAKES AND SLOUGHS OF THE DEVILS LAKE REGION IN NORTH DAKOTA

J.R. REILLY, Univ. of North Dakota, Graduate School, *Grand Forks, North Dakota* 58202

This information is designed to investigate the importance of the food chain in the initiation and continuance of epornitics of botulism intoxication among waterfowl and to evaluate possible control methods.

Investigations will involve the following: 1. Examination of natural outbreaks of botulism to determine the type involved, the sources of intoxication and the mechanism of transmission, via the food chain. 2. Determination of the mode of entrance of the organism and its toxin into the food chain. 3. The role of invertebrates in the intraspecific transfer to vertebrates. 4. The possible use of marsh inoculation with B. licheniforms as a control measure to reduce or eliminate botulism epornitics.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of North Dakota

6.0419, INTENSIVE COOPERATIVE INVESTIGATIONS OF SELECTED POTHOLES ON MISSOURI COTEAU IN DICKEY, WARD AND STUTSMAN COUNTIES, NORTH DAKOTA

W.S. EISENLOHR, U.S. Dept. of Interior, Northern Pr. Wlfe. Res. Ctr. , *Jamestown, North Dakota*

The purpose of these studies is to describe and evaluate factors causing water loss and water-replenishment in potholes, and to determine the relationship of water-levels to marsh and aquatic plant associations and to waterfowl use. Hydrological factors being investigated include evapotranspiration, bottom seepage, inflow and outflow, surface runoff, ground water influence, and size, topography, vegetation and land-use of watersheds. Instrumentation on each pothole includes a water stage recorder for pond level with two margin pens-one for a tipping bucket rain gage and the other for recording miles of wind movement, anemometers mounted 12 feet above water surface, water temperature recorders and ground water wells. Comparative data are obtained from both open-water ponds and heavily vegetated ponds. The information concerning varying rates of water loss and water replenishment should be useful in evaluating potholes that are being considered for management or acquisition. The Geological Survey is responsible for the hydrological investigations, while correlative biological relationships are being studied by the Bureau of Sport Fisheries and Wildlife. This project was initiated in FY 1961 and field work was completed in FY 1968. A number of reports have been published and project will be completed in FY 1970.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0420, DISTRIBUTION AND DENSITY OF BREEDING WATERFOWL POPULATIONS AS RELATED TO QUANTITY AND QUALITY OF WETLAND HABITAT IN NORTH DAKOTA

R.E. STEWART, U.S. Dept. of Interior, Northern Pr. Wlfe. Res. Ctr. , *Jamestown, North Dakota*

Objectives: (1) To identify and describe types of wetlands occurring in important waterfowl producing areas of North Dakota and determine their numerical and areal distribution, (2) to determine the distribution and density of waterfowl breeding populations and production as related to number, acreage and distribution of wetland types in each area, (3) to evaluate the importance of each area to breeding populations and production of waterfowl, (4) to determine the use of different wetland types by breeding waterfowl and broods as related to various physical and environmental factors, (5) to compare relative use of man-made and natural basin wetlands by breeding waterfowl and broods, (6) to obtain information useful in developing a classification for man-made and riparian wetlands, and (7) to determine if the sampling system established for breeding waterfowl population investigations may be suitable for analyses of other important facets of long-term regional ecological studies.

Procedures: The more important prairie wetland area of North Dakota has been grouped into four natural strata based upon physiographical, biogeographical and ecological factors. For pair counts a total of 194 randomly selected 1/4-square-mile quadrats will be optimally allocated among these strata on the basis of variance estimates in 1967. For pilot brood counts a total of 32 1/2-square- mile quadrats will be randomly selected on one of the four strata. Information recorded for each wetland occurring in a quadrat will include class, subclass, cover interspersion type, size, dominant vegetation, water levels and conditions and the land use of its basin and related watershed. Water samples will be collected for chemical analyses. Separate waterfowl pair and brood counts will be made so as to include the peak nesting and brood periods for early, mid and late breeding species. Records will be kept of travel and equipment requirements.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0421, COMPUTERIZED DESIGN AND SYSTEMS ANALYSIS OF WASTEWATER TREATMENT PLANTS

R. SMITH, U.S. Dept. of Interior, Water Research Laboratory, *Cincinnati, Ohio* 45226

Development of technology which will make it possible to predict by means of theoretical or empirical relationships the performance and cost of individual wastewater treatment processes or systems of one or more processes. Calculated performance and cost estimates must be sufficiently valid to act as a basis for making decisions concerning the most economic plant design which can be used to convert the influent wastewater stream to an effluent stream of sufficient qualtiy to satisfy the needs of the user or the receiving stream. Models for individual processes will be devised using theoretical relationships wherever possible and empirical relationships or performance factors when necessary to account for the lack of adequate physical, chemical, or biological theory.

A common stream vector will be used in developing all models in order that any effluent stream from a process can be used as an influent stream to any other process. Models or unit calculations for each process will be programmed for the digital computer as a subroutine. An executive program will be developed which will make it possible to compute performance and cost for any system of processes.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

6.0422, A SOCIO-ENVIRONMENTAL STUDY OF A RIVER VALLEY

M.R. ZAVON, Univ. of Cincinnati, School of Medicine, *Cincinnati, Ohio* 45221

This project will study the feasibility of establishing a long-term surveillance of the interactive effects of man and his environment in a single river valley complex. The Great Miami River Valley includes large cities, small towns and farmland. Animals and man living in the Valley produce sanitary waste and the products of daily living; industries in the Valley contribute heavily to the overall burden of waste which must disposed of by the air, the water, or put on the land. The people in this Valley complex came from different geographical sources with differing cultural and social backgrounds. Their heritage predisposes them to certain ways of solving problems and to the organization of their social fabric.

The project represents an approach to research in which the social, biological, and physical sciences contribute data to a centralized facility. During the phase supported by the present grant, three individual research investigations will be carried out at the same time as the central project office will determine whether research conducted in this context may be done at less cost, more productively, and more meaningfully than similar research done without the unifying concept proposed.

6. WATER RESOURCES PLANNING

SUPPORTED BY U.S. National Science Foundation

6.0423, POLLUTION TAXES AND THE COSTS OF WATER QUALITY MANAGEMENT

J.H. BOYD, Ohio State University, Graduate School, *Columbus, Ohio* 43210

The relationship between pollution taxes, designed to achieve efficient allocation of resources with respect to water quality, and the costs of investment and management activity designed to increase a river's waste assimilative capacity, will be examined. An extension of the economic theory of the multiple-product firm will be used, and engineering relationships will be investigated. The emphasis will be on deductive analysis rather than the collection of new data.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Ohio State University

6.0424, COLONIZATION RATES OF BENTHIC INVERTEBRATES IN AN OHIO RESERVOIR

W. DUDROW, Ohio State University, Graduate School, *Columbus, Ohio* 43210

During the summer water levels of reservoirs are lowered and littoral areas are exposed to the atmosphere. The purpose of this study is to estimate the rate invertebrates colonize the drawdown areas as water levels are raised in the spring and fall. A transect method is being used to sample natural populations. Artificial substrates are being used to estimate colonization rates on clay, sand and gravel. Representative littoral areas will be sealed off from fishes to estimate the impact of fishes on colonization.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
U.S. Dept. of Interior - Bu. Comm. Fish.
Ohio State University

6.0425, COMMUNITY REACTIONS TO WATER RESOURCES PROBLEMS IN RELATION TO PLANNING

R.R. DYNES, Ohio State University, Graduate School, *Columbus, Ohio* 43210

The proposal views flooding, water pollution and depletion as different forms of objective collective stress. It is suggested here that those types of collective stress which develop over long periods of time are more difficult to perceive and, therefore, it becomes more difficult to initiate planning and action to cope with them. The study focuses on interviews with a sample of community decision makers in five different communities. The five communities will be selected on the basis of having experienced different types of collective stress. In each community, the definition of the salience of such problems for the community will be determined. In each community the types of adaptation in terms of planning and inaction will be determined. Various social factors will be related to the differential perceptions and adaptations of each community.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Ohio State University

6.0426, A SYSTEMS ANALYSIS OF THE WESTERN BASIN OF LAKE ERIE

G.P. HANNA, Ohio State University, Water Resources Center, *Columbus, Ohio* 43210

The purpose of the research is to conduct a systems analysis of the Western Basin of Lake Erie and adjacent areas that will combine on-shore economic relationships with in-lake ecological relationships. The connections are viewed in both directions. Pollutants generated by economic growth in the drainage area of the Western Basin have given rise to biological phenomena in the lake. Pollutant controls, intended to improve water quality, will impose costs on the economic community. The system that this research proposes to develop will be designed to measure the effects of abatement costs, imposed in various ways, on the affected industries, on employment in the region and on other attributes of the local economy.

The proposed research will (1) establish the economic relationships relevant to the problem and (2) integrate the results of other water resources research projects that are already under way in the area. Included in the latter are studies of pollutant effects on biological processes in the lake. The system is visualized as comprised of two major subsystems, the economy of the Detroit Toledo Metropolitan Area, and the in-lake ecological sub-system; and two related subsystems, the geological effects and recreational demand. Linkages between these subsystems are envisioned as mainly the pollutants, and the resulting water quality. Special studies are proposed to determine pollutant costs and markets of the products that give rise to pollutants. Costs of municipal sewage treatment and the impact of municipal taxes are other special studies that will be investigated.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Ohio State University

6.0427, THE ECOLOGIC IMPACT OF THE INTERACTIONS AMONG MICROORGANISMS AND AQUATIC CONTAMINANTS IN LAKE ERIE

R.M. PFISTER, Ohio State University, Graduate School, *Columbus, Ohio* 43210

Particulate matter in Lake Erie water will be examined on a physical, chemical, and biological basis, and this matter will be characterized using density gradient centrifugation, electron microscopy, and certain chemical analyses. Microbial portions of the Lake Erie ecosystem will be characterized on the basis of physiological types (not identification). Primary productivity, chlorophyll distribution and photosynthesis-pigment relationships will be examined to obtain information pertinent to particulate and bacterial interactions. Algae will be collected and treated to remove physically associated bacteria. Cultures of bacteria obtained from the algae will be examined in the same manner (e.g., determine physiological types) as the non-algal associated bacteria in water. Surface tension and water content of selected chemicals will be experimentally altered to study the effects on microbial populations (physiological types) and on types of particulates found in the water. Data from these experiments will be correlated in an attempt to establish cause-and-effect relationships.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Ohio State University

6.0428, PUBLIC INVESTMENT CRITERIA FOR WATER-ORIENTED RECREATION IN THE LAKE ERIE BASIN

R.A. TYBOUT, Ohio State University, Graduate School, *Columbus, Ohio* 43210

The project has three parts: 1) The measurement of demand for water-oriented recreation at numerous sites. 2) Analysis of costs of pollution abatement and recreation facilities at the same sites. 3) Evaluation of the relative merits of alternative public investments for recreation enhancement and of selected financial policies.

Each part is assigned a year of research time. Demand will be measured by a simultaneous-origin adaptation of the Hotelling-Clawson method. Shifts in demand due to pollution and income changes will be measured and, in fact, play an important part in the determination of benefits from abatement. The analysis of costs of pollution will seek to relate marginal pollution contributions at recreation sites to costs of abatement. The third, or final part of the analysis will explore the implications of combining the results of the first two parts in a cost-benefit framework with various methods of financing, including pollution taxes, user charges and other revenue sources.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Ohio State University

6.0429, ECONOMIC AND LEGAL FACTORS IN PROVIDING, USING, AND MANAGING WATER RESOURCES IN AGRICULTURE

W.A. WAYT, Ohio State University, Agricultural Experiment Sta. , *Columbus, Ohio* 43210

Objectives: To determine the economic considerations that affect use and management of water in agriculture, and competing uses.

To identify widely used systems and sources of providing for farm water supply needs in different parts of the state.

Procedures: Costs and capital requirements data will be assembled from various sources regarding materials costs, construction of facilities costs, etc., to develop supply costs for different existing farm systems compared to costs of providing water by alternative centralized facilities.

SUPPORTED BY U.S. Dept. of Agriculture
Ohio State Government

6.0430, MINIMUM WATER CONCENTRATION OF ENVIRONMENTAL WATER CAPABLE OF SUPPORTING LIFE

G.W. WHARTON, Ohio State University, Graduate School, *Columbus, Ohio* 43210

Objective: a. Problem: To determine the minimum concentration of water than can support terrestrial life and make an estimation of the theoretical limit for any type of life based on protoplasm. b. Application: Information gained through the proposed research can be used to predict the concentration of water required to sustain life on other planets. c. Water is necessary for life, but the minimum concentration of water required to sustain life is unknown. It is known that a sufficiently high concentration must be present to be available to protoplasm, but this varies depending on the organism.

Approach: It is proposed to investigate polyhydric alcohols, sugars, and amino acids at temperatures and pressures within the biologic range. Concurrently the same methods will be used to determine the ability of organisms to extract water from unsaturated air and then from dilutions of molecules in equilibrium with the vapor content of the lowest relative humidity (R.H.) from which the organisms can extract water.

Progress: a. 01 05 66 to 30 04 67. b. The screening of fungi and lichens for their ability to take up water from low R. H. atmospheres continues. A green alga failed to show significant water uptake at low water activities. Five lichens were screened and one shows potential for growth in environments of low water activity.

Four Scientific papers are in preparation dealing with water exchange under equilibrium and non-equilibrium conditions and the fine structure of the cuticle of the mite. The fourth paper is concerned with the question of the paradox raised by the studies indicating that while water is essential for terrestrial life, living systems should be able to use essentially all of the water in an environment and yet, the deserts of the world are characterized by limited faunas and floras.

SUPPORTED BY U.S. Natl. Aero. & Space Adm.

6.0431, THE ALGAE AND ZOOPLANKTON OF PROTECTED AND EXPLOITED LENTIC HABITATS IN NORTHEASTERN OHIO

G.D. COOKE, Kent State University, Graduate School, *Kent, Ohio* 44240

A long-term survey of the species composition, distribution, and ecology of algae and aquatic microcrustacea in four representative bodies of water in Northeastern Ohio has been initiated. Two of the study sites (a lake and a reservoir) were selected on the basis that they have not been subjected to sewage or septic tank effluents or other pollutants, and the other two sites (strongly eutrophic lake and reservoir) were selected for comparative purposes.

The major objective is to prepare comparative species lists based on extensive seasonal collecting in pelagic and littoral areas. This information is to be compared with the ecological and cultural history of each body of water. This project is part of a larger study of the trophic typology of Ohio lakes.

SUPPORTED BY Kent State University
Ohio State Government

6.0432, THE INCORPORATION OF C14 BICARBONATE INTO PIGMENTS OF A NATURALLY OCCURRING BLUE-GREEN ALGAE COMMUNITY WITH RESPONSE TO WAVELENGTH

J.H. MORRISON, Kent State University, Graduate School, *Kent, Ohio* 44240

Oscillatoria rubescens is enclosed in dark and light bottles at depths of known wavelength and exposed for 6 hours to Sodium - C14 bicarbonate. The pigments are separated into chlorophyll, carotene, and phycobilin fractions by extractions. Seasonal ratios indicate a shift in the phycoerythrin/phycocyanin ratio by isotope incorporation studies.. Further evidence of metabolic change due to wavelength variation is indicated.

SUPPORTED BY Kent State University

6.0433, THE INCORPORATION OF C14-BICARBONATE INTO THE PIGMENTS OF BLUE-GREEN ALGAE POPULATION

J.H. MORRISON, Kent State University, Graduate School, *Kent, Ohio* 44240

This study deals with the diurnal and seasonal variations in the distribution of labelled carbon into the different photosynthetic pigments of Oscillatoria rubescens in Lake Hodgson, Portage County, Ohio.

Radioactive sodium bicarbonate is added to four liter light and dark bottles, and the bottles are incubated in the lake for four hours, beginning at 2400 hours and extending for 24 hours. Light penetration and temperature are measured. In the laboratory the four liter samples are divided and the following measurements made: cell density and total cell volume, total radioactivity, carbon-14 incorporation in phycobilin, and carbon-14 incorporation into chlorophylls and carotenoids. At intervals during the project, in situ enrichment studies will be conducted along with the carbon-14 study. These nutrient investigations may reveal depletion states and associated alterations of biosynthetic pathways.

SUPPORTED BY Kent State University

6.0434, A SURVEY OF PHYTOPLANKTON IN AND OLD AND A NEW RESERVOIR

R. RHODES, Kent State University, Graduate School, *Kent, Ohio* 44240

The object of this study is to qualitatively compare the summer phytoplankton of Mogadore Reservoir and the newly formed West Branch Reservoir, Portage County, Ohio.

Limnetic algae are collected, species identified, and dominant species counted. Routine limnological measurements are also made at the time of cellection.

SUPPORTED BY Kent State University

6.0435, THE ROLE OF TEMPERATURE AND ILLUMINATION IN THE BIOLOGY OF OSCILLATORIA RUBESCENS

R. RHODES, Kent State University, Graduate School, *Kent, Ohio* 44240

Seasonal changes in the density and activity of a population of Oscillatoria rubescens in Lake Hodgson, Ohio will be investigated. Particular emphasis will be placed on the importance of water temperature and illumination in the regulation of bio-activity of this species. Laboratory populations will also be studies under experimentally controlled conditions of termperature and light.

SUPPORTED BY Kent State University

6.0436, FLORISTIC AND FAUNISTIC SURVEY IN THE CUYAHOGA RIVER WATERSHED

R.G. RHODES, Kent State University, Graduate School, *Kent, Ohio* 44240

The major objectives of this study are twofold. The first objective is to develop for the Ohio Biological Survey a detailed list of algal and fish species in waters of the upper Cuyahoga River Basin. The second objective is to compare floral and faunal surveys made at selected Cuyahoga River stations above and below the East Branch Reservoir. An effort will be made to detect and assess biotic changes associated with the East Branch Reservoir and with the inflow from a tributary of the Cuyahoga River. Complete physical data will be collected at each station.

This project is a part of master plan which will involve the prosecution and integration of long-term surveys of flora and fauna in this river system and determination of the effects of pollution water impoundment, and tributary inflow on the indigenous biota.

SUPPORTED BY Kent State University
Ohio State Government

6.0437, COMPARATIVE STUDY OF PHYTOPLANKTON IN NEW AND RECLAIMED ACID MINE DRAINAGE PONDS

C.V. RILEY, Kent State University, Graduate School, *Kent, Ohio* 44240

The purpose of the project is threefold: to compare the algal flora of new (very acid) and reclaimed (near neutral) strip mine ponds, to evaluate the role of algae in the reclamation process, and to study the nutrition of algae in an extremely acid ecosystem.

Water samples are taken weekly in both pond types and phytoplankton species identified and enumerated. Routine limnological measurements of pH, dissolved oxygen, hardness, alkalinity, and plant nutrients are also made.

Control and experimental columns of water are isolated in transparent polyethylene bags and resuspended in the ponds. Plant nutrients are added to the experimental bags to determine those ions which may be in limiting concentration in the ponds. The importance of chelators is to be carefully evaluated.

In an effort to estimate the importance of algae in the reclamation process, laboratory algal populations are cultured under semi-natural conditions and changes in water quality with time are studied.

SUPPORTED BY Kent State University

6.0438, ROUTINE SAMPLING AT SEVEN INDEX STATIONS

V.C. APPLEGATE, U.S. Dept. of Interior, Biological Station, *Sandusky, Ohio*

Early work conducted by the R/V Cisco in Lake Erie in 1957 indicated the desirability of establishing regular sampling stations in the western basin of the lake for collecting both fishery and limnological data. Relatively rapid changes in both the environment and the fisheries that were known to be occurring could only be identified and defined on a long-term basis by such a program.

In 1958 and 1959, seven stations in the western end of the lake were visited in the spring, summer, and fall. Since 1960, only the summer visit to each station has been made due to limitations of funds, personnel, and equipment.

At each visit to each station, physical and chemical limnological data and plankton and bottom samples are collected by conventional procedures. Larger fish are collected by trawling and fry are sought with tow nets. Limnological data and plankton and bottom samples are turned over to the Biological Laboratory's Environmental Research Unit for analysis. Fish and fry collections are retained at the Sandusky Biological Station for current and future studies. Ultimately, all fishery and limnological data will be integrated by the two groups to demonstrate relationships that may exist between them.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0439, LIFE HISTORY AND ABUNDANCE OF THE YELLOW PERCH

H.D. VANMETER, U.S. Dept. of Interior, Biological Station, *Sandusky, Ohio*

The abundance of year classes, rate of growth, and the effects of exploitation are determined from data collected from fish captured in experimental and commercial nets. Information on food, spawning habits, distribution, competition with other species, and other life history aspects are obtained from collections of fish taken in experimental gear. Environmental factors--oxygen, water temperature, bottom organisms, plankton, water currents, seiches, and the interrelations with other species of fish are determined from limnological and fish-population data obtained with the fish collections.

Current studies nearing completion include the age and growth, abundance, and history of the commercial fishery for this species from 1949 through the calendar year 1966, spawning and fry development, age and size at maturity, fecundity and food habits. Studies of the effects of environmental conditions upon this species are described elsewhere as separate projects.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0440, LIFE HISTORY AND ABUNDANCE OF THE WALLEYE

D.R. WOLFERT, U.S. Dept. of Interior, Biological Station, *Sandusky, Ohio*

The abundance of year classes, rate of growth, and the effects of exploitation are determined from data collected from fish captured in experimental and commercial nets. Information on food, spawning habits, distribution, competition with other species, and other life history aspects are obtained from collections of fish taken in experimental gear. Environmental factors -- oxygen, water temperature, bottom organisms, plankton, water currents, seiches, and the interrelations with other species of fish are determined from limnological and fish- population data obtained with the fish collections.

Current studies nearing completion include the age and growth, abundance, and history of the commercial fishery for this species through the calendar year 1961, the food habits and food preferences of young-of-the-year walleyes, and the type and degree of parasitic infections of young-of-the-year and yearling fish. Studies of the effects of environmental conditions upon this species are described elsewhere as separate projects.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0441, EVALUATION OF NATURAL RIVER ENVIRONMENTS

M. MORISAWA, Antioch College, Undergraduate School, *Yellow Springs, Ohio* 45387

Objective methods for identifying and assessing comparative values of rivers in their natural states will be developed. Biological, geological and esthetic aspects of two wild or natural rivers will be compared with these same qualities in a developed river. Pertinent geological factors will include discharge and stream regimen, channel morphology and composition, soil types and profiles and the relations of these to biotic communities. Biological factors will include community types and compositions and methods of judging successional status. We will attempt to identify relations of geologic and biotic processes that are pertinent to present and future river qualities. Methods and criteria will be organized around the problem of judging over-all value of a river system in relation to human requirements. These criteria will be reported as an aid to agencies concerned with selection and management of rivers for wild, scenic, or recreational status.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0442, MULTISTRUCTURAL DEMAND MODELS FOR WATER REQUIREMENT FORECASTING

G.W. REID, Univ. of Oklahoma, Research Institute, *Norman, Oklahoma* 73069

Design and construction of municipal industrial water facilities require knowledge of future needs. Water supply facilities must be properly planned and executed or dis-economy of scale 'managerial efficiency' can develop prematurely. Generally system design involves principles and phenomena not altogether understood; as a consequence, resulting mathematical models are very complex. With computers, mathematical models can be constructed which integrate socio-economic factors in perspective.

This research proposes to develop appropriate models of future demands for municipal industrial water. The methodology will be applicable to other essential services.

The need is to utilize new notions in urban economics, 'banal' concepts of economic spaces, and the socio-economic forces determining their projections. The generation of these future values will use a supply base concept, not the more traditional demand base. Socio economic projects and constraints will be incorporated in the modes and system analysis of forecasts performed.

More specifically, the model will proceed from a macro level by disaggregation procedures, or step-down techniques to a micro level. The macro level will use a supply base concept with special distribution based on the concept of limiting or optimal resource. The intra regional distribution will continue to use the supply base concept but will be tempered by the interaction of individual mixes and reference to the export concept.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0443, LAND AND WATER USE, CONSERVATION, AND DEVELOPMENT IN OKLAHOMA WATERSHEDS

D.D. BADGER, Okla. St. Univ. of Agr. & Sci. , Agricultural Experiment Sta. , *Stillwater, Oklahoma* 74075

(1) To determine the actual and potential changes in use of flood plain land by farmers as a result of reduction in flooding afforded by the upstream watershed development programs (2) To develop alternate predictive models of flood plain land use change following flood protection (3) To estimate the effect of watershed development upon farm real estate values and prices (4) To determine the potential value of the water supply created by the floodwater retarding structures for irrigation purposes (5) To estimate the local secondary effects of the watershed development programs (6) To determine feasible institutional arrangements and probable costs of developing alternative recreational facilities.

A survey of about 200 farm operators with flood plain land in the watersheds of the Washita River Basin will be made for the purposes of obtaining basic land resource and type of farming data and of identifying changes in use of land following flood protection. Data from secondary sources will be used to identify major trends in the use of upland and bottomland in counties of the Washita Basin. Information on land values and market prices will be obtained in the survey of farmers in the watershed. Local and total multiplies effects of increases in agricultural revenue due to watershed development in the county will be estimated by mathematical techniques, and methods of adapting the results to other local areas will be developed.

SUPPORTED BY U.S. Dept. of Agriculture
Oklahoma State Government

6.0444, ECONOMIC EFFICIENCY IN THE ALLOCATION OF IRRIGATION WATER OVER TIME

V.R. EIDMAN, Okla. St. Univ. of Agr. & Sci. , School of Agriculture, *Stillwater, Oklahoma* 74075

The purpose of this project is to estimate the primary benefits from irrigation on the economic development of an area for alternative methods of water-use regulation. The study pertains to the portion of the Ogallala aquifer between the Canadian and the Arkansas Rivers.

The procedure involves programming optimum plans for representative farms using varying quantities of water to estimate the demand schedule for water for irrigation. These results will be aggregated to estimate the area demand. Estimates of both the annual recharge and quantity of water in storage will be obtained from the U. S. Geological Survey studies of the area. This demand and supply information will be used to evaluate alternative methods of regulating water-use for irrigation. The evaluation will be made on the basis of the method's effect on the representative farm organization, net returns to the farmer's fixed resources, the quantity of the major agricultural products that will be produced and water availability in future years. Results from these analyses will be used to determine the primary economic benefits from irrigation and its impact on the economic development of the area.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Oklahoma State University

6.0445, WATER RESOURCES PLANNING STUDIES - OKLAHOMA AND ARKANSAS

A.F. GAUDY, Okla. St. Univ. of Agr. & Sci. , School of Engineering, *Stillwater, Oklahoma* 74075

It is proposed to collect, correlate, and summarize all available hydrologic and water quality data pertinent to the Arkansas River and its tributaries as they affect the water resources of Oklahoma and Arkansas. The data will be utilized to determine, predict, and/or recommend the allowable conservation storage which may be equitably apportioned to each state in light of the present and future water requirements. A parallel proposal for the water resource in Arkansas is being submitted by the University of Arkansas. The approach will be to estimate the present total water production and quantity at the state lines by streams contributing to the Arkansas River Basin resource. After obtaining the most complete picture which is possible of present characteristics of the appropriate streams, existing federal, state, and private agency plans for future stream development will be analyzed. Also, in the course of the study, additional possibilities for reservoir sites may be considered. Using the present water production figures and assuming potential reservoirs are in operation, and assuming the needed releases for existing and predicted water requirements, the effect of the assumed proposed reservoir operations can be analyzed to determine if the usable supply is ample for all estimated needs, and if surplus water remains.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Oklahoma State University

6.0446, A PRELIMINARY ANALYSIS OF THE IMPACT OF THE ARKANSAS WATERWAY ON LAND TENURE AND VALUE IN OKLAHOMA

L.B. WARNER, Okla. St. Univ. of Agr. & Sci. , Graduate School, *Stillwater, Oklahoma* 74075

This work proposes to identify changes in land tenure and value associated with the Arkansas waterway in an area in Oklahoma bordering the waterway. Emphasis will be on major transactions, and the period of examination will be from 1957 to the present. The obstacles to obtaining such data are numerous; thus an implicit objective of this pilot project is to determine whether such information can be obtained in a sufficiently systematic manner so that reasonably valid inferences can be made. Since this is a pilot project, the investigator will maintain contact with a gegrapher and a business logistics expert who have already express interest. Future expansion of the project would involve such an interdisciplinary team.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Oklahoma State University

6.0447, ECOLOGY OF SPRING CHINOOK SALMON

W. BURCK, State Fish Commission, *Clackamas, Oregon* 97015

The work encompasses a complete ecological early life history study of spring-run chinook salmon (Oncorhynchus tshawytscha) in Lookingglass Creek, Grande Ronde River, near Elgin, Oregon. Principal objectives are to determine the following: 1. Productivity of a given stream area by complete adult upstream enumeration and by sampling of downstream fingerlings and smolts. 2. The physical and biological factors affecting production by monitoring physical factors and by studying all aquatic biological populations. 3. Kinds of significant mortality which occur and stream population densities or carrying capacities at different time periods. 4. Develop behavior patterns for spring chinook in natural conditions to provide information on basic environmental needs of this species.

SUPPORTED BY Oregon State Government

6.0448, FACTORS INFLUENCING THE FRESHWATER RESIDENCE OF JUVENILE FALL CHINOOK SALMON

P.E. REIMERS, State Fish Commission, *Clackamas, Oregon* 97015

This study is investigating factors influencing the length of freshwater residence of juvenile fall chinook salmon in coastal streams. The study is being conducted primarily in the Sixes and Elk Rivers. Main segments of the investigation are concerned with documenting the early life history of fall chinook in relation to length of residence in streams and estuary, timing of seaward migration, physiological adaptation, and basic life history in streams concerning growth rate, population, scale pattern, movement, and behavior. The role of aggressive behavior is being studied in the natural stream environment and in two artificial environments (an observation aquarium and two identical observation troughs). An analysis of the study will include the phases of genetics, population density, and physiological adaptation.

SUPPORTED BY Oregon State Government

6.0449, LIMNOLOGY AND MANAGEMENT OF OREGON FARM PONDS AND SMALL IMPOUNDMENTS

C.E. BOND, Oregon State University, Agricultural Experiment Sta., *Corvallis, Oregon* 97331

1. To formulate suitable management practices for rearing fish in Oregon farm ponds and irrigation impoundments. 2. To provide basic limnological knowledge for small bodies of water.

Progress to Date: Toxicity to fish of several pesticides, mainly herbicides, has been studied by static water bioassay, 90-day tank experiments, and other methods.

Considerable time has been spent in evaluating the effect of trifluralin upon fish, which has been found in laboratory tests to be extremely toxic to salmonids.

Pond production experiments have been carried out with largemouth bass and channel catfish stocked both as young adults and juveniles.

Data have been gathered for a comparison of invertebrate production in ponds fertilized by organic and by inorganic fertilizers.

SUPPORTED BY U.S. Dept. of Agriculture
Oregon State Government

6.0450, OREGON FISHES - THEIR CLASSIFICATIONS, DISTRIBUTIONS AND LIFE HISTORIES

C.E. BOND, Oregon State University, Agricultural Experiment Sta., *Corvallis, Oregon* 97331

Objectives: In general, to provide basic information concerning Oregon's fish fauna. Immediate objectives involve compilation of faunal lists, keys to Oregon marine fishes and studies of the Zoogeography and speciation of freshwater fishes. A special investigation will assess populations of certain estuarine fishes.

Work Proposed: A. Freshwater studies: Collection, cataloging, and ecological analysis will be continued in order to provide faunal lists and Zoogeographical Information. Collections of lampreys from inland as well as coastal areas must precede studies of speciation in this group. B. Marine studies: For lists and keys, additional collection, cataloging and taxonomic studies will be necessary. Populations of bay fishes will be studied by mark-and-recapture methods.

SUPPORTED BY Oregon State Government

6.0451, ECONOMIC CONSEQUENCES OF INTERBASIN WATER TRANSFERS

W.G. BROWN, Oregon State University, School of Agriculture, *Corvallis, Oregon* 97331

It is proposed to develop a theoretical framework which will relate the economic consequences of both direct (primary) and indirect (secondary) economic benefits resulting from interbasin water diversion projects. However, the empirical research on this project will be concentrated on estimating the direct (primary) benefits which could be expected from interbasin water diversion projects. These direct benefits play a crucial role in evaluating the necessary conditions for water transfer. For reliable computations of direct economic benefits from interbasin water transfer, the marginal value productivity of water in its least valuable use in the area of origin and in the area of destination must be estimated. The empirical research on this project will be focussed on the estimation of these marginal value productivities. These estimates will depend crucially upon the costs and returns from various irrigated crops and present and projected acreages of these crops.

Once direct economic benefits have been identified and estimated, it should be possible to isolate the conditions under which indirect (secondary) benefits are likely to arise. Alternative methods for empirically estimating these indirect benefits will be evaluated.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0452, ECOLOGICAL STUDIES OF RADIOACTIVITY IN THE COLUMBIA RIVER ESTUARY AND ADJACENT PACIFIC OCEAN

W.V. BURT, Oregon State University, Graduate School, *Corvallis, Oregon* 97331 (AT(45-1)-1750)
PEARCY

Neutron-induced radionuclides, originating primarily from the nuclear reactors at Hanford, Washington, are continually introduced into the Columbia River estuary and adjacent Pacific Ocean. The presence of Zn65, Cr51, Sc46, Mn54, Co60, and several other radionuclides in dilute, but often measurable concentrations, permits studies of the cycling of these elements.

Studies in the estuary which have already been defined show that the levels of radioactivity and distribution of radionuclides in water, sediment, and biota will concentrate on specific activities (activity of radionuclide per gram of total element) in various components of the ecosystem to determine reservoirs, routes, and rates of transfer.

In offshore areas, planktonic and nektonic organisms will be collected from discrete depths using electrical cable to monitor depth and actuate opening and closing devices. A special study will be made of vertical migrations of euphausiids. Radioanalysis and stable element analysis of midwater and benthic animals from various depths will enable estimates of vertical changes in radionuclide levels and vertical transport rates. Comparisons between specific activities of zinc in animals and water will be attempted in the plume region. Study of seasonal and regional variations of gamma emitters in albacore, tuna and salmon, which have provided insight into the migratory behavior of these species will be completed.

The radioecology of benthic organisms on the continental shelf and slope is being studied along the northern Oregon coast. Stomach contents will be analyzed and food webs will be delineated and related to radionuclide distribution. A deep-sea camera linked to a sediment sampler will help relate bottom topography to the sediment and infauna. Animal-sediment relationships, which have already been shown to be important aspects of benthic radioecology, will become more meaningful when viewed in terms of specific activities.

SUPPORTED BY U.S. Atomic Energy Commission

6.0453, AN ESTIMATION OF THE THERMAL POTENTIAL FOR GROWING IRRIGATED CROPS ON OREGONS DRYLAND

R.H. CALLIHAN, Oregon State University, Agricultural Experiment Sta., *Corvallis, Oregon* 97331

Objectives: 1. Develop a technique based on climatological, phenological and yield data to predict a crop-growing risk and relative productivity in irrigable dryland areas in Oregon. 2. Identify dryland areas in Oregon having thermal potential for increased productivity through irrigation using the above technique. 3. Identify, via the above technique, crop species best adapted to those areas if irrigated. 4. Publish an information source for persons interested in the agricultural potential of Oregon's irrigable dryland areas.

Description of work proposed: Summarize, analyse, and interpret available topographic, soil, and weather data to identify Oregon's irrigable drylands and their thermal characteristics, and available phenologic and yield data to determine the response of various crops to thermal regimes. Prepare mapped isograms of thermal adaptation areas for crops, heat unit probabilities, coldspell probabilities, and other information which will enable a better assessment of potential agricultural productivity.

SUPPORTED BY Oregon State Government

6.0454, AN ECONOMIC EVALUATION OF WATER POLLUTION CONTROL, YAQUINA BAY, ORE

E.N. CASTEL, Oregon State University, Agricultural Experiment Sta., *Corvallis, Oregon* 97331

OBJECTIVE: (1) Identify the items of economic value that will be sacrificed if pollution is not controlled in a particular case study situation. (2) Insofar as possible, determine the unit prices and physical quantities of those items of economic value identified in (1) above. (3) Determine the cost of alternative engineering plans designed to provide for varying degrees of pollution control. (4) Relate the above variables in a mathematical model that will permit the unknown physical, biological and economic data to be isolated. (5) Relate the unknown variables in (4) above to needed research in the physical, biological and economic fields. This work will involve the establishment of a complete mathematical model which will relate all monetary elements of benefits and costs. It will be necessary to make quantitative determination of so many of the benefits and cost items as possible. It will then be necessary to solve for the crucial range of values for the unknown variables. The results of this case study will then be related to the more general problem of benefit-cost analysis in water pollution control.

SUPPORTED BY Oregon State Government

6.0455, APPRAISAL OF WATER MANAGEMENT INSTITUTIONS-SURVEY OF OREGON WATER LAW

C.D. CLARK, Oregon State University, Water Resources Research Inst., *Corvallis, Oregon* 97331

Object. 1. To conduct a survey study of Oregon water law. 2. To evaluate the adequacy of selected portions of Oregon water law, such as pollution controls. 3. To assess the vitality of common law principles expressed in early Oregon decisions. 4. To identify for further research legal problems of water resources management important to the Northwest.

Description of Work: Analysis will be made of Oregon court decisions, constitutional and statutory provisions, and Attorney General opinions regarding the use of the various water resources, surface and underground, of the state. This survey study will trace the historical development of Oregon water law, synthesize and evaluate existing Oregon water law, critically compare it with water law in other Western states, and otherwise seek to attain the objectives stated above.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Oregon State University

6.0456, SIMULATION AS A MEANS OF STUDYING RESOURCE ALLOCATIONS

A.N. HALTER, Oregon State University, School of Agriculture, *Corvallis, Oregon* 97331

Objectives: 1. To build mathematical models of the environment and decision-making processes of various resource allocating units (firm, industry, agency, both public and private). 2. To operate and test these models on digital computers. 3. To design and test alternative decision-making criteria and processes.

Progress to Date: A computer simulation model of a relatively small river basin has been developed that is capable of comparing sizes of reservoirs, channel capacities, water use priorities, operating procedures, and other management policies that come within the economic framework.

SUPPORTED BY Oregon State Government

6.0457, SOCIO-CULTURAL IMPACTS OF WATER RESOURCE DEVELOPMENT IN THE SANTIAM

T.C. HOGG, Oregon State University, Graduate School, *Corvallis, Oregon* 97331

This project is to examine the effects of Santiam water resource development projects on social organizational (behavioral) and cultural (attitudinal) patterns of Santiam inhabitants. It is to focus on such effects just following the construction phase of the Foster and Green Peter Reservoirs and to test a socio-cultural model of a water resource development project in its institutional phase.

The research will make use of written documents and interview data to ascertain the social and attitudinal characteristics of the people of the Santiam as they relate to the dams. Checks on interview data are to be obtained through the use of a participant observation technique in special community settings.

Comparisons are to be made with on-going and proposed projects in the Western Region. These will include aspects related to the project's developmental cycle,i.e., planning, construction, intitutionalization, and evaluation, and those of public recreation and education, political restructuring and economic reorientation, and social and attitudinal adjustments.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Oregon State University
Oregon State Government

6.0458, ECOLOGY OF RECREATIONALLY IMPORTANT ESTUARINE FISHES IN OREGON

H.F. HORTON, Oregon State University, Agricultural Experiment Sta., *Corvallis, Oregon* 97331

The first objective of this project is to provide fundamental understanding of the ecological factors which influence the abundance and well being of the recreationally important fish species in Oregon estuaries. The second objective is to develop the understanding of the ecology of the various species into recommendations for management practices for the conservation of populations of estuarine fishes. Immediate objectives are: (1) To study the movements and migrations of Oregon's estuarine fishes in relation to the factors of their environment. (2) To estimate the periodic abundance and angler yield of the various populations of estuarine fishes. (3) To study the growth and mortality factors which may influence the maintenance of populations of estuarine fishes.

Intra-estuarine and coastal movements of the recreationally important fishes will be determined by the analysis of recoveries of tagged specimens. Estimates of population size and angler yield will be determined by use of the capture-mark-release-and-recapture technique. Growth rates will be determined by scale analysis, length- frequency distributions and empirical data on length recorded at periodic intervals. Mortality factors will be determined by fecundity, longevity and angler yield data. Environmental factors as temperature, salinity, tidal cycle and associated fauna will be recorded and related to the factors listed above. Based on the relationships developed, recommendations for management will be made.

SUPPORTED BY Oregon State Government

6.0459, HYDROSTATIC PRESSURE-TEMPERATURE, AS ENVIRONMENTAL PARAMETERS, ON GROWTH, BIOCHEMISTRY AND PHYSIOLOGY OF MICROORGANISMS

R.Y. MORITA, Oregon State University, Graduate School, *Corvallis, Oregon* 97331

Objective - a. Problem: The study of metabolic processes under the environmental extremes of temperatures near 0 degrees C and between 50 and 100 degrees C under hydrostatic pressure. b. Application: To determine whether the maximum growth temperature (at 1 atm.) can be elevated by manipulation of hydrostatic pressure and temperature. c. Specifically, interpretations of growth processes will be made at the molecular level to determine the general and specific mechanisms through which temperature-pressure interaction influences or controls these reactions.

Approach - Pressure between 1 and 1,100 atmospheres (17,600 psi.) and temperatures near 0 degrees C and 50 to 100 degrees C will be employed. In vitro studies concerned with the molecular volume and conformational changes of hot and cold marine microorganisms will furnish data concerned with the precise concept and mechanism of the pressure-temperature interrelationship that can happen in vivo.

Progress - a. 30 04 67 to 01 05 68 b. Research indicates generally that microorganisms (terrestrial and marine) coming from environments close to 1 atm. cannot tolerate pressures greater than 600 atm. Certain organisms have been isolated from deep sea environment but in the laboratory have not been shown to withstand elevated pressures from where they were isolated. Three types of organisms have been categorized according to their pressure sensitivity: 1) Cultures able to survive 4 weeks at 1,100 atmos. 2) Cultures able to survive 1 week at 1,100 atmos. 3) Cultures not able to survive 1 week at 1,100 atmos.

SUPPORTED BY U.S. Natl. Aero. & Space Adm.

6.0460, DEVELOPMENT OF A MODEL RESOURCE ANALYSIS FOR RANGE WATERSHEDS

C.E. POULTON, Oregon State University, Agricultural Experiment Sta., *Corvallis, Oregon* 97331

Objectives: (1) Develop and field test a practical method of resource analysis for use by B.B.M. personnel. (2) Demonstrate how the information may be interpreted and used in management decisions. (3) Coordinate field testing throughout the western region and revise the procedures as necessary to meet locally varying conditions. (4) Provide specialized technical training of personnel as needed to insure successful application of the new method.

Description of Work: On sample areas selected to represent different kinds of range, apply knowledge from the tri-state contribution to W-25, 'Ecology and Improvement of Brush-Infested Ranges,' in an improved method of resource analysis. Refine aerial photo interpretation as a tool in analysis. Base field mapping on existing conditions not on interpretations. Map both vegetation and the physical environment. Mapping intensity will be such as to map pure, homogeneous types or no more than three different types within a single delineation. Where complexes are mapped, the percentage of each component will be estimated and they will be written up separately. Interpretations will be made on overlays or on photo mosaic copies. Detailed instructions will be prepared. Objectives 3 and 4 will be undertaken as subsequently determined.

SUPPORTED BY Oregon State Government

6.0461, EXPERIMENTAL REARING OF SALMON AND STEELHEAD IN BRACKISH WATER IMPOUNDMENTS

H.J. RAYNER, Oregon State University, State Game Commission, *Corvallis, Oregon* 97331

1. To determine the feasibility of rearing salmon and steelhead fry to smolts in brackish water impoundments. 2. To determine optimal stocking intensities, survival rates, mortality cause, and environmental control procedures that produce the largest return of adult fish.

Progress to date: Fall chinook fry, coho fry and steelhead fingerlings are introduced into the pond which is usually filled with fresh water. As the salinity tolerance of the fish increases, seawater from Alsea Bay is added. The growth rate of the fish at various stocking densities is closely watched. Differential marking and adjustment of the point of release is being used to test the homing imprint of saltwater-reared smolts. The size of fish released and the location of release will be tested at the time of return of marked adults.

Limited supplemental feeding is planned for fall chinook reared in brackish water in 1969. An investigation is under way of the saltwater fish disease, Vibrio angularium Type C, that has become a problem in pond rearing.

SUPPORTED BY Oregon State Government

6.0462, WATER NEEDS FOR IRRIGATION IN OREGON

M.N. SHEARER, Oregon State University, Agricultural Experiment Sta., *Corvallis, Oregon* 97331

Objectives - To estimate the water needs for the ultimate development of irrigated agriculture in Oregon.

Procedure - 1. Criteria for determination of lands suitable for ultimate irrigation will be restricted to factors of soil, climate, and topography. 2. Determine the acreage in each soil class suitable for irrigation for the designated 17 river basins. 3. Stratify for climate as needed within each river basin to determine the potentially irrigable land. 4. Estimate for the potentially irrigable land an annual water requirement equal to a 'full season' crop. 5. Adjust the net water requirement for anticipated conveyance and application efficiencies. 6. Determine the estimated water use and supplemental needs on presently irrigated land. 7. Summarize the estimates of water needs for irrigation for the years 1980, 2000, 2020, and 2070 for each of the river basins.

SUPPORTED BY Oregon State Government

6.0463, GENERAL SOIL MAPS OF REGIONS IN OREGON WITH POTENTIAL FOR IRRIGATION

G.H. SIMONSON, Oregon State University, Agricultural Experiment Sta., *Corvallis, Oregon* 97331

1. To prepare general soil maps of those major regions of the state that have potential for irrigation development. 2. To estimate the area of soils with various degrees of suitability for irrigation. 3. To develop descriptive material about the soils so that the maps will be useful as a general information source and inventory of the soils in each region.

Progress to Date: High altitude aerial photographs have been obtained for all areas where needed and field work completed in several areas totaling nearly 8,000 square miles. In some instances it was necessary to set up and describe unnamed taxonomic units.

Typical profiles of the major units have been sampled for laboratory analysis including determination of salt and alkalinity.

SUPPORTED BY Oregon State Government

6.0464, INVESTIGATE THE FEASIBILITY OF INTRODUCING SOCKEYE SALMON INTO RESERVOIRS

L. KORN, State Fish Commission, *Portland, Oregon* 97201 (14-17-001-1429)

Determine the ability of juvenile sockeye to survive and rear in and emigrate from certain reservoirs. Catalog reservoirs in Oregon as to their physical, chemical, and biological properties; evaluate these with respect to the potential for rearing sockeye.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0465, ECONOMICS OF WATER QUALITY FOR A REGIONAL SYSTEM

W. ISARD, Regional Science Res. Inst., *Philadelphia, Pennsylvania* 19104

To develop workable methods for the integration of empirical materials on possible supply, demand and quality conditions for the development of an efficient water basin investment and management program. These methods would be generally applicable to water basin investment and management in various regions of the world. More specifically, our objective would be to interrelate (1) quality conditions simulated by the diffusion model for the Delaware estuary, (2) supply conditions as derived from the current simulation model for the Delaware River basin and (3) probable demand conditions projected with the use of Philadelphia Regional economic base studies, to guide investment and quality management policy on the Delaware estuary.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

6.0466, THE ECONOMIC IMPLICATIONS OF THE INTERCONNECTION OF URBAN WATER SYSTEMS

P. SEIDENSTAT, Temple University, Graduate School, *Philadelphia, Pennsylvania* 19122

An examination of the Philadelphia metropolitan area will be undertaken to determine the economic feasibility of water interchange among contingent urban water systems. Data on these systems will be collected, including demand, supply, and related planning information.

With the data for the 1961-66 period, an analysis of the possibilities of interchange to have met peak demands in this 'drought' period will be attempted. Then an examination of the planning of water supply augmentations through 1980 in the light of possibilities of tradeoffs of water will be undertaken, culminating in a cost-benefit analysis of the tradeoff method compared to other supply-increasing alternatives.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0467, AN OPTIMAL WATER MANAGEMENT PLAN FOR THE MIAMI VALLEY

H.J. DAY, Carnegie Mellon University, School of Engineering, *Pittsburgh, Pennsylvania* 15213

The objectives of this study are twofold: (1) to develop an optimal plan for conjunctive use of surface and ground water in the lower valley of the Great Miami River in southwestern Ohio, and (2) to develop systems analysis techniques appropriate for study of alternatives in other regions faced with similar conjunctive use water resource problems.

The Miami River was chosen because of the possibility of examining a number of interesting alternatives which show some promise for meeting future water demands in the Miami Valley. These include:

1) Examination of the feasibility of using dams as combined flood control and groundwater recharge devices 2) Examination of the feasibility of using surface water and groundwater interactions for low flow augmentation.

The aquifer in the Miami Valley is heavily used, well defined, and relatively well documented. Systems analysis techniques such as dynamic programming, linear programming, geometric programming and simulation will be applied in an attempt to evaluate all feasible alternatives and select an optimum.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0468, A CONTINUATION OF THE STUDY TO DETERMINE THE COSTS OF WATER IN INDUSTRIAL USES

H.C. BRAMER, Cyrus William Rice & Company, *Pittsburgh, Pennsylvania* 15205

This investigation seeks to acquire, evaluate, and correlate data with which the costs of water in industrial uses can be quantified. The industries to be studied are those not included in the present research study being completed for the Office of Water Resources Research under Contract No. 14-01-0001-1581. Data is to be determined according to industry classification, quantities of water used, within plant uses, raw water sources and qualities, geographical distribution, and value added by the industry. The secondary objective of the investigation is to refine and thoroughly test the model developed as a result of the current research, to computerize the model, and to generate data on industrial water values through the use of the model on the basis of available information. The results of the research would be expected to be a highly developed and reliable technique for the determination of the costs of water in general industrial uses and a compilation of data which would be of immediate use to water resources planners and industrial users.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0469, STUDIES ON THE PRODUCTIVITY OF VASCULAR HYDROPHYTES AND THEIR ROLE IN MINERAL CYCLING IN AQUATIC ECOSYSTEMS

R.T. HARTMAN, Univ. of Pittsburgh, Graduate School, *Pittsburgh, Pennsylvania* 15213 (AT(30-1))

The relationships between the intensity and spectral quality of light reaching submersed aquatic plants and the photosynthetic efficiency of these plants and the photosynthetic efficiency of these plants will be investigated. Spectroradiometric measurements of available radiation will be used, in calculating these efficiencies in field studies. Attention will be given to factors responsible for previously observed changes in these efficiencies throughout the day. Field study will be supplemented by laboratory investigations using a high intensity monochrometer or transmission filters.

Measurements will be made on the rate of release of tagged carbon dioxide released through respiration by surface-floating duckweeds while the plants are fixing 14-carbon photosynthetically. Information on rates of recycling of newly fixed carbon compounds can aid in the interpretation of results from the application of radiocarbon tracer methods.

The uptake mineral elements by rooted aquatic plants will be studied. Radioisotopes of selected nutrient elements will be supplied to isolate root and shoot systems and the effect of different types of substrates, in various degrees of oxidation and reduction, will be observed. Work will continue on the preparation of a mineral budget for a small pond in which submerged vascular plants are the most important primary producers.

SUPPORTED BY U.S. Atomic Energy Commission

6.0470, STUDY OF METHODS FOR CONTROLLING AQUATIC GROWTH AT PYMATUNING RESERVOIR AND CONNEAUT LAKE, PENNSYLVANIA

C.H. MCCONNELL, Univ. of Pittsburgh, Graduate School, *Pittsburgh, Pennsylvania* 15213

To conduct studies and prepare reports on various methods of controlling aquatic vegetation growth; to make recommendations and to furnish technical advice as may be required from time to time, to assure an orderly development of a program to control these growths.

SUPPORTED BY Pennsylvania State Government

6.0471, RURAL LAND USAGE

R.A. BARTOO, Penn. State University, Agricultural Experiment Sta., *University Park, Pennsylvania* 16802

Develop the framework for a research program to investigate the problems of rural land usage. Devise methods and select criteria for measuring the economic and social values which can be attached to alternative uses of rural land. Devise methods of measuring the compatibility of rural land uses so that the relative desirability of proposals for single use or combination of uses may be evaluated.

SUPPORTED BY U.S. Dept. of Agriculture
Pennsylvania State Government

6.0472, ECONOMIC IMPACT OF WATER RESOURCE DEVELOPMENT ON LAND USE

J.C. FREY, Penn. State University, Agricultural Experiment Sta., *University Park, Pennsylvania* 16802

1. To measure changes in land use, land value and business enterprises in selected rural areas where water reservoirs have been developed. 2. To measure quantitatively the extent to which variations in rates of development can be explained by characteristics of the water reservoirs and other relevent variables. 3. To develop methods of estimating the probable impact of water resource development projects on economic growth. 4. To determine optional organization and management programs for business enterprise attracted by water resource development projects.

An inventory of land use, land value and business enterprise will be undertaken in selected rural areas of Pennsylvania where water reservoirs have been constructed. Types of development at the various reservoir sites will be classified, trends in development will be established, and levels of development will be compared. Regression analyses will be used to isolate factors which are relevant in explaining variation in rates of development. From these analyses, equations for estimating growth at reservoir sites will be derived. Input-out analysis of community accounts will be undertaken to ascertain the influence of new enterprise development on community income and employment. Mathematical programming techniques will be employed to develop optimum income producing models for representative enterprises attracted to the reservoir sites.

SUPPORTED BY U.S. Dept. of Agriculture
Pennsylvania State Government

6.0473, STREAM POLLUTION AND RECREATION

H.B. GAMBLE, Penn. State University, Inst. For Res. on Land & Water, *University Park, Pennsylvania* 16802

The basic hypothesis in the proposed research is that there is a negative correlation between the degree of pollution and the intensity of recreational use of streams. The major objective is to examine a number of streams in Pennsylvania in order to derive estimates of one of the social costs of pollution - that of recreational development and use foregone.

Field investigations will include the selection of a number of streams or stretches of streams throughout Pennsylvanis showing varying degrees of recreational use. Variables other than pollution which affect recreational use and development along any given stream will have to be accounted for. A detailed study of the degree and kinds of pollution will be made, and will involve physical and chemical testing of the waters as well as development and application of schematic scaling techniques for the aesthetic and nonbiochemical qualities of the water and environs. Detailed data will be gathered through field interviewing as to the amount and kinds of expenditures by recreational users of streams.

Regression analysis will be the statistical tool employed to describe the relationship between direct and indirect expenditures from recreationists and kind of stream pollution and the control factors.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Pennsylvania State University

6.0474, WILDLAND RECREATIONAL MANAGEMENT

J.L. GEORGE, Penn. State University, Agricultural Experiment Sta., *University Park, Pennsylvania* 16802

(1) Develop, evaluate, and compare various combinations of uses of timber, wildlife, water, and land resources to determine the degree of compatibility of such use with the economic and social needs of our society and the interests of the landowner. (2) Explore the possibilities of developing unique recreational activities in the use of a wildland area, introducing new game species, and devising new techniques or methods of harvesting wildlife and timber resources on a wildland area. (3) Determine the characteristics of the demand curve for various recreational uses of a wildland area at different user fee rates. Relate the demand curves to production functions and cost analysis resource combinations for recreational purposes.

To be conducted on Quehanns, 40,000 acre wilderness area in conjunction with state action agencies relating to forests and water, game, and fish.

SUPPORTED BY U.S. Dept. of Agriculture

6.0475, CRITERIA FOR DETERMINING ECONOMIC PRIORITIES IN AWARDING SEWAGE FACILITY CONSTRUCTION GRANTS

J.D. JANSMA, Penn. State University, Inst. For Res. on Land & Water, *University Park, Pennsylvania* 16802

The State of Pennsylvania uses a point system to determine relative needs in assigning priorities for awarding sewage facility construction grants. The relative needs considered are water pollution control (50 points), per capita costs (10 points) and financial need (40 points). The major objective of this research is to develop economic indices which measure financial need and per capita costs. Factor analysis will probably be the technique employed to group the various measures of a communities economic-well-being and thus provide the basis for the index of financial need. Alternative approaches for setting priorities will be evaluated in terms of economic efficiency and equity.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Pennsylvania State University

6.0476, SOCIOLOGICAL IMPACT OF A FLOOD-CONTROL RESERVOIR

S.M. LEADLEY, Penn. State University, School of Agriculture, *University Park, Pennsylvania* 16802

The social organization of a community adjacent to a new flood control reservoir is under pressure to change. This research proposes to measure (1) the nature of perceptions of the flood-control reservoirs by influentials, (2) the more significant sociological and social psychological variables related to influentials' perceptions, and (3) the consequences of influentials' perceptions on community governmental and formal voluntary organizations. This study is an attempt to relate ecological change to shifts in both individual perceptions and organizational structures and processes.

Existing Guttman and Likert scales for measuring individual perceptions will be utilized. Influentials to be interviewed will be selected using purposive sampling techniques. Additional longitudinal data from previous community studies (complete household enumerations) in 1937, 1949, and 1960 will be used in order to establish bench modes of individual perceptions and social structural variables. Current organizational information will be obtained from key informants from within the community and specific organizations.

Recommendations will be made regarding procedures for central office and field staff personnel in the areas of reducing social costs of adjustment and assisting community organizations in their attempts to maximize the multiplier effect of the ecological change.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Pennsylvania State University

6.0477, A WATER SUPPLY-DEMAND ANALYSIS IN CLINTON COUNTY, PENNSYLVANIA - A STUDY IN ECONOMIC HYDROLOGY

D.L. RAPHAEL, Penn. State University, School of Engineering, *University Park, Pennsylvania* 16802

For a given region, water, in many ways, can be likened to the flow of money into, through and out of the economy. Economics has developed a model that simulates the flow of money through a regional economy. This type of model has already been utilized for the economic study of Clinton County, Pennsylvania. This Leontief type input- output model was constructed and programmed on a large capacity digital computer. The model has already been tested and proven feasible.

The data for the water portion of the model will be obtained or reasonably approximated from existing sources of data. This will essentially consist of an approximated water balance for Clinton County. The hydrological data is used only to implement the study of the methodological goal and is not intended to reflect a detailed water balance of the study area. The water flow model will then be related to the existing Clinton County microregional model by means of water use functions. The nature of those empirical water use functions is the primary goal of this stage, and they will relate levels of water usage with levels of economic activity. Finally, impact studies of the effects of economic change in the region on water usage will be conducted. This will include a study of the water resource as a constraint on economic activity. However, water availability as a generator of economic activity per se will not be considered in this study but will be dealt with later in subsequent studies.

In the first phase of this study the effort was centered on dealing with the water resource only in quantitative terms. It will be the objective of the continuation phase to explore the direct and indirect relationship between water usage and economy of a microregion with respect to water quality. This emphasis on water quality will also include attention to an adequate definition of water quality in the context of the general study.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Pennsylvania State University

6.0478, COMPARATIVE STUDY OF THE BENTHIC MICROBIAL BIOTA IN SOME COASTAL AREAS OF PUERTO RICO

E. ANGEL, Univ. of Puerto Rico, Water Resources Research Inst. , *Mayaguez, Puerto Rico*

Three marine areas of the Southwest coast of Puetro Rico supposedly affected or not by chemical or animal residues are to be studied. (1). The characteristic bacteriological biota of the neritic benthic zone is going to be studied in order to find the actual population. (2). The standard physical and chemical characteristics of sea water are going to be studied in the three different areas. (3). Comparative studies will be conducted in order to establish relations between pollution and physical change to bacterial population changes, and to establish which are the believed 'normal' bacterial population (unaffected areas) and 'abnormal' bacterial population (affected areas).

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Puerto Rico

6.0479, RELEVANCE OF SELECTED ECOLOGICAL FACTORS RELATED TO WATER RESOURCES & SOCIAL ORGANIZATION OF FISHEMEN VILLAGES IN PUERTO RICO (ABBREV)

F. BLAY, Univ. of Puerto Rico, School of Engineering, *Mayaguez, Puerto Rico*

This study aims to discover some relevance, if any, between fishing products as an aspect of water-resources, and the structure, processes and changes of some fishermen communities in Puerto Rico. The impact of changes in the availability of this water resource upon the culture, the social relationships and the personality of fishermen will be observed.

Three fishermen villages of Puerto Rico will be selected that would show differences as to the past, actual and potential availability of the water resource to be studied - fishing products.

Personal interviews and questionaires and other statistical methods to a sample of the population and direct observation will be used to gather the data. Reliable information already obtained by government agencies might also be used. Proper statistical analysis will determine the relevance between the variables.

Practical application of these results would be useful in development programs of International, local, private and government agencies interested in bringing desirable changes to fishermen villages.

A contribution to the ecological appraoch in the sociological theories is expected by this research.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Puerto Rico

6.0480, THE MANAGEMENT AND CONTROL OF WATER IN PUERTO RICO

I.A. CORDERO, Univ. of Puerto Rico, Water Resources Research Inst. , *Mayaguez, Puerto Rico*

This study seeks to discover some of the problems involved in the management and control of water in Puerto Rico.

The subject will be discussed under the following topics -- irrigation, Hydroelectric Power, Domestic and Industrial Water Supply, Water Pollution, Flood Control, Drainage and Wildlife and Recreation.

The principal objectives of the study are: I) To bring together a summary of data in the management and control of water in Puerto Rico. II) To examine and analyze the data in respect to management and control of water. III) To offer recommendations where necessary for the improvement in the management and control of water in Puerto Rico. Data will be gathered from both public and private water related agencies. Upon completion of the study, the project is expected to provide valuable information to the said agencies and the Institute.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0481, HUMAN FACTORS INVOLVED IN THE DEVELOPMENT OF A WATERSHED PROJECT IN YABUCOA, PUERTO RICO

F. DELRIO, Univ. of Puerto Rico, School of Engineering, *Mayaguez, Puerto Rico*

This study aims to determine the present social, economic and cultural situation of an area in the southeastern coast of Puerto Rico in which plans are underway for the establishment of a watershed project. (Guayanes Watershed Project)

The specific objectives of this study are to: 1. Determine some of the personal characteristics of farmers in terms of age, education, main occupation, income and levels of living. 2. Determine the knowledge, attitudes, and opinions of farmers toward the Guayanes River Watershed Project. 3. Determine the farming situation in relation to land tenure and other variables as stated in objective 1. 4. To arrive at conclusions and make suggestions that may help for the program planning and evaluation of the watershed project.

Information will be secured from a sample of around 200 farm operators through personal interviews by the investigators and through the administration of a questionnaire by trained interviewers.

The findings and conclusions of this study are expected to provide for both the program planning and evaluation of the Guayanes River Watershed Project.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Puerto Rico

6.0482, STUDIES WITH BARBADOS OR WEST INDIAN CHERRY (MALPIGHIA PUNICFOLIA, L)

G.C. JACKSON, Univ. of Puerto Rico, Agricultural Experiment Sta. , *Mayaguez, Puerto Rico*

To determine the adaptability of selected West Indian cherry varieties for porduction in the different regions of Puerto Rico and develop optimum agronomic techniques to be utilized in their production.

Description of work: The screening os seedling trees for high yielders of ascorbic acid will be continued. Matorial will be propagated from these trees and will be established in experiments to study effects of irrigation on cropping cycle, fruit yield, and ascorbic acid content. The effects of pruning in respect to ascorbic acid yield of this economic crop will be investigated.

SUPPORTED BY Puerto Rico Government

6.0483, THE DEMAND FOR WATER BASED RECREATION IN SOUTHWEST PUERTO RICO

R.B. RAMGOLAM, Univ. of Puerto Rico, Water Resources Research Inst. , *Mayaguez, Puerto Rico*

This study will be centered on an estimation of the present and future demand for water based recreation in the southwestern area of Puerto Rico. The primary objectives of the study are: 1) to evaluate the use of water based recreational facilities. 2) To determine people's willingness to pay for the use of the areas and facilities. 3) To examine the characteristics of recreational uses and the effect of these characteristics on demand for various areas and facilities. 4) To determine the satisfaction of visitors with the areas and facilities. 5) To make recommendations, if any, for the improvement of existing areas and facilities and the establishment of new ones.

A questionnaire will be designed to acquire the relevant data by random sampling of use of water-based recreation areas. The data collected will be arranged for analysis by computer to prepare the findings and conclusions for study.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Puerto Rico

6.0484, QUANTITATIVE ANALYSIS OF WATER USE PATTERNS IN PUERTO RICO

A.S. VAZQUEZ, Univ. of Puerto Rico, School of Engineering, *Mayaguez, Puerto Rico*

The objectives: (1) To inventory the past and present water use situation in Puerto Rico. (2) To estimate major future trends on residential, commercial, industrial and agricultural water uses.

Plan of work for Objective (1) - To conduct a survey to obtain data on water uses for residential, industrial, commercial and agricultural purposes. Data will be used to determine present water consumption patterns. Statistical experiments will be designed and conducted cooperatively with the Puerto Rico Resources Authority and other Agencies.

Plan of Work for Objective (2) - To project trends and estimate effects of new technology and the socio-economic changes for future uses in residential, industrial, commercial and agricultural purposes. Survey data will be subject to mathematical analysis in order to identify major trends in water use.

The research will be conducted by stages, with residential water uses past, present and future patterns being the first stage.

6. WATER RESOURCES PLANNING

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Puerto Rico

6.0485, SOCIO-ECONOMIC STUDY OF NARRAGANSETT BAY, RHODE ISLAND

N. RORHOLM, Univ. of Rhode Island, Agricultural Experiment Sta., *Kingston, Rhode Island* 02881

To identify, measure and evaluate the economic and social values of the marine resources of the Bay to the State of Rhode Island. The project will be based on secondary source information currently available to the University of Rhode Island with additional surveys or interviews being made as necessary to supplement existing data. To identify, measure and analyze economic and social trends in Rhode Island which would be significant in terms of water pollution control or land use regulation of the Bay and that portion of the watershed which is significant in determining the quality of the estuarine water resources.

To explore how benefit cost analysis techniques may be best applied to determine the effects of various combinations of beneficial uses on the estuarine resources. To identify and recommend needs for future studies or basic data systems which would be useful in obtaining optimum public benefits from use of the Bay resources.

SUPPORTED BY Rhode Island State Government

6.0486, ANALYSIS OF SOCIAL AND MOTIVATIONAL CHARACTERISTICS ASSOCIATED WITH SELECTED OUTDOOR RECREATIONAL ACTIVITIES IN RHODE ISLAND

I.A. SPAULDING, Univ. of Rhode Island, Agricultural Experiment Sta., *Kingston, Rhode Island* 02881

Objective: To analyze social and motivational characteristics of participants in selected outdoor recreational activities using Rhode Island resources; priority is given to participants in boating, hunting and fishing, and hiking.

Procedure: Through Rhode Island's registries and licensing agencies for power boats and hunting and fishing, samples of power boat owners and licensed hunters and fishers will be secured. Questionnaires will be used to secure data pertaining to social characteristics, motivation, and responses to participation. Hiking clubs will be contacted, and relevant data will be secured by questionnaire and/or interview from members or samples of members. When desired, intensive case studies will be made.

SUPPORTED BY Rhode Island State Government

6.0487, THE FRESHWATER ALGAE OF SOUTH CAROLINA - FLORISTICS AND ECOLOGY

G.E. DILLARD, Clemson University, Agricultural Experiment Sta., *Clemson, South Carolina* 29631

Objectives: 1. To identify the species of freshwater algae occurring in South Carolina. 2. To study the ecology of the individual species of algae of both lotic and lentic habitats in the state.

Procedure: Initial efforts will involve extensive algal collections over the state as a whole and intensive collections in one or two upper Piedmont stream habitats. As suitable equipment can be acquired the ecological requirements of the various species will be determined. The project will require revision and delineation of more specific objectives after 2 to 3 years.

SUPPORTED BY U.S. Dept. of Agriculture
South Carolina State Government

6.0488, IRRIGATION AND FERTILIZER ON UPLAND FOREST

W.H. MCGREGOR, Clemson University, Agricultural Experiment Sta., *Clemson, South Carolina* 29631

1. To determine the relative importance of (a) moisture stress and (b) mineral nutrient deficiency in restricting growth on an upland mixed hardwood-pine stand by measuring increased growth when supplemental water and mineral nutrients are supplied.

2. To determine what changes in understory vegetations take place when supplemental water and nutrients are supplied.

A ridgetop site of mixed upland hardwood-shortleaf pine will be selected on the Clemson Forest and sprinkler-irrigated from a nearby stream. There will be four irrigated and four non-irrigated 1/4 acre plots. Vegetation will be sampled before and for at least 8 years after irrigation. Growth of tree species will be measured each year. Fertilizer will be added to one-half of each plot approximately two years after initiation of the study. Weather data will be recorded on the plots.

0gtxt-249:2

SUPPORTED BY U.S. Dept. of Agriculture

6.0489, STUDY OF COSTS OF TREATING TEXTILE WASTES IN MUNICIPAL AND INDUSTRIAL SEWAGE PLANTS

J.M. STEPP, Clemson University, Water Resources Research Inst., *Clemson, South Carolina* 29631

The textile industry, which is concentrated and still growing in the Carolinas and Georgia, is a major user and polluter of water while at the same time requiring high-quality water for dyeing and finishing operations. The liquid wastes from such operations are strong, complicated, variable, and difficult to remove from wastewater. The public interest requires effective treatment of industrial wastes; hence it is in the interest of the general public, the textile industry and the people and communities supported by it to obtain information on methods, problems and costs of treating textile wastes, and the relation of such costs to other components of the cost and income structure of the plants.

The study will cover all of the 32 sewered South Carolina municipalities which accept and treat textile wastes in their municipal sewage plants, and a substantial number of the 89 South Carolina wet- process textile manufacturing plants which operate waste-treatment facilities. Data will be obtained from the managers of the sewage systems and plants by means of questionnaires, from published reports, from the records of public agencies, and from consulting engineering firms which specialize in the design and operation of waste-treatment systems. The municipal phase of the study will precede the industrial phase.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Clemson University

6.0490, A STUDY OF SOUTH CAROLINAS STATE LEGISLATION, POLICIES AND PROGRAMS PERTAINING TO WATER AND RELATED LAND RESOURCES

J.M. STEPP, Clemson University, Agricultural Experiment Sta., *Clemson, South Carolina* 29631

1) To compile a statement of the statutory authority and the operating policies, procedures and programs of South Carolina state agencies concerned with water and related land resources. 2) To list and summarize the functions of federal agencies in South Carolina which have water resource responsibilities; 3) To evaluate South Carolina's water-related laws, policies, programs, and procedures in relation to the experience of other states.

The State constitution and State statutes concerning water will be studied in order to determine South Carolina's official policies relating thereto. Detailed study of court decisions is beyond the scope of this project. State and federal agencies that are concerned with water and related land resources will be visited, and their programs and policies in regard to water and related land resources will be ascertained. Data obtained in this study will be compared with similar data that are available from other states. Advantages or deficiencies in South Carolina's laws, policies, or programs will be determined and specified. Ways for improving South Carolina's position on water and related land resources will be evaluated.

SUPPORTED BY U.S. Dept. of Agriculture
South Carolina State Government

6.0491, ECONOMIC ANALYSIS OF THE SANTEE-COOPER PROJECT - A RETROSPECTIVE STUDY UTILIZING CURRENT EVALUATION STANDARDS

J.M. STEPP, Clemson University, Agricultural Experiment Sta., *Clemson, South Carolina* 29631

Santee-Cooper is a state-owned, multipurpose reservoir, located in the Coastal Plain of South Carolina, which was completed in 1942 at a cost of approximately $64 million. The facilities include two lakes (connected by a diversion canal) which cover 160,000 acres, a hydroelectric plant, a thermal electric plant, and electricity distribution facilities. In recent years the lakes have achieved a growing popularity with sports fishermen.

The objectives of this study are: (1) to discover and describe the economic assumptions and estimates of those who promoted and planned the project in the 1930's; (2) to evaluate estimated primary and secondary benefits in light of present benefits and costs of the project; (3) to determine the nature and extent of discrepancies between the predicted and the actual benefits and costs of the project; (4) to propose methods by which these discrepancies might be reduced in future projects.

Procedures will include documentary research, study of records of operation of the project, and interviews with project officials.

SUPPORTED BY South Carolina State Government

6.0492, LEGAL ASPECTS OF WATER USE AND CONTROL IN SOUTH CAROLINA

C.H. RANDALL, Univ. of South Carolina, Graduate School, *Columbia, South Carolina* 29208

This research proposes to evaluate the present law applicable to water use and control in the State of South Carolina, as well as making suggestions for the clarifying and amendment of the law. Consideration will be given to all aspects of legal control and regulation of water. Judicial and legislative trends in water law through out the United States, and their potential for the laws of South Carolina, will be investigated.

The specific objectives of the study are as follows: (1) to analyze and report on the scope and extent of Federal law governing the use and control of water resources within the State of South Carolina; (2) to analyze and report on existing statutes, constitutional provisions and judicial decisions of the State of South Carolina affecting water use and control, as well as laws and activities of neighboring States affecting water flow in which the State of South Carolina has an interest; (3) to survey the important developments in the law, both judicial and legislative and regulatory, relating to water use and control throughout the United States; (4) to give critical consideration to proposed additions to or amendments of the laws of South Carolina relating to water use and control.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of South Carolina
South Carolina State Government

6.0493, THE MODIFICATION OF A PREDICTIVE RIVER BASIN MODEL

R.P. COVERT, South Dakota State University, School of Engineering, *Brookings, South Dakota* 57007

The proposed research plan involves the modification of and verification of a systematic reach analysis of a predictive river basin model. The original model was designed to predict the effects of economic activity on the Blackwater River Basin in Central Missouri. Although every effort was made to keep the model general, it is expected that this model has features that make it applicable only to that basin. The true generality of the model can be determined only by testing it in another basin and making the necessary modifications and generalizations. Further, this verification will provide an indication of the manhours and procedures necessary to use this model on any other basin.

Since the basic model is developed, the majority of the effort can be expended on securing the best possible coorelation between the model and the segments of the river basin under study. The basin selected is ideal for these purposes since it contains a metropolitan area as well as agriculture economic activity.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
South Dakota State University

6.0494, THE IMPACT OF IMPOSING A WATER QUALITY STANDARD ON A LIVE STREAM

J.N. DORNBUSH, South Dakota State University, School of Engineering, *Brookings, South Dakota* 57007

This proposed study involves an evaluation of the impact of imposing quality standards on a stream which is presently being considered for multipurpose development through reservoir construction.

Water resources development frequently requires long-range decisions involving huge expenditures; however, these decisions are often made without complete consideration of existing information. It is the purpose of this study to appraise information for decision- making regarding beneficial uses including flood control, recreation, irrigation, fish propagation and quality control.

The approach will be to evaluate statistically existing information in order to relate the proposed quality requirements to the projected uses. The case study will consider the interrelationships of existing and projected stream quality, the frequency of low stream flows, the pollution abatement requirements, the effect of river impoundment and the need for flow augmentation.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
South Dakota State Government
South Dakota State University

6.0495, HIDDEN COSTS OF USING SUBSTANDARD QUALITY WATER, AS EXPERIENCED BY WATER USERS IN WEBSTER, SOUTH DAKOTA

A.J. MATSON, South Dakota State University, Graduate School, *Brookings, South Dakota* 57007

A survey is being conducted of residential, institutional, commercial, and industrial water users in Webster, South Dakota. The object is to determine the hidden costs associated with the use of substandard quality water formerly supplied, as compared with the present use of the product water from OSW's Saline Water Conversion Demonstration Plant. A breakdown of comparative costs incurred before and after the change-over from brackish to potable water service is being prepared.

In addition, the project is to include a number of other cities using substandard water in the same state, correlating the retardation of economic growth with the use of water high in mineral content, quantifying economic losses, and assessing the benefits which might accrue

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

6.0496, ECONOMIC ANALYSIS OF IRRIGATION SYSTEMS APPLICABLE TO THE NORTHERN GREAT PLAINS

G.D. ROSE, South Dakota State University, Graduate School, *Brookings, South Dakota* 57007

The proposed research plan involves cooperative efforts with agricultural engineers, soil scientists and agronomists to identify economically feasible irrigation systems for Northern Great Plains conditions. The main approach is a linear programming analysis of selected bench-mark farms to determine optimum combinations of alternative irrigation systems and farming enterprises to meet the economic objectives of individual farm firms. A prime consideration will be the opportunities and investment strategies necessary for shifting from privately developed water sources to publicly developed sources as such are developed.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
South Dakota State University

6.0497, PHYSICAL, CHEMICAL, AND BIOLOGICAL LIMNOLOGY OF OAHE RESERVOIR

J.R. HIGHAM, U.S. Dept. of Interior, Biological Station, *Mobridge, South Dakota*

Limnological studies began October 1966 as an expansion of research on Oahe Reservoir. Studies of physical, chemical, and biological features of the reservoir will provide information on causes of fluctuations in survival and growth of fish populations. The knowledge will help predict levels of abundance in the fish stocks for the optimum management of these resources. Collections at a number of limnological stations will include records of water level fluctuations, erosion, silt deposition, reservoir soil characteristics, water temperatures, turbidity, plankton, bottom fauna, and water chemistry.

Analyses of 61 soil samples from six transects of the reservoir are underway at South Dakota University. Determinations are being made for organic matter, phosphorus, potassium, soluble salts, and pH.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0498, GROWTH AND MORTALITY RATES OF YOUNG YELLOW PERCH IN OAHE RESERVIOR

L.G. BECKMAN, U.S. Dept. of Interior, North Cen. Reservoir Invg., *Yankton, South Dakota*

Yellow perch is the most abundant game fish in Oahe Reservoir, S.D., and an important food for both young and adult predatory fishes. Because of its apparent key role in the ecology of the reservoir, information on the dynamics of juvenile stocks has been accomplished since 1964. Measures of apparent abundance in selected nurseries, along with estimates of growth and mortality rates, provide the vital statistical data used to assess the annual status of juvenile stocks.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0499, ABUNDANCE OF YOUNG-OF-THE-YEAR FISHES IN OAHE RESERVOIR

L.G. BECKMAN, U.S. Dept. of Interior, North Cen. Reservoir Invg., *Yankton, South Dakota*

Measures of the relative apparent abundance of larval and juvenile fishes in Oahe Reservoir have been obtained from standardized haul seine and trawl catches since 1964. These measures not only provide estimates of the initial success of annual spawning but also furnish information on the future status of individual game fish populations. Estimates of the first year's growth and mortality rates of selected species are derived from these data.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0500, DISTRIBUTION AND RELATIVE ABUNDANCE OR POPULATION OF YOUNG FISHES IN LAKE SHARPE RESERVOIR

J. ELROD, U.S. Dept. of Interior, North Cen. Reservoir Invg., *Yankton, South Dakota*

Measures of the relative apparent abundance of larval and juvenile fishes in Lake Sharpe, S. D., are obtained from standardized haul seine and trawl catches to determine the distribution of young and success of annual spawning. Estimates of the first year's growth and mortality rates of selected species are derived from these data.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0501, ABUNDANCE AND COMPOSITION OF ADULT FISH STOCK IN LAKE SHARPE

J. ELROD, U.S. Dept. of Interior, North Cen. Reservoir Invg., *Yankton, South Dakota*

Measures of the relative apparent abundance of the adult fish stock in Lake Sharpe, S.D. have been obtained from standardized gill net catches since 1964. The purpose of the study is to describe changes in species composition and the size, age, and sex composition of the individual species populations following impoundment. Estimates of recruitment, growth, and mortality rates of selected species also are derived from the data.

SUPPORTED BY U.S. Dept of Interior - Bu. Sport Fish.

6.0502, VITAL STATISTICS OF NORTHERN PIKE IN LAKE SHARPE

J. ELROD, U.S. Dept. of Interior, North Cen. Reservoir Invg., *Yankton, South Dakota*

Northern pike is a much sought-after game fish in Lake Sharpe, S.D. To provide current information on the status of the population, annual estimates of recruitment, growth, and mortality rates are derived from catch per-unit-effort data (gill net), and independent estimates of these parameters will be sought from mark and recapture data.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0503, VITAL STATISTICS OF WALLEYE IN LAKE SHARPE

J. ELROD, U.S. Dept. of Interior, North Cen. Reservoir Invg., *Yankton, South Dakota*

Walleye constitutes a sizeable game fish population in Lake Sharpe, S. D. To provide current information on the status of the population, annual estimates of recruitment, growth, and mortality rates are derived from catch per-unit-effort data (gill net), and independent estimates of these parameters will be sought from mark and recapture data.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0504, RELATIVE ABUNDANCE OF ADULT FISH IN LAKE FRANCIS CASE

C.R. GASAWAY, U.S. Dept. of Interior, North Cen. Reservoir Invg., *Yankton, South Dakota*

Studies on adult fish are conducted bi-annually using gill nets and trap nets. Nets are fished in June, July, and August in lower, middle, and upper areas of the reservoir. Species and age composition, relative abundance, year-class strength, growth rates, and maturity are determined from collected samples.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0505, YOUNG-OF-THE-YEAR FISH IN LAKE FRANCIS CASE

C.R. GASAWAY, U.S. Dept. of Interior, North Cen. Reservoir Invg., *Yankton, South Dakota*

Sampling of young-of-the-year is conducted from July through October to determine year-class strength, growth, and mortality rates. Environmental factors are measured to determine cause and effect relations. Sampling is conducted in the lower, middle, and upper areas of the reservoir, using seines, bottom trawls, and mid-water trawls.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0506, EARLY LIFE HISTORY OF WALLEYE IN LAKE FRANCIS CASE

C.R. GASAWAY, U.S. Dept. of Interior, North Cen. Reservoir Invg., *Yankton, South Dakota*

Walleye have increased in number in Lake Francis Case during the past 5 years. Studies will be conducted to determine time and location of spawning, environmental factors influencing survival of embryos and larvae, and vital statistics of young-of-the-year. Initial work will consist of exploratory sampling to find spawning areas. Eggs will be collected with a suction device. Adults will be collected with gill nets and electric shocker.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0507, EFFECTS OF TEMPERATURE AND SILT ON NORTHERN PIKE DEVELOPMENTS IN THE LABORATORY

T. HASSLER, U.S. Dept. of Interior, North Cen. Reservoir Invg., *Yankton, South Dakota*

Empirical results of field studies of survival rates of young northern pike in relation to specific environmental factors are to be tested under controlled conditions in the laboratory. Initial studies will deal with effects of water temperature and silt on artificially- fertilized embryos, yolk-sac larvae, and larvae.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0508, EFFECTS OF TEMPERATURE AND SILT ON YELLOW PERCH DEVELOPMENT IN THE LABORATORY

T. HASSLER, U.S. Dept. of Interior, North Cen. Reservoir Invg., *Yankton, South Dakota*

Empirical results of field studies of survival rates of young yellow perch in relation to specific environmental factors are to be tested under controlled conditions in the laboratory. Initial studies will deal with effects of water temperatures and silt on naturally fertilized embryos, yolk-sac larvae, and larvae.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0509, EFFECTS OF TEMPERATURE AND SILT ON WHITE BASS DEVELOPMENT IN THE LABORATORY

T. HASSLER, U.S. Dept. of Interior, North Cen. Reservoir Invg., *Yankton, South Dakota*

Empirical results of field studies of survival rates of young white bass in relation to specific environmental factors are to be tested under controlled conditions in the laboratory. Initial studies will deal with effects of water temperature and silt on artificially- fertilized embryos, yolk-sac larvae, and larvae.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0510, ENVIRONMENTAL FACTORS AND YOUNG NORTHERN PIKE SURVIVAL IN RESERVOIRS

T. HASSLER, U.S. Dept. of Interior, North Cen. Reservoir Invg., *Yankton, South Dakota*

To determine if variable survival of northern pike young is related to specific environmental factors, naturally-occurring and artificially- fertilized embryos are placed in rearing trays and pens at selected spawning sites. Survival of embryos and yolk-sac larvae is compared with variations in silt, wind, water temperature, and substrate.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0511, ENVIRONMENTAL FACTORS AND YOUNG YELLOW PERCH SURVIVAL IN RESERVOIRS

T. HASSLER, U.S. Dept. of Interior, North Cen. Reservoir Invg., *Yankton, South Dakota*

To determine if variable survival of young yellow perch is related to specific environmental factors, naturally-spawned embryo clusters are placed in rearing pens and trays at selected spawning sites. Survival of embryos and yolk-sac larvae is compared with variations in silt, wind, water temperature, and substrate.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0512, ENVIRONMENTAL FACTORS AND YOUNG WHITE BASS SURVIVAL IN RESERVOIRS

T. HASSLER, U.S. Dept. of Interior, North Cen. Reservoir Invg., *Yankton, South Dakota*

To determine if variable survival of white bass young is related to specific environmental factors, naturally-occurring and artificially- fertilized embryos are placed in rearing trays and pens at selected spawning sites. Survival of embryos and yolk-sac larvae is compared with variations in silt, wind, water temperature, and substrate.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0513, EFFECTS OF PLANTING TERRESTRIAL VEGETATION ON EXPOSED RESERVOIR BOTTOM ON AQUATIC BIOTA

P.L. HUDSON, U.S. Dept. of Interior, North Cen. Reservoir Invg., *Yankton, South Dakota*

About 50% of the bottom of Lake Francis Case is exposed each fall by a drawdown. The timing of the drawdown prevents aquatic or terresterial vegetation from being established. Preliminary trials with 8 commercially available varieties showed that sorghum-sudan hybrid seed planted in early August on exposed bottom reached 5 feet by the end of the growing season. These plantings held the foliage during winter and may be inundated this spring. Other varieties showed promise. The effects of vegetation on plankton, benthos, and fish (spawning sites and feeding area) will be measured. Additional plant varieties will be tried and new plantings made. Seeds will be distributed by airplane and by normal cultivation methods. The South Dakota Department of Game, Fish and Parks assists in the work.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0514, BENTHOS IN LEWIS AND CLARK LAKE

P.L. HUDSON, U.S. Dept. of Interior, North Cen. Reservoir Invg., *Yankton, South Dakota*

Chironomids (Diptera) and Hexagenia (Ephemeroptera) comprise numerically over 95% of the benthos in this lake. We have extensive knowledge on abundance and distribution of both groups and we monitor a 3,500 acre study area each spring. Past work has been concerned principally with physical and chemical factors and future work will emphasize biota interrelationships. The analyses will include species diversity, predator-prey relationships, production, movement, and fish predation. Recent work on chironomids will allow us to work at the species level.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0515, BENTHOS IN LAKE FRANCIS CASE

P.L. HUDSON, U.S. Dept. of Interior, North Cen. Reservoir Invg., *Yankton, South Dakota*

Water levels of Lake Francis Case (Ft. Randall Reservoir) fluctuate greatly due to normal water management operations. Past studies of drawdown effects show that large numbers of benthic invertebrates are stranded and habitat for burrowing forms is destroyed. The trophic dynamics of the benthic communities will be studied and related to primary productivity and zooplankton work. Measurements and analyses will include production rates, species succession and diversity, predator-prey relationships, and fish predation.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0516, GENERAL HYDROGRAPHIC FEATURES OF OAHE RESERVOIR AND LAKE SHARPE

F.C. JUNE, U.S. Dept. of Interior, North Cen. Reservoir Invg., *Yankton, South Dakota*

To provide measures of environmental changes following impoundment of Oahe Reservoir and Lake Sharpe, S. D., periodic cruises, begun in 1966, are made during the open-water period. Routine station observations include water temperature, turbidity, conductivity, and oxygen, along with phyto and zooplankton samples. Measures of major chemical ions, elements, and compounds also are obtained periodically.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0517, LIMNOLOGICAL FEATURES LAKE SHARPE IN RELATION TO COLD-WATER FISHES

F.C. JUNE, U.S. Dept. of Interior, North Cen. Reservoir Invg., *Yankton, South Dakota*

Preliminary studies of Lake Sharpe, S. D. indicate that cold water entering through Oahe Dam essentially establishes a cold-water environment during the warm months. To determine the suitability of the impoundment for cold-water fishes, studies will be made of the annual water temperature regimen, current pattern, available food, and potential spawning habitats in relation to the requirements of several cold-water species.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0518, VARIATIONS IN SPAWNING OF FISHES IN RELATION TO TEMPERATURE

F.C. JUNE, U.S. Dept. of Interior, North Cen. Reservoir Invg., *Yankton, South Dakota*

6. WATER RESOURCES PLANNING

A preliminary study of the reproductive cycle of 19 common fishes in Oahe Reservoir and Lake Sharpe, South Dakota, showed marked variability in the onset of maturation and spawning within species. Maximum spawning of every species, however, was associated with specific water temperatures, and temperature anomalies appeared to be a cause of spawning failure (retention of eggs) in some species. To investigate these apparent relationships further, measures of water temperature and the maturation and release of ovarian ova are obtained at selected sites during the spawning period.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0519, COMPOSITION OF THE SPAWNING STOCKS IN OAHE RESERVOIR AND LAKE SHARPE

F.C. JUNE, U.S. Dept. of Interior, North Cen. Reservoir Invg. , *Yankton, South Dakota*

To determine the relation between changes in the biological characteristics of the spawning stock and variations in annual spawning success, studies are conducted of fecundity, attainment of sexual maturity, sex ratio, and the age and size of spawners of selected species in Oahe Reservoir and Lake Sharpe, S. D. ,

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0520, SEXUAL MATURATION AND SPAWNING OF NORTHERN PIKE

F.C. JUNE, U.S. Dept. of Interior, North Cen. Reservoir Invg. , *Yankton, South Dakota*

Marked annual variations in the spawning success of northern pike have occurred since impoundment of Oahe Reservoir, S. D. Studies based on an examination of ovaries are conducted of the times and places of spawning to determine the relation between egg deposition and the spring water regimen.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0521, SPAWNING OF YELLOW PERCH

F.C. JUNE, U.S. Dept. of Interior, North Cen. Reservoir Invg. , *Yankton, South Dakota*

Annual variations in the spawning success of yellow perch have occurred since impoundment of Oahe Reservoir, S. D. Studies based on an examination of ovaries are conducted of the times and places of spawning, to determine the relation between egg deposition and the spring water regimen.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0522, EARLY LIFE HISTORY STAGES OF OAHE AND BIG BEND RESERVOIR FISHES

F.C. JUNE, U.S. Dept. of Interior, North Cen. Reservoir Invg. , *Yankton, South Dakota*

The identity of embryos and larvae of many reservoir fishes is imperfectly known and is basic to early life history studies to be conducted in Oahe and Big Bend Reservoirs. The work will involve collection of young with plankton nets, seines, trawls, and electrical shocker; rearing of eggs and larvae in captivity; and the preparation of taxonomic keys and descriptions, using meristic, morphometric, pigmentation, and other anatomical characteristics. Fish species to be studied in detail initially include yellow perch, northern pike, and crappies.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0523, LIFE HISTORY OF RESERVOIR FISHES, SPAWNING OF OAHE AND BIG BEND RESERVOIR FISHES

F.C. JUNE, U.S. Dept. of Interior, North Cen. Reservoir Invg. *Yankton, South Dakota*

Time and place of spawning, size and age at maturity, developmental stages of ova, and fecundity will be determined in Oahe and Big Bend Reservoirs for yellow perch, northern pike, and crappies. Ovaries will be collected throughout the year from experimental, sport, and commercial fish catches. Verification of the times and places of spawning will be made from plankton collections of embryos and newly- hatched larvae. Biological information will be collected concurrently, and observations on spawning behavior will be conducted when possible. The project will be expanded to include other species after 2 years.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0524, PRIMARY PRODUCTIVITY IN LAKE FRANCIS CASE

D.B. MARTIN, U.S. Dept. of Interior, North Cen. Reservoir Invg. , *Yankton, South Dakota*

The carbon 14 light and dark bottle technique will be used to measure primary productivity in St. Phillips Bay (3 miles from dam) and in a mid-lake station adjacent to the bay. Measurements will also be taken of organic matter sedimentation, inorganic phosphorus, chlorophyll, and phytoplankton standing crop. This work will be related to studies on benthos and fish in the same area.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0525, PRIMARY PRODUCTION IN LEWIS AND CLARK LAKE

D.B. MARTIN, U.S. Dept. of Interior, North Cen. Reservoir Invg. , *Yankton, South Dakota*

This work will describe the difference in photosynthetic rates in 6 stations of the reservoir and the causes of these differences. The carbon 14 light and dark bottle method is used to measure primary productivity. Concurrent measurements are taken of chlorophyll concentrations, phytoplankton standing crop, light penetration, turbidity, nitrogen, phosphorus, and sedimentation of organic matter. The primary productivity of the entire reservoir will be estimated and areas of low and high production will be delineated.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0526, PLANKTON POPULATIONS IN LEWIS AND CLARK LAKE AND LAKE FRANCIS CASE

J.F. NOVOTNY, U.S. Dept. of Interior, North Cen. Reservoir Invg. , *Yankton, South Dakota*

Automatic plankton samplers are installed in powerhouses of both reservoirs and they screen an average of 11,000 liters of water per week. Only the No. 10 screen is now used for sampling zooplankton. Weekly grab samples of 10 liters of water are used for sampling phytoplankton and rotifers. The samples are analyzed by species, number, and weight. Comparisons are made with plankton and fish studies in the reservoirs.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0527, LIFE HISTORY OF CYCLOPS BICUSPIDATUS

J.F. NOVOTNY, U.S. Dept. of Interior, North Cen. Reservoir Invg. , *Yankton, South Dakota*

Cyclops bicuspidatus accounts for over 50% of the annual numerical standing crop of cladocerans and copepods in Lewis and Clark Lake and Lake Francis Case. Birth rates, productivity rates, population structure, and mortality rates will be related to food, temperature, and water chemistry. Both field and laboratory studies will be conducted.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0528, LIFE HISTORY OF WHITE BASS IN LEWIS AND CLARK LAKE

R.E. SIEFERT, U.S. Dept. of Interior, North Cen. Reservoir Invg. , *Yankton, South Dakota*

Since introduction of white bass in Lewis and Clark Lake (1959- 61) this species has become an important sport fish. Studies will be conducted to determine (1) age and rate of growth; (2) spawning history; (3) food habits in relation to food availability; (4) mortality rates; (5) factors affecting strength of year class.

Early life history stages will be emphasized. The work will determine time and location of spawning, and mortality and growth during the first year of life.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0529, FISH POPULATION OR ABUNDANCE STUDIES IN LEWIS AND CLARK LAKE

C.H. WALBURG, U.S. Dept. of Interior, North Cen. Reservoir Invg., *Yankton, South Dakota*

Studies on young-of-the-year are completed annually in June, July, and August to determine year-class strength, growth, and mortality rates. Physical and environmental factors are measured to determine cause and effect relations. Sampling is conducted in two areas near the center and one area in the upper end of the reservoir. These areas are representative of the various reservoir habitats. Gears used include seines, bottom trawls, and small-mesh frame nets.

Studies of adult fish are conducted annually in September and October. Sampling is conducted for 30 days with trap nets and gill nets. Information on relative abundance, growth, mortality, and other vital statistics are obtained from collected data. Strength of year- classes estimated from young-of-the-year and adult collections will be compared to determine accuracy of sampling methods.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0530, LIFE HISTORY OF CHANNEL CATFISH IN LEWIS AND CLARK LAKE

C.H. WALBURG, U.S. Dept. of Interior, North Cen. Reservoir Invg., *Yankton, South Dakota*

Channel catfish abundance in Lewis and Clark Lake has declined 50% since early years of impoundment. This study will include: (1) larval growth, feeding, and mortality; (2) age composition; (3) growth; and (4) environmental factors influencing the above vital statistics. Work will be conducted in the reservoir and in aquaria.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0531, FISH POPULATION IN TAILWATER OF LEWIS AND CLARK LAKE

C.H. WALBURG, U.S. Dept. of Interior, North Cen. Reservoir Invg., *Yankton, South Dakota*

The decline of sport fishing success in the tailwater has paralleled the decrease in abundance of fish stock in Lewis and Clark Lake. It is known that large numbers of young fish and some adults move through the powerhouse during summer. This project will determine the relations between the reservoir and tailwater fish stocks.

Fish sampling in the tailwater will be conducted biweekly, for one year, using gill nets and seines. Data are available from the lake. The analyses will include species and age composition of the fish populations, movement, and food habits of selected species.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.

6.0532, A FORECAST OF AGRICULTURAL DEVELOPMENT IN THE IRRIGATED AREAS OF SPAIN

A. ZORILLA, Inst. Nac. De Inv. Agron., *Madrid, Spain*

Object: The objective of this study is to determine the optimal uses of irrigation water for crops in Spain taking into consideration technical factors which may affect future farm productivity and such environmental factors as population growth, per capita food consumption trends, crop patterns, food production in the non-irrigated areas of Spain, and foreign competitive factors all of which will have a bearing on the future potential demand for farm products to be produced in the irrigated areas.

Plan of work: Macro data on population, trade, industrial activity, and income will be used in determining future potential demands for agricultural products. The cost functions for various alternative crops under irrigation will be determined by economic analysis of field trials conducted by the Instituto Nacional de Investigaciones Agronomicas that associate the volume of water used with final yields under differing agronomic conditions. When necessary, new trials may be conducted to supplement those already fulfilled. Thus, it will be possible to establish the most economical patterns of crop production in the irrigated areas and further to provide a basis for determining cost and benefit relationships for new irrigation projects. The data obtained will also be arranged into tables that will be utilized for advising farmers through the Extension Service about the use of water.

SUPPORTED BY U.S. Dept. of Agriculture

6.0533, INVESTIGATION OF LINKAGES OF WATERFRONT MANUFACTURING

M.I. FOSTER, U.S. Tennessee Valley Auth., *Knoxville, Tennessee*

Using publicly available data, a method was developed to trace the inputs and outputs of the Tennessee River waterfront manufacturing plants. The method permits the estimating of the number of jobs required to provide the chief inputs and to utilize the outputs of nonfinished goods. Input-providing and output-using industries were identified at the 4-digit level.

For a selected waterfront community, case study methods were applied to trace local linkages of waterfront manufacturing plants with other manufacturing and service industries.

SUPPORTED BY U.S. Tennessee Valley Auth.

6.0534, THE DEVELOPMENT OF METHODS USED IN EVALUATING RECREATIONAL BENEFITS OF MULTIPLE-PURPOSE WATER RESOURCE PROJECTS

H. HINOTE, U.S. Tennessee Valley Auth., *Knoxville, Tennessee*

This study traces the treatment of outdoor recreation as an economic good in a benefit-cost analysis. Methods proposed and/or utilized in evaluating recreational benefits are examined in detail. The methods examined are: (1) expenditures method or gross volume of business method, (2) value-added by recreation expenditures method, (3) national income or gross national product method, (4) cost method, (5) market value method, (6) methods based on a consumers' surplus, (7) monopoly revenue method or Clawson's demand curves, (8) discriminating monopoly revenue method. Major extensions of the monopoly revenue and discriminating monopoly revenue methods are examined.

The study concludes that the market value method is the commonly accepted technique for evaluating recreational benefits; however, because of its inherent weaknesses, alternative methods based on demand curve analysis using travel cost data as a proxy for price has been proposed. The proposed alternative methods are discussed in detail.

Finally the study presents some suggested areas of additional research so that recreational benefits can be given equivalent status with other types of benefits in the benefit-cost analysis.

SUPPORTED BY U.S. Tennessee Valley Auth.

6.0535, HIGH ANALYSIS FERTILIZER INVESTIGATIONS - FISHERIES

B.D. JACO, U.S. Tennessee Valley Auth., *Knoxville, Tennessee*

A comprehensive test of the effect of high-analysis plant nutrient application on fish production, particularly sport fish reproduction and survival, in limited areas of large TVA reservoirs. This project completed; results show:

Increasing sport fishing in selected coves of a deep reservoir through application of inorganic fertilizer during one growing season does not appear to be practical. The fertilizer produced little lasting increase in nutrients in the water of the coves. Most of it presumably sank into the mud or was sluiced out of the coves.

Fertilization increases the number of bottom organisms and zooplankton but there was no significant change in numbers, size, species composition, or survival of fish. Temperature and oxygen profiles coupled with the physical characteristics (directional axis of coves in relation to main creek and cove depth and length) suggest that the age of the water may be very significant in increasing production in coves.

The exact effect of fertilizer still remains unknown since the amount of fertilizer loss to sinking and sluicing could not be measured. But one thing seems clear: the measured increase in production was due to only a small fraction of the total application.

SUPPORTED BY U.S. Tennessee Valley Auth.

6.0536, PINE TREE BRANCH WATERSHED RESEARCH

P.C. SPATH, U.S. Tennessee Valley Auth., *Knoxville, Tennessee*

Research started in 1941 to determine the effects of intensive reforestation and simple erosion control measures upon hydrologic factors, including runoff, erosion, and underground storage and movement of water, in small watersheds of highly erodible soils. The 88-acre watershed is located in Henderson County in western Tennessee. The plan involved changing the watershed from many years of row-crop cultivation to well-managed pine forest cover. Fine sandy loam soils of the Mississippi Embayment physiographic province were seriously eroded to depths up to 10 feet. Hydrologic observations include precipitation, streamflow, sediment and ground-water levels.

Treatment in 1945-1946 included erosion-control measures and extensive reforestation. Construction of a network of logging roads was begun in 1963 and special devices were installed to measure erosion losses due to road construction. Selective cutting of pine stands was carried on in 1966. The watershed was reinventoried in the fall of 1966. Cull and other poor quality, inoperable hardwood trees were killed in the spring of 1967. The study is continuing.

Analyses of results show large reductions in peak discharges, surface runoff volumes, and sediment yield, some loss in annual water yield, and increased evapotranspiration. A comprehensive report has been published entitled, 'Reforestation and Erosion Control Influence Upon the Hydrology of the Pine Tree Branch Watershed 1941-1960.'

SUPPORTED BY U.S. Tennessee Valley Auth.

6.0537, THE EFFECT OF WATER RESOURCES ON ECONOMIC GROWTH IN THE TENNESSEE VALEY

C.B. GARRISON, Univ. of Tennessee, Graduate School, *Knoxville, Tennessee* 37916

The proposed study involves a statistical investigation of the effect of water availability on the location of manufacturing activity in the Tennessee Valley Region. The region, consisting of 201 counties in seven states, includes all of the Tennessee Valley and part of the Cumberland Valley. Shift analysis will be used to determine the competitive rate of employment growth by four-digit industrial classification for each county during the period 1959-1967 (a distinction will be made between 'water-intensive' and all other industries). The region was chosen because of the availability of high-quality employment and streamflow data on a county basis. The statistical approach is the rank correlation test of independence. This technique requires less stringent assumptions than the analysis of variance, and its efficiency relative to the latter is quite high. Further, this technique permits observation of the effect of water availability in conjunction with other location variables (e.g., labor availability, market access).

The importance of the study is derived from the fact that both the Congress and water resource agencies have viewed 'regional development' as a goal of water resource projects (in addition to the orthodox 'efficiency' goal). The proposed study will provide policy- makers with an improved understanding of the relationship between water resource projects, water availability, and economic growth.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Tennessee

6.0538, USE OF WATER ON FEDERAL IRRIGATION PROJECTS

UNKNOWN, U.S. Dept. of Interior, Bureau of Reclamation, *Amarillo, Texas*

The purpose of this Bureau-wide study is to document historic use of irrigation water and to obtain data from selected projects to determine present use and efficiency as well as possible improvements in efficiency in both existing and future projects. The first phase of the study, which is the updating of the 1952 report, 'Use of Water on Federal Irrigation Projects,' is complete. The second phase, the collection and analysis of more detailed data from selected areas, was begun in F.Y. 1964 and will be conducted for a period of five years.

The Region 5 detailed study is being conducted on seven selected irrigated fields, 40 - 60 acres each, located in the Mercedes Division of Lower Rio Grande Rehabilitation, Weslaco, Texas. The fields are operated by private farmers under their normal farming schedules while data are collected on irrigation diversions, precipitation, surface runoff, water table elevations, soil moisture depletion, climatic conditions, crop growth, and cultural operations. Preliminary annual summary reports will be made in addition to a final report on completion of the study about 1970.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

6.0539, FLATHEAD CATFISH STUDY

R.M. BAMBERG, State Parks & Wildlife Dept., *Austin, Texas*

Procedures: l. Monthly surveys will be made on Lake Kirby, except during the spawning season, when additional surveys will be conducted. Experimental gill nets will be used for collecting flathead catfish. Those fish collected will be dissected and their stomach content recorded. 2. Fish collected will be sexed and their sexual maturity noted. 3. Fish collected will be weighed, measured and the coefficient of condition ('K' factor) calculated. The age of the fish will be determined by the use of length - frequency studies. Some of the fish collected will be tagged and released. 4. Samples will be taken from all habitat types to attempt to locate preferred habitat and to determine a seasonal distribution patterns.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Texas State Government

6.0540, EVALUATION OF CLEARED SEINING AREAS

E.W. BONN, State Parks & Wildlife Dept., *Austin, Texas*

Procedures: Four areas were cleared by the Corps of Engineers in Pat Mayse Reservoir in Lamar County to serve as collection sites. These areas were cleared at the request of the Texas Parks & Wildlife Department. The areas will be marked with offset markers so that they may be located after they are inundated. Trawl, beach seine and net collections will be made on the sites and compared with similar collection efforts in uncleared areas in order to determine the value of clearing such areas on future reservoir projects.

Schedule: First year of a three-year study.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Texas State Government

6.0541, WALLEYE AND NORTHERN PIKE STUDY

J.E. CRABTREE, State Parks & Wildlife Dept., *Austin, Texas*

1. Monthly collections of various sizes of fish will be made utilizing gill nets, frame nets and seines. Collections will be made more often during periods of particular importance such as the spawning period. The stomach contents of specimens taken will be analyzed. Fish foods will be identified to Species and invertebrate foods to Order, if possible.

2. Determination of spawning sites and time will be made through observations and sampling with nets and seines. Fecundity and age at maturity will be determined from samples taken in number 1 above.

3. Samples taken under number 1 above will be weighed, measured and K-factors figured. Age will be determined by scale annuli counts and by length-frequency studies. Fish of known age will be marked to aid in age-growth determination and in determining longevity.

4. Seasonal distribution will be determined by collecting in each ecological habitat during each month. Records of re-release sites for marked fish, in number 3 above will be recorded and compared with returns to determine movements of the marked fish.

5. All samples taken will be examined grossly for the presence of parasites.

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SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Texas State Government

6.0542, FISH STOCKING EVALUATION

B.J. FOLLIS, State Parks & Wildlife Dept., *Austin, Texas*

PPS Objectives: To assess the practice of supplementary stocking of hatchery produced fish as a management tool.

Procedures: The method of application, necessary equipment, and successfulness of various mass marking techniques will be studied to determine their adaptability to the needs of this job.

The selected equipment will be purchased. Project personnel will be familiarized with the operation of equipment, proper methods of application and means of identifying recaptured marked fish.

The effects and duration of the selected marking method or methods will be determined by marking known numbers of small game fish (including largemouth bass, channel catfish and sunfish) and releasing them in hatchery ponds. Collections will be made periodically with seines. The survival and retention of the mark will be recorded. This will be continued as long as deemed necessary (maximum time thought to be one year).

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Texas State Government

6.0543, THE EFFECTS OF ENGINEERING PROJECTS ON THE ECOLOGY OF JONES BAY

R.B. JOHNSON, State Parks & Wildlife Dept., *Austin, Texas*

Objectives: To study the ecology of Jones Bay prior to alteration and to evaluate the effects of the proposed Hitchcock extension of the Texas City Hurricane Protection Levee.

Procedures: The study will include description of the area, an analysis of bottom sediments, chemical and physical water quality, and species composition and abundance. The extent and quality of nursery habitat will be evaluated.

Representative stations will be established and sampled systematically in affected areas and in control sites. Catch per unit effort records will be maintained so that all work can be duplicated and compared. Sampling procedures will compare to those used in estuarine research by the Texas Parks and Wildlife Department and the Bureau of Commercial Fisheries Laboratory at Galveston.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.
Texas State Government

6.0544, THE EFFECTS OF ENGINEERING PROJECTS ON THE ECOLOGY OF MOSES LAKE

R.B. JOHNSON, State Parks & Wildlife Dept., *Austin, Texas*

Objectives: To study the ecology of Moses Lake and compare data accrued prior to the construction of the Texas City Hurricane Protection Levee, and to evaluate the effects of levee alterations in progress.

Procedures: The study will include description of the area, an analysis of bottom sediments, chemical and physical water quality, and species composition and abundance. The extent and quality of nursery habitat will be evaluated.

Representative stations will be established and sampled systematically in affected areas and in control sites. Catch per unit effort records will be maintained so that all work can be duplicated and compared. Sampling procedures will compare to those used in estuarine research by the Texas Parks and Wildlife Department and the Bureau of Commercial Fisheries Laboratory at Galveston.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.
Texas State Government

6.0545, USE OF NEW ANALYTICAL METHODS FOR WATER RESOURCES DEVELOPMENT

C.S. BEIGHTLER, Univ. of Texas, School of Engineering, *Austin, Texas* 78712

The objective of this research is to apply recently developed analytical techniques to the problem of planning for optimal water resource development. An optimal plan with regard to the size and location of proposed reservoirs is that physical configuration which provides the greatest net economic benefit to the people of the region while meeting future water needs. Optimizing a water resource system is difficult, since the output from each reservoir provides an input to all downstream reservoirs, and the streams form nonserial (branched) inputs.

Reservoir design in a river basin system may be formulated as a branched multistage decision process. In such processes, the decisions made at each stage (potential reservoir site) affect the circumstances under which all subsequent decisions in the system must be made. Under certain favorable circumstances, small branched systems may be formulated and solved as complex nonlinear programming problems. However, the intercoupled staging structure of such problems may be exploited by means of recently developed decomposition techniques, permitting the analysis of the large systems which are met in practise. These new methods can be used to break down the nonserial process into a sequence of simple serial problems which are then amenable to solution.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

6.0546, A STUDY OF SELECTED CHEMICAL AND BIOLOGICAL CONDITIONS OF THE LOWER TRINITY RIVER AND THE UPPER TRINITY BAY

R.J. BALDAUF, Texas A & M University System, School of Agriculture, *College Station, Texas* 77843

The Galveston Bay System of Texas serves as an essential nursery area for commercial shrimp and certain fishes. The System serves in this capacity because of the discharge of fresh water from the Trinity River and the subsequent mixing of this water with the saline waters of the Gulf of Mexico. Available data suggest that a reduction in the flow of water will cause the System to become more saline and thus unable to serve as a nursery area.

The Texas Basins Project, the proposed dredging of the Trinity River for navigation, and the current construction of the Wallisville Dam just above the Trinity River Delta will influence the chemical, physical, and biological conditions of the System. The purpose of this project is to determine the nature of this influence.

Samples of fishes, crustaceans, and water will be collected from above and below the proposed site of the Wallisville Dam to determine (1) the chemistry of the water, (2) the fish and crustacean fauna, (3) the salinity tolerances of the animal species collected, (4) the role of a dam on the flow of nutrients into a major bay system, and (5) the population dynamics of the fauna.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Texas A. & M. University System

6.0547, A STUDY OF THE ECOLOGY OF THE NAVASOTA RIVER, TEXAS

W.J. CLARK, Texas A & M University System, Graduate School, *College Station, Texas* 77843

The project proposes a study of the physical, chemical and biological characteristics of the Navasota River, Texas. The Navasota River is a 100 mile long tributary of the Brazos River, and joins the Brazos 30 miles south of Texas A&M University.

The study will provide information about a realtively undisturbed stream. This information will be beneficial in understanding the effects of stream development, and will provide a firm basis for evaluating the effects of the impoundments which are soon to be built on the Navasota River.

Plankton and water chemistry will be studied by bi-monthly sampling at four stations spaced along the river. Zooplankton will be sampled with a No. 20 net. Phytoplankton will be separated by centrifuge or by millipore filtration.

Fishes and benthic organisms will be sampled throughout the drainage. The fishes will be collected by seining, trapping and electrofishing. The benthos will be sampled by dredges or grab samplers.

Physical data are collected at four U.S. Geological Survey Stations and chemical data as well at one of them. Project personnel will collect supplementary data where necessary, including some trace element analyses.

6. WATER RESOURCES PLANNING

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Texas A. & M. University System

6.0548, INTRODUCTION OF RISK AND UNCERTAINTY CONCEPTS TO OPTIMIZATION OF WATER RESOURCE SYSTEM DESIGN

R.J. FREUND, Texas A & M University System, Graduate School, *College Station, Texas* 77843

The proposed research plan is directed at the evaluation of water resource system design under conditions of hydrologic and economic risk and uncertainty by applying operations research techniques. The specific objective of the investigation is to provide mathematical models capable of incorporating elements of risk and uncertainty into the solution of optimal water resource system design.

The research methodology will involve examination and modification of basic system design models. The various factors or parameters in the models will be further examined to see if they are subject to risk and/or uncertainties. Final model modifications will be made, as necessary, depending on various assumptions to be made regarding underlying probability distributions and desired optimization criteria.

Various methods presently being proposed in the literature for handling risk and uncertainty in programming models will be examined for possible application to the above outlined models. Solution procedures for the models used will be obtained and solutions provided using data from a specific watershed. A simulation study will be set up to enable comparative studies to be made of the behavior of the derived solutions and of the solutions obtained from presently available methods.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0549, THE EFFECTS OF FERTILIZATION ON PRODUCTIVITY OF FARM PONDS

J.M. INGLIS, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

OBJECTIVES: 1. To determine how the gross productivity of pond waters is affected by application of varying amounts of selected kinds of fertilizers. 2. To determine how seasonal changes in physical pond environment influence the effect of fertilization in ponds. 3. To evaluate the effect of fertilization of ponds on bottom-dwelling organisms and game fish that eat them. 4. To develop fertilization recommendations relative to amount and ratio of nutrients for farm ponds on the Lufkin-Susquehanna soil types of Central Texas. 5. To make preliminary evaluations of the economics of recommendations prior to extensive field testing based on research results.

WORK PROPOSED: This study is designed to provide basic information about the normal patterns of physical conditions in farm ponds, the kinds and rates of fertilizers best suited for their management and the biological effects of these fertilizers on productivity of different trophic levels in them.

The studies will be conducted on ponds located on the Tex A&M University Range and Forestry Area and will provide management data applying to typical ponds in the lower Post Oak Belt of Texas.

SUPPORTED BY U.S. Dept. of Agriculture
Texas State Government

6.0550, THE EVALUATION, BREEDING AND IMPROVEMENT OF LETTUCE VARIETIES FOR TEXAS

P.W. LEEPER, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

Objectives: Test the adaptability of lettuce varieties and strains for commercial production in Texas. Develop varieties of superior quality which will produce higher yields under commercial production through a program of selection and breeding. Incorporate resistance to downy mildew and to other diseases into commercially desirable types. Determine the proper plant spacings, irrigation levels and nutrient levels for new varieties developed in this program.

SUPPORTED BY Texas State Government

6.0551, APPLICATION OF SPECIALIZED OPTIM TECH IN WATER QUANTITY & QUALITY MANAGEMENT WITH RESPECT TO PLANNING FOR THE TRINITY RIVER BASIN

W.L. MEIER, Texas A & M University System, School of Engineering, *College Station, Texas* 77843

A multistage optimization approach to planning for the optimal beneficial use of water resources within a river basin will be developed. Techniques will be developed which permit formulation of a complex water resource system as a multistage decision problem. Using this approach, an existing complex macrosystem can be decomposed into more manageable parts for subsequent analysis. An algorithm will be developed and coded for computer solution in the course of the study.

A unique feature of this algorithm will be its provision for incorporating water quality management into a general water resource planning problem. The computational algorithm developed in this study will permit objective analysis of alternatives regarding (1) the interrelation between waste treatment and low-flow augmentation for quality control, (2) the influence of water quality on other beneficial uses of water, and (3) the consideration of water quality control as a competing beneficial use of water.

An actual river basin in Texas, the Trinity, will be used as a testing ground for determining the applicability of the method developed.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Texas A. & M. University System

6.0552, WATER RESOURCE SYSTEM OPTIMIZATION BY GEOMETRIC PROGRAMMING

W.L. MEIER, Texas A & M University System, School of Engineering, *College Station, Texas* 77843

Techniques useful in the optimization of water resource system design problems will be developed in this research. A new and powerful optimization method, geometric programming, will form the basis for this study. Using geometric programming, highly nonlinear problems may be solved with relative ease.

In this investigation, the geometric programming optimization technique will be applied to a variety of water resource design problems to tests its usefulness in design optimization. Two such problems are concerned with the optimal design of waste treatment units and pipelines. A computer algorithm will be developed to make the geometric programming available for use by water resource analysts.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Texas A. & M. University System

6.0553, FERTILIZER TREATMENTS AND CULTURAL PRACTICES ON VEGETABLES

D.R. PATTERSON, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

Objectives: 1. To determine the differential response of yield and shipping qualities among varieties of different species of vegetables to different rates, ratios, and sources of nitrogen, phosphorus and potassium. 2. The influence of time, method, and location of placement of fertilizers upon yield and shipping qualities. 3. The effect of different levels of fertility and soil types upon the behavior of different varieties of the same species of vegetable, with particular reference to shipping amd market qualities. 4. The interaction of differential fertilization with certain cultural practices.

SUPPORTED BY Texas State Government

6.0554, ECONOMIC IMPACT OF WATER IMPOUNDMENT - VALIDITY TESTING OF A COMPARATIVE- PROJECTION MODEL

J.E. PEARSON, Texas A & M University System, Graduate School, *College Station, Texas* 77843

The proposed research plan involves the accuracy testing of a comparative-projection model designed to measure the economic impact of water impoundment. The model is unique since it contains three time/action phases and uses empirical local data as the basic inputs. A now-being-completed impoundment project in central Texas is to be the primary study area. The projections established for this impoundment project through an earlier study are to be evaluated as data are collected. The projections are to be compared to a synthetic index which has been established earlier for this purpose. An analysis of the economy surrounding the reservoir will be made to detect certain economic developments which can affect the accuracy of the model.

In completing the second phase of the study, a generalized testing of the model will be undertaken. Established impoundment projects across the state of Texas will be selected for testing the model and the results are to be compared to the synthetic index. Modifications and adjustments will be made to the model as needed in order to obtain a generalized form with adequate predictive value.

A recreational phase will be conducted concurrent with the above. This part is to involve on-site interviewing of recreators at reservoirs. The purpose of this phase is to strengthen the third phase (post-fillup) projection of the model.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Texas A. & M. University System

6.0555, AN ECONOMIC STUDY OF CROP PRODUCTION PRACTICES AND THE USE OF FARM EQUIPMENT ON THE HIGH PLAINS OF TEXAS

W.B. ROGERS, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

Objectives: The general objective will be to determine the most effective cropping practices as a means of reducing production costs of both irrigated and dryland crops. More specifically, the objectives are: 1. Evaluate various preplanting practices, including the kind of operation and the type of tool used together with the time when each operation is performed in preparing a seed bed for both dryland and irrigated crops. Particular attention will be given to conservation of soil moisture, control of soil blowing, crop residue management and proper tilth correlated with soil type. 2. Determine the cost and benefits occurring from the use of special planting attachments. Also, evaluate other practices associated with establishing both irrigated and dryland crops correlated with soil type. (see project statement).

SUPPORTED BY Texas State Government

6.0556, AN ECONOMIC ANALYSIS OF THE DEMAND FOR LAND AND/OR WATER-BASED OUTDOOR RECREATION IN TEXAS

I.W. SCHMEDEMANN, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

OBJECTIVES: 1. To construct demand functions and to estimate structural coefficients for those types of outdoor recreation which require the use of land and/or water. 2. To analyze consumer preferences for outdoor recreation activities and facilities and to measure the effects of factors which affect those preferences.

DESCRIPTION OF WORK: Estimates of demand and consumer preferences generally will be for those activities and facilities located in recreation areas falling into Marion Clawson's classification of (a) intermediate, (b) resource-based. Data for the analyses will be obtained from participants in recreation areas and from populations classed as (a) rural, (b) urban, (c) metropolitan. The estimates of demand for outdoor recreation activities will be expanded to represent the demand for outdoor recreation from the population groups mentioned above. Preference data pertaining to activities and facilities will be extended to provide solutions to acceptance problems facing both the private and public sector of the state. Cooperation will be continued with Texas Parks and Wildlife Department, USDA and other Federal agencies charged with responsibilities in outdoor recreation.

SUPPORTED BY U.S. Dept. of Agriculture
Texas State Government

6.0557, DEVELOPING AGRICULTURAL LAND IN RECREATIONAL USES UNDER PRIVATE OWNERSHIP OPPORTUNITIES IN A TEXAS ECONOMIC AREA

I.W. SCHMEDEMANN, Texas A & M University System, School of Agriculture, *College Station, Texas* 77843

Research was conducted to determine the effects of selected factors upon the intensity of recreational use of Texas lakes. Factors analyzed were grouped into four categories (1) Physical Characteristics, (2) Location of Lakes, (3) Demographic Characteristics of the Surrounding Populations, (4) Types of Recreational Facilities Provided at the Lakes. A representative sample was selected from lake sizes ranging between 10 and 500 surface acres being used for recreational purposes. Regression analysis showed that four independent variables, distance to nearest lake with comparable facilities, size of lake, picnic facilities, and Swimming significantly influenced recreational use intensity at the .10 level. They had a coefficient of multiple determination of .52.

Those lakes that were publicly administered were found to receive more recreational use than those which were privately administered. This contrast in recreational use was attributed to (1) Poor Quality Facilities, (2) Poor Management, (3) Improper Location, and (4) Insufficient Advertising in the private sector.

It was found that non-club lakes received more recreational use than did club lakes in the study. This was attributed to the fact that people hold memberships in club lakes to escape the crowding existing in public areas and to associate with people of a given social status. One, therefore, would not expect use rates at club lakes to be as high as those at non-club lakes.

SUPPORTED BY Texas State Government

6.0558, EVALUATION OF RESOURCE USE AND ECONOMIC EFFECTS DUE TO IRRIGATION WATER AVAILABILITY IN TEXAS

F.A. SCHMER, Texas A & M University System, Water Resources Institute, *College Station, Texas* 77843

The State of Texas is presently developing a State Water Plan which is to become a basic guide for water development through the year 2020. The objective of this research is to evaluate the total effect of the water plan on the Texas agricultural industry. The availability of water to agriculture in the future and its effect on the Texas economy as set forth by the plan is of utmost importance to Texans considering the relative merit of this plan.

To develop meaningful projections of water requirements which could be used in planning for water resource development, four models of agricultural resource requirements and production will be analyzed. Each model will contain (1) assumptions of restrictions on production and marketing of products; (2) assumptions relative to resource availability and use, and (3) estimates of output with the specified employment of resources. These models will illustrate the potential of Texas agriculture to produce food and fiber as effected by various restrictions on resource availability and marketing potential.

Analysis techniques by computer will be developed to evaluate the different restraints imposed on resource availability and market limitations and project the effect of these restraints into the future.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Texas A. & M. University System

6.0559, ECONOMICS OF AGRICULTURAL WATER USE NORTH OF CANADIAN RIVER

J.L. SHIPLEY, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

Objectives: 1. To obtain physical input-output coefficients. 2. To determine maximum-profit resource combinations for livestock and crop enterprises. 3. To develop maximum-profit short-run farm plans for selected cost-price situations and resource limitations. 4. To develop criteria for investment decisions, and to develop maximum-profit farm plans for intermediate-run and long-run planning horizons.

WORK PROPOSED: An experiment field will be established and out- farm experiments conducted to supplement data from experiment stations and farm surveys. Input-output coefficients will be estimated by regression analysis and maximum-profit resource combinations for enterprises will be estimated by marginal analysis. Maximum-profit farm plans will be obtained by mathematical programming. Investment decision criteria will be developed from applications of investiment and production theory.

SUPPORTED BY Texas State Government

6.0560, EFFECTS OF VARIOUS PRE-HARVEST AND POST-HARVEST TREATMENTS ON SWEET POTATOES

D.E. SPEIGHTS, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

Objectives: 1. To determine the most efficient method for obtaining maximum number of sweet potato plants per bushel of seedstock. 2. To determine the proper source, rate and placement of NPK and minor elements. 3. To determine the amount and time of application of irrigation water to obtain the highest yields of No. 4. To evaluate all sweet potato lines and varieties released for testing by the Southern Regional Testing program. 5. To screen herbicides for broad leaf weed and grass control in sweet potatoes.

SUPPORTED BY Texas State Government

6.0561, ALTERNATIVE DEVELOPMENT PATTERNS, PLANS, CONTROLS AND IMPACT ASSOCIATED WITH NEW RESERVOIRS

F.W. SUGGITT, Texas A & M University System, Graduate School, *College Station, Texas* 77843

Investigation: Develop an 'ideal' plan based upon optimum utilization of the lake, the shore and the backland. This will assume that ways and means are available whereby such an optimum utilization of the resources can be obtained, to provide a maximum of recreation- residence-business satisfaction to the people of the local area, to absentee owners, and to visitors. Evaluation of implications: Develop a 'probable' development plan showing what would likely attain without overall comprehensive planning and control, based upon whatever controls and guidance is now available, and transferring developmental history from other comparable lake situations. Evaluation of the ultimate costs, benefits, problems. Develop a 'practical' development plan that appears to be likely to be achieved with the installation of planning procedures and control. Evaluation of costs, benefits, deficiencies and problems. Procedure Organization and function of a Lake Livingston area regional planning commission, or council of governments, or development authority. Analysis of statutes, legal procedures, organization, finances, and operation of one or several instrumentalities. Measures needed to adopt and enforce ordinances and codes relating to land use, subdivisions, water supply, waste disposal, traffic control, (land and water), building and related codes. Steps needed to assure public understanding of recommended plans and organizations and ordinances. Evaluation of additional studies and efforts needed. Evaluation of additional sources of funds for such studies.

SUPPORTED BY Texas A. & M. University System
Lake Livingston 4-county Development Assn.

6.0562, INSTITUTIONAL FACTORS INFLUENCING WATER DEVELOPMENT IN TEXAS

W.L. TROCK, Texas A & M University System, School of Agriculture, *College Station, Texas* 77843

The proposed research involves (1) identification of institutional factors which have influenced important water developments in Texas, (2) evaluation of the impacts of these factors on development, allocation and subsequent uses of water, and (3) determination of possible changes in institutions or ways of dealing with institutional factors which will facilitate planning and developmental efforts concerned with water resources.

Identification of significant institutional factors will require examination of issues which have been publicly debated, counseling with expert witnesses, and interviews with individuals affected by developments. Impacts of factors will be measured in terms of time requirements for development, litigation needed, changes in resource use, added costs of resource development attributable to institutional factors, and other terms appropriate to the measurement of impacts.

Determination of relationships of institutional factors to water resource developments will provide a basis for suggestions for improving authorizations and procedures in developmental activities.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Texas A. & M. University System

6.0563, INSTITUTIONAL FACTORS AFFECTING WATER RESOURCE DEVELOPMENT IN THE LOWER RIO GRANDE RIVER BASIN

W.L. TROCK, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

A. Classify and inventory existing institutional arrangements in the Lower Rio Grande River Basin that potentially affect achievement of optimum management and development of water resources, and to describe their historical development. B. Analyze and describe the particular ways in which the identified institutional arrangements may act as obstructing or facilitating elements in achieving optimum management and development of water resources. C. Suggest the nature and extent of modification needed in existing institutional arrangements to facilitate achievement of optimum water management and development.

SUPPORTED BY Texas State Government

6.0564, ECESIS AND STABILIZATION OF PRICKYPEAR (OPUNTIA SPP.) ON THE RIO GRANDE PLAINS

UNKNOWN, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

1. To determine the various methods of reproduction and the importance of each in the spread of Opuntia spp. 2. To determine the edaphic factors favoring the persistent occurrence and proprgation of Opuntia spp. and the extent to which this species modifies the soil and other environmental factors of the habitat. 3. To determine the interactions of Opuntia spp. with the rate of recovery of the more desirable herbaceous species following control measures on selected soil sites.

Procedures: Field and laboratory studies will be established to determine the methods of reproduction and the importance of each in the propagation of Opuntia spp., the environmental factors favoring its persistent occurrence and spread and the effects of Opuntia spp. on the environmental factors of the habitat. Appropriate studies will be made to determine the effects of Opuntia spp. on the more desirable herbaceous species of the Rio Grande Plains.

SUPPORTED BY Texas State Government

6.0565, EXPERIMENTAL SEEDING (SHRIMP AQUACULTURE PROGRAM)

T.J. COSTELLO, U.S. Dept. of Interior, Biological Laboratory, *Fort Crockett - Galveston, Texas*

Following a 3-year study of the ecology of the waters in Florida Bay and Keys, it is apparent that only a portion of the suitable nursery areas are used by shrimp. Project objectives are to rear large numbers of shrimp from eggs spawned in the laboratory and seed underutilized nursery grounds.

Selected areas will be enclosed and stocked with laboratory-reared postlarvae. By systematic measurements of shrimp populations and physical features, rates of growth and survival of shrimp in different population densities will be related to physical conditions. The ultimate goal will be to determine the carrying capacities of nursery grounds and maintain an optimum level of shrimp population by seeding.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0566, STUDY OF TEMPERATURE EFFECTS IN COOLING WATER LAKE

H.C. MCKEE, Southwest Research Institute, *Houston, Texas*

Ecological Effects of Plant Cooling Water in Lake - 1967, 1968.

SUPPORTED BY Southwest Research Institute

6.0567, THIODAN AS A TOXICANT FOR ERADICATION OF FISHES IN LAKE MANAGEMENT

R.N. HAMBRIC, State Parks & Wildlife Dept. , *Houston, Texas* 77028

Several ponds or lakes will be treated with Thiodan to evaluate its effectiveness as a toxicant for fish eradication. Thiodan is an insecticide often used to spray fruits and vegetables. It has a fairly low mammalian toxicity and has been known to kill fish when applied at vary low ppm levels. Results of field applications of Thiodan to reclaim lakes will be compared with results that are normally expected when rotenone or toxaphene is used.

SUPPORTED BY Texas State Government

6.0568, RESULTS OF APPLICATIONS OF KARMEX FOR CONTROL OF PLANTS IN PONDS AND LAK

R.N. HAMBRIC, State Parks & Wildlife Dept. , *Houston, Texas* 77028

This study is to evaluate the effectiveness of Karmex (diuron) as applied under field conditions for control of various aquatic plants. Attention will be given to water quality, degree of control, methods of application, and dispersal of the herbicide.

SUPPORTED BY Texas State Government

6.0569, SIGNIFICANCE OF STOCKING SUB-ADULT FIN CLIPPED CATFISH IN HUNTSVILLE STATE PARK LAKE

R.N. HAMBRIC, State Parks & Wildlife Dept. , *Houston, Texas* 77028

An initial stocking of 9,000 marked catfish, that weighed approximately one ounce each, in this 210 acre lake greatly expanded the channel catfish population as shown in an intensive sampling effort. The program will be continued by releasing additional fin clipped sub- adult catfish with emphasis on the study of survival rate and degree of harvest by fishermen.

SUPPORTED BY Texas State Government

6.0570, LAKE BASTROP NETTING STUDY

A.G. WENGER, State Parks & Wildlife Dept. , *Houston, Texas* 77028

P.P.S. Objective: To evaluate - through field study - the effects of commercial fishing on certain game fish species.

Procedures: (1st year) Description of the basic features of the study area; establishing routines for collecting fish population data; tabulating data to show fisherman catch rate, gill net catch rate, and baited-trap catch rate; tagging catfish for age and growth study; tabulating gill net data to show relation of mesh size to size and species of fish caught. (2nd and 3rd years) Continued collection and calibration of catch-rate data. (4th and 5th years) Introduce commercial netting - with continued catch-rate data collection. (6th year) Data analysis and publication.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Texas State Government

6.051, ECONOMIC ANALYSIS OF ALTERNATIVE WATER USE TECHNIQUES IN PRODUCTION OF COTTON, GRAIN SORGHUM & RELATED CROPS - SOUTHERN HIGH PLAINS OF TEXAS

H.W. GRUBB, Texas Technological College, School of Agriculture, *Lubbock, Texas* 79409

(1) To develop analytical procedures to be used in selecting optimum combined precipation and irrigation water use plans in the Southern High Plains of Texas. (2) To develop input-output information (Production coefficients) for farm enterprises produced with recently developed water savings production techniques. (3) To develop water- value-maximizing farm plans for alternative water precipitation plus groundwater) saving techniques. Economics models will be formulated for the purpose of evaluating alternative investments in water conserving and water saving techniques. The analytic procedures will relate alternative water conserving techniques in terms of investment and maintenance costs and productivity in terms of crop yield values through time. The study area will be subdivided into homogeneous irrigation water supply sub-areas. The analysis will be done for typical farms of each sub-area. The economic analysis will utilize yield and cost data obtained from land modification research at the South Plains Research and Extension Center, yield and cost data from studies or irrigation techniques, data obtained from selected farmer interviews, and data from secondary sources. Records of precipitation in the study area will be analyzed for the purpose of estimating precipitation available for crop production. Engineering-economic evaluation techniques will be used to establish physical input requirements and costs of water conserving projects. Farm enterprise budgets will be used to estimate costs and returns of alternative crops produced on modified lands. Dynamic Linear Programming techniques will be utilized to estimate long-range farm plans for optimum combined precipitation and groundwater use.

SUPPORTED BY Texas State Government

6.0572, CULTURAL, SOCIAL ORGANIZATIONAL, AND SOCIAL PSYCHOLOGICAL FACTORS ASSOCIATED WITH PROPOSED CHANGES IN WATER USE PATTERNS

W.H. ANDREWS, Utah State University, Graduate School, *Logan, Utah* 84321

The project deals with an interstate river basin and the sociological factors associated with development of the water resources of the basin. A development plan has been proposed and this will be a field study to investigate the attitudes, soial values and goals that effect the decisions made about this proposal and the people that behave in relation to it. In addition a measure of the kind and quality of knowledge the public has about the proposal and the social systems through which the knowledge was diffused as well as how it was done. These elements are expected to begin to shed some light on the institutional constraints on water resource development for improvement of development programs and for management planning.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Utah State University

6.0573, THE HISTORY AND ECONOMICS OF RECLAMATION PROJECTS IN UTAH

L.J. ARRINGTON, Utah State University, Agricultural Experiment Sta. , *Logan, Utah* 84321

The most important federal reclamation projects in Utah will be studied, and individual articles on each project will be prepared for publication in the Utah Historical Quarterly, the Western Economic Journal, Pacific Historical Review, Agricultural History, and other professional journals. During the year 1964-65, the Strawberry Reservoir and Hyrum Dam will be given intensive study. In future years, studies of the Provo River Project, Weber Basin Project, Ogden River Project, Newton Project, and other important projects in Utah will be examined. These studies will treat the early history, the construction, and the management and use of the project. Particular attention will be given to the economic and social impact of each project on the economy of the state and region. The effect of the project upon population growth, the development of agriculture, industry, and trade, will be traced and estimated, as well as the impact on public services. Both quantitative and qualitative data and analysis will be utilized.

6. WATER RESOURCES PLANNING

SUPPORTED BY Utah State Government

6.0574, LABORATORY CATCHMENT INVESTIGATIONS RELATING TO HYDROLOGIC SYSTEMS ANALYSIS

D.L. CHERY, Utah State University, Utah Water Research Laboratory, *Logan, Utah* 84321

General investigation of watershed morphological and input parameters and their relation to parameters of system transfer functions, descriptive of measured hydrologic systems.

In particular, system identification will be developed for a laboratory catchment which will be subjected to controlled variations of geometry and input. The influence on the parameters of the system function caused by the controlled changes will be analyzed. Ultimately the laboratory information will be extended to the investigation of the natural system, by duiding the design of field measurement system and development or refinement of system functional relations describing the natural system.

SUPPORTED BY U.S. Dept. of Agriculture

6.0575, APPLICATION OF OPERATIONS RESEARCH TECHNIQUES FOR ALLOCATION OF COLORADO RIVER WATERS IN UTAH

C.G. CLYDE, Utah State University, Utah Ctr. For Water Resour. , *Logan, Utah* 84321

The State of Utah, through its commitment to develop a State Water Plan, has the responsibility of allocating the available water supplies in such a manner as to provide for the most beneficial control and utilization of the supplies within the various basins of the State. In this responsibility, the State of Utah is faced with a problem common to all of the states.

The objectives of the proposed research are to assist the State of Utah in particular and the other states in general by formulating a methodology for optimal allocation of available waters. More specifically, the objectives are: 1. To formulate a mathematical model with the appropriate constraints for the water resource system composed of the portion of the State of Utah which feasibly could recieve Colorado River waters either directly or by transfer. 2. To solve the mathematical model using an appropriate optimizing algorithm to determine the least-cost allocation of Colorado River waters in the State of Utah. 3. To carry out optimizations for various assumed operating rules. 4. To evaluate the usefulness of the analytical approach for state water planning.

In carrying out the intended research, preliminary screening will be necessary to define the actual study area. Physical features as well as legal characteristics of the area and the limitations imposed by the Colorado River Compact will be formulated as system constraints. Various water costs associated with the alternative sources and demands will be determined and an appropriate objective function will be established. Alternative operating rules and assumptions will also be established. Optimal allocations for the alternative operating rules and assumptions can be determined then by use of the linear programming algorithm or some other suitable optimizing method. The optimal allocations of Colorado River water on an interregional basis will yield information of great value to subystem projects composed of tributary river basins.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Utah State University

6.0576, THE VALUE OF WATER IN COMPLEMENTARY INDUSTRY COMPLEXES

B.D. GARDNER, Utah State University, Economics Research Institute, *Logan, Utah* 84321

Objective: To determine the marginal productivity of water within the structure of selected agriculturally related industrial complexes.

Work Plan: Input-output analysis and simulation techniques are being used to establish the economic structure of given local economies in Utah. From this structure it will be possible to trace the impact of a given augmentation in the water supply to certain uses on the entire economy of the region. In this way the marginal social value of the water resource can be estimated.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch •
Utah State University

6.0577, THE ECONOMICS OF WATER TRANSFER

B.D. GARDNER, Utah State University, Agricultural Experiment Sta. , *Logan, Utah* 84321

1. To identify and describe the legal, institutional and administrative structures, processes, and techniques currently used in Utah that effect transfers of water or act to deter them.

2. To appraise these legal, institutional, and administrative devices and processes with respect to: (a) the degree of flexibility in water allocation they permit leading to efficiency in use, and (b) the permanency of tenure they bestow as a stimulant to investment and economic growth.

3. To study the markets for water rights and water rentals in Utah and to evaluate their adequacy in permitting water transfers and in promoting economic efficiency and equity.

A survey and analysis will be made of the roles and functions of water law, water markets, state administrative agencies, such as the State Engineer's Office, Water and Power Board, and local organizations such as the metropolitan water districts, water conservancy districts, and irrigation companies. The focus will be on the ease or difficulty of water transfers and the resulting impact on economic efficiency and wealth redistribution brought about by transfer.

SUPPORTED BY U.S. Dept. of Agriculture
Utah State Government

6.0578, THE POTENTIAL DEMAND FOR WATER AND LAND IN SELECTED AREAS OF UTAH

B.D. GARDNER, Utah State University, Agricultural Experiment Sta. , *Logan, Utah* 84321

Objectives: 1. To determine the value productivities of water in competing uses. 2. To identify and determine the relative importance of factors which affect the amount of water demanded by various user types. 3. To compute rates of return to various investment practices associated with water conservation, quality maintenance, and storage. 4. To gauge the impact of water transfers on income and wealth distribution between individual users and between affected geographical regions.

Procedure: Farms, households, and industrial firms will be surveyed to determine how much water is used and the factors that are thought to be important in determining use. Regression analysis will then be used to indicate the importance of each factor. Costs and returns information will also be collected that relate to investment in storage facilities, water conserving practices, and maintaining water quality. This will permit calculation of rates of return on investment. Aggregate county census information will be used to determine average net income for various classifications of water users. Then as assumed water transfers are made to different uses and to different regions, the impact on area income and economic activity can be estimated.

SUPPORTED BY Utah State Government

6.0579, STATE WATER PLAN INVESTIGATIONS

F.W. HAWS, Utah State University, Utah Water Research Laboratory, *Logan, Utah* 84321

Water supply and water use determinations and projections are being made according to major hydrologic areas of the state. All hydrologic information is evaluated and analysed in terms of frequency occurrence. The total flow picture from headwater reaches to final stream disposition is being pieced together so that the effects of development and management can be traced throughout the balance of the hydraulic system. Basic data evaluation and interpretation are made with view toward planning requirements in which alternative development possibilities must be tested.

This work was begun in 1961 and will continue to hydrologic subdivisions until all areas of the state have been thus studies and reports prepared. Reports to be published in 1968 include: Water Related Land Use in the Provo River Divisions, Land Use in the Weber River Drainage Systems, Land Use in the Bear River System, Hydrologic Budgets have been completed for Provo, Weber, Bear river system and the Uinta Drainage area.

SUPPORTED BY Utah State Government

6.0580, THE EFFECTS OF DIELDRIN ON MALLARD DUCKLING BEHAVIOR

P.N. LEHNER, Utah State University, State Coop. Wildlife Res. Unit, *Logan, Utah* 84321

Objective of this project: To determine if various levels of dieldrin affect the ability of juvenile mallards to discriminate wavelength (color).

Procedures: Adult Mallards will be fed 0,1.6,4 and 10 ppm of dieldrin in their feed. The eggs will be collected and artificially incubated. Ducklings will then be placed either on clean feed or on feed at the same dosage level as that fed their parents.

Ducklings will be raised to approximately 50 days of age and then tested on their ability to discriminate color. Automated psychological testing equipment will be used to produce stimulus generalization gradients for each duckling. Measurements of inter and intraducklings effects will be made by graphic comparison.

Whole brain analyses of dieldrin residues will be made on all ducklings tested and on a sample of the parent population at the termination of the study. These will be correlated with the stimulus generalization gradients.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Utah State University

6.0581, HOME RANGE AND BREEDING BIOLOGY OF SHOVELERS (ANAS CLYPEATA) IN THE ALBERTA GRASSLAND

J.B. LOW, Utah State University, State Coop. Wildlife Res. Unit, *Logan, Utah* 84321

A four-year study of the breeding ground home range and biology of the shoveler (Anas clypeata) was undertaken on a small tract of agricultural land in the grassland of southern Alberta. Three objectives of the study were: (1) to study the movements of shovelers using the home range concept, (2) to investigate the function of a shoveler's home range, and (3) to study the breeding biology of shovelers. Work is being done in the Strathmore study area near Strathmore, Alberta, Canada.

SUPPORTED BY Utah State University

6.0582, WATER QUANTITY AND QUALITY REQUIREMENTS ON WESTERN SALINE MARSHLANDS

J.B. LOW, Utah State University, State Coop. Wildlife Res. Unit, *Logan, Utah* 84321

The basic objective of this research was to supply the State Engineer with factual information on the quality and quantity of water required for effective operation of Waterfowl Management areas. Allocations to wildlife areas are important because of water resources of Utah are rapidly being developed for agriculture and industry. This study, begun in 1960 through the cooperation of the Utah State Department of Fish and Game, the Engineering Experiment Station at Utah State University and the Utah Cooperative Wildlife Research Unit, has operated on two phases of the subject; (1) the actual water required (quantity) to operate efficiently a marshland and (2) the quality of water needed to propagate the desirable marsh and aquatic plants needed as food and cover by waterfowl. The study area selected was the 700 acre State area known as Howard Slough Waterfowl Management Area.

Field work completed; bulletin in manuscript form, but not published.

SUPPORTED BY Utah State University
Utah State Government

6.0583, FOOD AND FOOD ENERGY REQUIREMENTS OF WILD DUCKLINGS

J.B. LOW, Utah State University, State Coop. Wildlife Res. Unit, *Logan, Utah* 84321

Objectives of this study are to: (1) determine the composition of the diet of four species of flightless young ducks using the same habitat, (2) determine the abundance of animal and plant foods in the habitat and relate it to duck use as determined in objective '1', previous, (3) investigate factors which influence food use by ducklings, (4) determine nutritional composition of natural duck foods, (5) determine food energy requirements of growing ducks, using species considered in objective '1'.

Over a three-year period, samples of each age class of flightless young of lesser scaup, baldpate, and pintail, will be collected on the study area. Tentative minimum sample size has been set at 70 usable gullets more or less evenly distributed among the several classes of flightless young. Birds will be collected during the period they are normally abundant for a given species or age class.

The relative abundance of aquatic invertebrates will be measured at each duck collecting site by means of 'sweep' and bottom sampling.

Vegetation at duck collecting sites will be measured by a modification of the line point method. Plants will be sampled with a square-foot frame divided into 0.01 sq. ft. squares by a wire grid.

Analyses for the major nutrients of important foods will be contracted to the Provincial Analytical Laboratory. Foods to be analyzed will be collected on the study area. In order to measure daily food intake of growing ducklings, four groups of 3 or 4 ducks each will be used for feeding trials with natural foods provided ad libitum. The factorial method involves determining the requirements for maintenance, daily activity, and growth, which together make up the net energy requirements. Use of the two methods for determining food energy requirements of growing wild ducklings will provide an excellent check. Work being performed in the Strathmore study area, Strathmore, Alberta, Canada. Work started fiscal year 1966 and will terminate fiscal year 1970.

SUPPORTED BY Utah State University
Canadian Government

6.0584, EFFECTS OF REGULATED GRAZING ON WATERFOWL PRODUCTION

V.R. PANCAKE, Utah State University, Graduate School, *Logan, Utah* 84321

The proposed study is designed to determine the effects of regulated grazing on waterfowl production in a salt grass-bulrush marsh. This will be done by correlating variations in production of waterfowl with the amount of cover removal on plots receiving different grazing pressures. During the first grazing season, (winter, 1968 69), there will be heavy grazing on two acre 'pilot' plots. These will serve as guides in establishing grazing intensities for the 1969- 70 grazing experiments. During this season, grazing will be at light, medium, and heavy intensities, but will include controls and a pair of plots which will be grazed according to practises of local cattlemen. These plots will be 25 acres with 2 replications for each treatment. Nesting censuses will be conducted over the whole marsh, by quadrat sampling, in the spring of 1969. The 1970 nest census will be restricted to the 25 acre plots.

SUPPORTED BY Utah State Government

6.0585, APPLICATION OF AN ELECTRONIC ANALOG COMPUTER TO THE SIMULATION OF THE TOTAL HYDROLOGIC-ECONOMIC FLOW SYSTEM

J.P. RILEY, Utah State University, Utah Ctr. For Water Resour. , *Logan, Utah* 84321

Efficient management of water resources involves a consideration of interacting hydrologic and economic variables, and, therefore, requires an examination of the system as a whole. The overall approach requires the integration of the many system components, and to this end the electronic analog computer is well suited. The validity of the analog simulation approach to hydrologic problems has already been demonstrated by the results of recent research at Utah State University. Under the proposed study this background experience will be applied to the development of a fundamental model of the hydrologic-economic flow system. Both the engineering and the economics disciplines are involved.

Briefly, the major objectives of the research proposal are to (1) develop, improve, and evaluate basic relationships which link the hydrologic and economic flow systems, and (2) investigate the feasibility of using an electronic analog computer to synthesize fundamental hydrologic and economic processes into a working model of the total hydrologic-economic flow system.

The model will be verified by simulating a prototype basin for which both hydrologic and economic data are available.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Utah State University

6.0586, THE DEVELOPMENT OF A SIMULATION MODEL FOR THE BEAR RIVER BASIN

J.P. RILEY, Utah State University, Utah Ctr. For Water Resour., *Logan, Utah* 84321

The overall objective of this study is to apply analog computer simulation techniques as a planning and management device for the water resources of the Bear River system. This is an interstate stream in a water-short area. Distribution of the available water supplies among the multiplicity of demands will require the consideration of many alternative plans of development.

The study will proceed by assembling available hydrologic data and formulating a mathematical model based on previous experiences and equipment developments. The mathematical model will then be tested and verified on the analog computer. The utility of the model will be demonstrated by examining various alternative management possibilities within the Bear River basin.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Utah State University

6.0587, A STUDY OF THE INTEGRATION OF THE WATER RESOURCES OF THE BEAR, WEBER, AND JORDAN RIVERS IN NORTHERN UTAH

J.P. RILEY, Utah State University, Utah Water Research Laboratory, *Logan, Utah* 84321

The overall objective of this study is to determine the magnitude and variations in the quantity of water that might be feasibly exchanged between the Bear and Jordan River systems, using the waters of the Weber River as the exchange medium. In view of the scope of this objective, the simulation approach to the problem seemed particularly applicable. Through the formulation of computer models of the physical system, it is possible to consider quickly the influence of a wide range of constraints and input functions. The electronic analog computer is the primary computational device being applied in the formulation of the models.

SUPPORTED BY Utah State Government

6.0588, WATERFOWL UTILIZATION OF SAGO PONDWEED (POTAMOGETON PECTINATUS) ON A SELECTED MARSH IN NORTHERN UTAH

M. STERLING, Utah State University, Graduate School, *Logan, Utah* 84321

The utilization of sago pondweed will be determined by the establishment of 48 sets of study plots from which comparisons of productions of sago pondweed tubers, vegetation, and seedheads will be made. Each set of study plots will consist of (1) an enclosed plot, (2) a plot available to carp and waterfowl use, and (3) a plot available only to carp. Water levels and soil depths will be recorded in conjunction with the tuber sampling to determine what effect these two variables had on waterfowl utilization of sago pondweed tubers.

The effect of waterfowl utilization on sago pondweed production will be determined by the establishment of fifteen, 50 by 50 foot pens. These pens will be stocked with semi-domestic mallard ducks at specific rates to simulate the desired densities of use. Samples of sago pondweed vegetation, tubers, and seedheads will be taken after utilization periods to determine the effect utilization had on production of these elements.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Utah State University

6.0589, FARM ADJUSTMENT TO LIMITED IRRIGATION WATER WITH REFERENCE TO CENTRAL UTAH PROJECT

C.E. STEWART, Utah State University, Agricultural Experiment Sta., *Logan, Utah* 84321

The general objective is to determine the most profitable individual farm adjustments to conditions of inadequate irrigation water supplies and to appraise the effect on farm incomes and on other criteria of economic success of incremental changes in water supply to individual farms. The analysis is oriented to relevant market, climatological, and physical resource conditions.

The study is focused primarily on conditions of inadequate irrigation water supplies. What adjustments are desirable from the standpoint of the individual farmer? What is the most profitable and efficient use he can make of the available supply? What is the value of an increment of water from the water from the standpoints of individual farmers and of the public?

Economic data have been collected for 140 farms on Strawberry Valley Project and for 60 farms in Ashley Valley. Detailed input data were collected on about 400 fields of crops on these farms. Work remaining is entirely analytical. A large portion of the data has been coded; this job will soon be completed. Data will then be punched on IBM cards and analyzed by budgeting and linear programming techniques to estimate the most profitable combinations of resources and farm adjustments under limited supplies of irrigation water. Value of increments of irrigation water will be estimated.

SUPPORTED BY Utah State Government

6.0590, SOILS, PESTICIDES, AND THE QUALITY OF WATER

S.A. TAYLOR, Utah State University, Agricultural Experiment Sta., *Logan, Utah* 84321

Objectives: 1. To establish whether movement through the soil constitutes a significant source of the pesticides found in surface and ground water. 2. To identify the properties of pesticides and of soils that control the extent of movement of pesticides in and through soils. 3. To ascertain the solubility characteristics of pesticides sorbed on soil particles and hence the effect of suspended soil on the concentrations of pesticides in water. 4. To ascertain the effects of management of pesticides and land on the transport, by all means, of pesticides to water supplies.

This Utah project is devoted to furthering above Objectives 2 and 3. Adsorption, flow, and thermodynamic properties of a variety of pesticides will be studied in connection with montmorillonitic and kaolinitic types of clays, sand, and complete soil. Specific compounds will be selected to give carboxyl, carbonyl, amine, amide, and double bonded oxygen, sulfur, or phosphorus positions that may interact with clay or exchange with cations present in the colloidal complex of soil materials. Thermodynamic properties of systems consisting of various soil materials and water will be studied. Organic pesticides will then be adsorbed onto the soil solids and the thermodynamic properties will again be studied. In this way the change in properties will be evaluated.

SUPPORTED BY U.S. Dept. of Agriculture
Utah State Government

6.0591, IMPACT OF RECREATIONISTS ON SELECTED SITES

S.K. TOCHER, Utah State University, Agricultural Experiment Sta., *Logan, Utah* 84321

Objectives: 1. Establish initial impact of recreationists on vegetation and soils on previously unused sites. 2. Relate changes in low level vegetation to treatment by irrigation and fertilization, amount of use, and site factors. 3. Study responses of growth rate of overstory trees in camp to pair trees outside camp.

Description of Work: 27 0.064 acre plots have been laid out, mapped and measured. Treatment effectiveness will be tested by vegetation responses and changes in rates of infiltration. Selected plots will be irrigated and fertilized. Regressions analysis will relate vegetation to use, facility location and site factors.

SUPPORTED BY Utah State Government

6.0592, METHODOLOGY FOR DETERMINING VALUATIONS OF WATER FOR ALTERNATIVE USES

E.B. WENNERGREN, Utah State University, Agricultural Experiment Sta. , *Logan, Utah* 84321

1. To develop economic models designed to estimate marginal values for water in its alternative uses in the Intermountain West. 2. To develop economic models designed to estimate marginal value relationships for water in its alternative uses and levels of use in the Intermountain West.

Water use classification systems will be developed. Methods of measuring water input-output relations for economic analysis will be explored. Alternative economic 'choice indicators' will be studied. Types of water markets will be determined. Methods for determining the present economic efficiency of resource allocation within and among water-using industries will be developed. Also, the direction of resource reallocation to increase water use efficiency will be established conceptically. Economic models developed will be tested on a diminutive cable for selected water use complexes.

SUPPORTED BY Utah State Government

6.0593, RECREATION VALUE OF WATER FOR THE PRODUCTION OF WATERFOWL

R.S. WHALEY, Utah State University, Graduate School, *Logan, Utah* 84321

The proposed research has the following objective: To develop and test methods that can be used for valuing on-site and off-site benefits originating from the production of waterfowl at selected Utah waterfowl refuges and state marshes.

There are fundamentally three steps in the procedures for this project: (1) Defining the kind and distribution of benefits resulting from particular refuges; (2) estimating the amount of use of the varied kinds of recreation opportunities offered by the operation of the refuge; and (3) placing value estimates on these uses.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Utah State University

6.0594, UPDATING AND REPUBLICATION OF FACTORS INFLUENCING THE RESTORATION AND DEVELOPMENT OF OGDEN BAY REFUGE

N.F. NELSON, State Div. of Fish & Game, *Salt Lake City, Utah* 84116

Objective: To determine ecological changes as they occur on saline marshes and to determine the impact of these changes on waterfowl habitat and use.

Status: This is the second year of a proposed three year study to update and revise a previous W-290R publication on the ecology of saline marshes. Project plans call for formal publication in the form of a Department bulletin.

Justification: The ecology of saline marshes is of extreme interest to waterfowl technicians throughout western North America. Continuing ecological studies of these areas are critical in view of todays increased demand for total utilization of existing water supplies. The impact that changes in water supplies will have on ecology of any waterfowl area will directly affect waterfowl production and use of saline marshes in the Great Basin. Publication and revision of this manuscript will satisfy the increasing demand for copies of the orginal publication which is out of print, and at the same time enlarge our knowledge of saline marsh ecology.

Procedures: Relocation of original study areas and transects on the Department's Ogden Bay Waterfowl Area; establishment of new transects whereever ecological change has altered the original study area; reading of these transects at established intervals; summarization and tabulation of new data; comparison of ecological change with patterns of waterfowl use during production and migration periods; comprehensive review of the orginal manuscript; consolidation of new data with the orginal manuscript; and formal publication of this consolidation.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Utah State Government

6.0595, THE EFFECT OF LIVESTOCK UTILIZATION ON WATERFOWL HABITAT AND PRODUCTION

UNKNOWN, State Div. of Fish & Game, *Salt Lake City, Utah* 84116

Objective: To determine the impact of unregulated livestock utilization of wetlands on waterafowl habitat and production.

Status: This the first year of an estimated three year study to determine the impact of cattle on waterfowl production and wetland habitat.

Justification: Livestock interests in Utah continually pressure the Department for grazing privileges on State-controlled waterflowl areas. With one exception these areas are not currently utilized by livestock. The Department feels that livestock use on waterfowl areas is not compatible with the basic purpose of the development; however, no evaluation of this problem has been attempted in the State. This study will endeavor to determine specific effects of livestock on waterfowl production, the effect of cattle on wetland habitat, and the effect of cattle on habitat quality.

Procedure: Establishment of ground transects on the Department's Locomotive Springs (study) and Salt Creek (control) Waterfowl Management Areas. These areas are both spring fed saline marshes similar in all respects with the exception that cattle are allowed to utilize Locomotive Springs. Cover mapping of both areas has been accomplished. Transects will be established in similar cover types and read at regular intervals throughout the spring, summer, and early fall. A comparison as to waterfowl use, habitat development, and production of the two areas will be made. This comparison will indicate the impact of cattle on waterfowl and waterfowl production and will be evaluated in an effort to formulate management recommendations.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Utah State Government

6.0596, THE BIOLOGY AND CONTROL OF TABANIDAE IN MARSHLANDS ALONG THE EASTERN SHORE OF THE GREAT SALT LAKE, UTAH

D.M. REES, Univ. of Utah, Graduate School, *Salt Lake City, Utah* 84112

Object: To survey marshlands along the eastern shore of the Great Salt Lake to determine most favorable breeding areas for tabanids, to determine life cycle under existing conditions, and to devise water and land management schemes to minimize breeding of tabanids.

Plan of Work: Collections of larvae and adults of tabanids will be made along the eastern shore of the Great Salt Lake by soil sampling, emergence cages, light traps, car traps, and animal bait traps. Samples of larvae and adults collected from suspected breeding areas will be used to determine species present, preferred egg laying sites, life cycles, and preferred hosts. Adult collections will also be used to determine ecology, dispersion and flight patterns and habits of various species. Observations will be made on the seasonal cycles and succession of adults of different species and their habits in relation to meteorological and other environmental factors. The micro environment of favorable larval breeding habitats will be determined. Current water and land management practices at Salt Lake will be evaluated for their effect on the production of tabanids.

SUPPORTED BY U.S. Dept. of Agriculture

6.0597, ECONOMIC EFFECTS OF WATER ALLOCATION AMONG ALTERNATIVE INDUSTRIAL (NON-AGRICULTURAL) USES

G.S. THOMPSON, Univ. of Utah, Graduate School, *Salt Lake City, Utah* 84112

The demands for water in Utah have expanded more rapidly than the total supply available. If the state's growth is to continue, wise allocations of water among competing uses must be made.

The allocation process is complicated by the rapid transformation of the state from a rural, agricultural to an urban, industrial-commercial economy.

Objectives: The primary purpose of the proposed research is to assemble data and undertake analysis which will attempt to determine the marginal productivity and the economic effects of water allocation among alternative industrial or non-agricultural uses.

Procedures: A dual approach will be used. 1. An industrial complex will be selected based on a Utah mineral and composed of a series of related dependent industries. Information will be collected from each segment of the industry complex which when processed and applied to an economic model will indicate the marginal productivity of water for each segment of the industry as well as for the total complex. 2. The second approach is to calculate the number of jobs per acre foot (or per gallon) of water which exists in mining and manufacturing industries within the state and determine the contribution to total state income of such employment and water use.

The first approach will be intensive in nature and will stress methodology; the second will attempt to obtain useful information over a broader range of industries in order to offer immediate assistance in water allocation decisions. The techniques developed will be useful to other regions.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Utah

6.0598, AN EVALUATION OF THE LAMPREY IN LAKE CHAMPLAIN

J.K. ANDERSON, State Fish & Game Department, *Montpelier, Vermont*

Objectives: To determine the size of the lamprey population in Lake Champlain and to locate their principal spawning streams. To determine the extent of their predation upon fish in Lake Champlain and to determine fishes most readily attacked.

Procedures: Spawning streams will be located utilizing electro- fishing gear to sample adults and to locate ammocoetes. These streams will be catalogued with reference to spawning locations and the approximate size of the lamprey population utilizing it as a spawning site. All fish collected in Lake Champlain studies will be examined for lamprey scars and records kept of such scars. These records will be used to evaluate the lamprey predation upon each species of fish and to determine the susceptibility of each species to lamprey predation.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Vermont State Government

6.0599, CLIMATOLOGICAL FACTORS AFFECTING WATER USE IN AGRICULTURE

R. BAJWA, U.S. Dept. of Agriculture, *Arlington, Virginia*

Objectives: To develop improved methods for incorporating climatological factors into analyses of water use in agriculture.

Approach: A study of techniques for computing consumptive water use requirements by agricultural crops will be undertaken to determine reliability for use in estimating such requirements in various regions of the United States. Estimates will be made of consumptive use of water by various crops in selected regions of the United States. These estimates will be combined with data describing water supplies and irrigable soils in the selected regions to derive estimates of irrigation potential and the total water requirements needed to realize the potential.

SUPPORTED BY U.S. Dept. of Agriculture

6.0600, ECONOMIC INVENTORY OF AGRICULTURAL WATER USE IN THE UNITED STATES

C. DICKASON, U.S. Dept. of Agriculture, *Arlington, Virginia*

Objectives: To formulate and maintain a systematic and continuing economic inventory of agriculatural water use in the United States.

Approach: The formulation and maintenence of this inventory will be accomplished by collecting and analyzing data from Federal, State and local organizations such as irrigation, drainage, conservancy and soil conservation districts will also be included as sources of data. The research will include appraisal of current and prospective economic demands for water by agriculture in relation to current and prospective economic supplies of water. Analyses of economic aspects of agricultural water use and development and the relationships between water development or conservation programs and various agricultural problems will also be included. The inventory will include pertinent facts on quantity, quality and uses of water; comparative expenditures for major uses, including demand and supply relationships; and trends in use.

SUPPORTED BY U.S. Dept. of Agriculture

6.0601, ECONOMICS OF IRRIGATION, DRAINAGE AND RELATED PROBLEMS IN THE NORTHWEST

G.A. PAVELIS, U.S. Dept. of Agriculture, *Arlington, Virginia*

Objectives: To conduct economic analyses pertinent to: (1) Measurement or irrigation water values; (2) use of irrigation return flows; (3) alternative drainage methods; and (4) water quality management.

Approach: Experimental and survey data will be used in production function analyses and mathematical programming techniques to determine values of water in irrigating selected crops. Irrigation return flows data will be collected from the Northwest Hydrology Research Watershed for use in economic studies of transfer of this water to other uses in other locations. Initially, economic analyses of drainage methods will depend upon an experimental research program at Oregon State University for data. This will be followed by an economic analysis of drainage methods in the Willamette Valley. An input-output framework is being used in selecting a suitable water quality management policy for the Yaquina Bay Area in Oregon. Welfare economics will provide the selection criteria and the analysis will include various interest groups represented as economic sectors.

SUPPORTED BY U.S. Dept. of Agriculture

6.0602, ROLE OF WATER IN THE PATTERN OF REGIONAL ECONOMIC DEVELOPMENT

A. SOKOLOSKI, U.S. Dept. of Agriculture, *Arlington, Virginia*

Objectives: To examine the role of water as a determinant in location of economic growth and development as related to specific methods of designating regions by natural resource, geographic, population density, or economic characteristics.

Approach: Economic growth and development in the New England States will be analyzed in a framework based on location theory. Specific attention will be devoted to the effects of water resources on the pattern of economic development over time.

SUPPORTED BY U.S. Dept. of Agriculture

6.0603, SYSTEMS STUDY - MARYLAND PROJECT

D. OBRYAN, U.S. Dept. of Interior, Water Resources Division, *Arlington, Virginia*

The study is concerned with the relationships between a natural water system and its physical environment, and the forces of planning, development, and management during the stages in which the water resource is utilized to the ever greater advantage of the local economy and human desires. Specifically to assist public officials toward: a. A general understanding of hydrologic knowledge as a background vital to water resources planning, design, and management. b. Use of specific hydrologic findings as working tools in the hands of planning and reviewing bodies. c. Recognition of and consideration for the alternatives and compromises to be encountered in the planning of the development of water systems.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

6.0604, ECONOMIC ANALYSIS OF RECREATIONAL USE OF RESERVOIRS CONSTRUCTED BY PRIVATE POWER COMPANIES

A. DEGN, Virginia Polytechnic Institute, Agricultural Experiment Sta., *Blacksburg, Virginia* 24061

Objectives: Determine practices, problems and opportunities associated with recreational use of reservoirs, explain recreational use of reservoirs, determine impact of reservoirs on local economies.

Description of Work: In depth interviews with power company officials to identify problems of recreational use of reservoirs, role of public agencies in providing recreational facilities on private reservoirs. Survey of users of reservoirs to determine their social and economic characteristics and expenditure patterns to be used in projecting future use of these reservoirs. Inventory recreational facilities associated with private reservoirs. Survey of recreational establishments to determine cost and returns in order to determine their contribution to the local economy in terms of gross volume of business, employment, payrolls and taxable investment.

SUPPORTED BY Virginia State Government

6.0605, PERCEPTION OF WATER RESOURCE PROBLEMS - A PILOT STUDY

C.A. IBSEN, Virginia Polytechnic Institute, Graduate School, *Blacksburg, Virginia* 24061

The proposed research plan is a pilot study directed at gaining insight into the relationship the perception of water problems by the public and the attempts of the water expert to deal effectively with water problems. The study will deal with the following research questions: 1. What are the factors related to the public's perception of water problems? 2. To what extent does the public view water as a problem and what is the basis of a problem perception? 3. What action does the public feel should be taken toward the solution of the problems perceived?

A random sample of 500 will be selected and these respondents will be interviewed by telephone. The interview will gather data on the characteristics of the respondent, his perception of water problems, the source of these perceptions, and his feelings about what could be done to solve the perceived problems. This data will then be analyzed according to the significance of differences between types of respondents and their perceptions of lack of perceptions of water problems, source of perceptions, and suggested solutions. The interpretation of findings of the pilot study will be made as hypotheses to be tested in a larger research effort.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Virginia Polytechnic Institute

6.0606, WATER RIGHTS RELATED TO WATER QUALITY STORAGE

W.R. WALKER, Virginia Polytechnic Institute, Water Resources Research Ctr. , *Blacksburg, Virginia* 24061

In the early 1960's, Congress amended the Federal Water Pollution Control Act to permit Federal agencies to give consideration to the inclusion of storage for regulation of streamflow for the purpose of water quality control. To date, little consideration has been given to the claims which might be made on this water under various state laws after it has been released from the reservoirs. This study proposes to define the rights of both riparian owners and appropriative users to this water in the states which now have, or soon will have, impoundments with water quality storage. If the investigation reveals a conflict of interest, the research should suggest alternative solutions in forms of compacts, uniform laws, or federal legislation.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

6.0607, UTILIZATION OF PHYSICAL AND MATHEMATICAL MODELS IN ESTUARINE WATER RESOURCES RESEARCH AND MANAGEMENT

W.J. HARGIS, Virginia Inst. of Marine Sci. , *Gloucester Point, Virginia* 23062

Increased use of hydraulic and mathematical models in research, planning engineering and conserving estuarine and coastal environments is important. The proposed project will utilize VIMS hydraulic model of the tidal James system and analogue, digital and hybrid mathematical modeling capabilities in a program of research designed to evaluate and improve the capabilities of each technique. Thus, the accuracy, precision and capabilities of all likely will be improved, or at least clarified.

It is expected that improved ability to predict the changes which will result in such biologically, economically, socially and politically important environmental factors as salinity distribution, currents sedimentation, bottom scour and shore erosion will result.

This program is relevant to the projected Chesapeake Bay Hydraulic Model.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0608, THE IMPACT OF FEDERAL WATER LEGISLATION AT THE STATE AND LOCAL LEVEL

K.A. HAMMOND, Central Washington State Coll. , Graduate School, *Ellensburg, Washington* 98926

The proposed project would identify the reasons for, and assess the implications of, the actual impact of federal water resource legislation. Study would include institutional adjustments, financial arrangements, and the long-term physical and economic implications of development in selected case areas. Interrelationships between the dedication of water to a particular use and the effect on related resource use would be explored.

The initial focus is on the Land and Water Conservation Fund Act as it operates in the State of Washington. Attention would subsequently be given to other laws and other areas. This phase of study would be directed toward the Federal Water Projects Recreation Act and the Water Quality Act of 1965.

Findings of actual impact would be compared with what was anticipated by those who framed the legislation. It is hoped that conclusions would prove useful both in the implementation of existing legislation and the development of new water policy.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Central Washington State College

6.0609, SOME EFFECTS OF WATER IMPOUNDMENTS ON WATERFOWL POPULATIONS AND REPRODUCTION ON THE SNAKE RIVER, WASHINGTON

I.O. BUSS, Washington State University, Graduate School, *Pullman, Washington* 99163

Aim: To study the ecology and reproduction of waterfowl (mainly Canada goose and mallard) of the Snake River between Clarkson and Central Ferry for comparison with similar data obtained subsequent to impoundments created by Lower Granite and Little Goose dams. Secondly, to study the physiological pattern of reproduction in the mallard, and to study the migratory pattern of waterfowl on the Snake River prior to impoundment of water between Clarkston and Central Ferry.

Description: Continue investigations of nesting sites including density of breeding populations and ecological changes in islands used by waterfowl (primarily geese). Study behavior of Canada geese netted with cannon nets (with cooperation of State Game Department) and marked with conspicuous plastic neckbands. Ascertain percentage of neck banded geese nesting on islands and the percentage nesting on canyon ledges, by direct observation. A cooperative banding study will be conducted with biologists of the State Game Department and the Atomic Energy Commission (W. C. Hanson and B. L. Browning) to enhance nesting and migration studies. During the waterfowl hunting season, hunters will be checked to obtain bands and other data on movements and population phenomena of the local breeding population.

This investigation would be of considerable importance from the standpoint of waterfowl management both locally and nationally. Valuable information would be provided for elucidating our present knowledge of waterfowl reproduction, supplemental information would be provided on behavior, ecology, physiology of waterfowl. Finally, information obtained prior to impoundment of water would be provided for comparison with post-impoundment information.

6. WATER RESOURCES PLANNING

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Washington State University

6.0610, MAXIMIZING PRODUCTIVITY OF WATER USED FOR IRRIGATION OF AGRICULTURAL LANDS

W.R. BUTCHER, Washington State University, School of Agriculture, *Pullman, Washington* 99163

The proposed research involves empirical and theoretical determinations of the relations between water-use and agricultural output. The purpose is economic analysis of alternative use patterns to determine opportunities for gains through more efficient water-use patterns and to suggest criteria for use in water allocations among crops, farms, and areas.

The procedure emphasizes construction of economically valid valuation and choice processes. Some data on the relevant water/plant yield relationships are available from past studies. Models will be constructed, using these data, to portray the relevant relationships and the decision process. Solutions from these models will indicate the principles involved and disclose the most critical data needs for a more complete analysis of water productivity in the State.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Washington State University

6.0611, PRUNE ORCHARD MANAGEMENT

E.L. PRIEBSTING, Washington State University, Agricultural Experiment Sta. , *Pullman, Washington* 99163

1. To study response of Early Italian prune to varied soil nitrogen and water management practices. 2. To investigate the nature and causes of internal browning of Early Italian prunes. a. Develop practices that will reduce losses from this disorder. 3. To investigate further the effect of reduced fruit load on the functioning of fruit and foliage.

1) Nitrogen will be applied at different rates over a period of years. Moisture stress will be induced at critical periods. Effects on yield, size, maturity, and quality will be measured. 2) Internal browning will be studied from numerous angles: weather, post-harvest temp. and atmos., growth regulators, relation to maturity. 3) Gumspot- leaf curl will be induced by defloration and modification by soil moisture and growth regulator manipulations will be attempted.

SUPPORTED BY Washington State Government

6.0612, ESTIMATION OF RECREATION WATER REQUIREMENTS - ULTIMATE NEEDS STUDY (OREGON)

M.H. KARR, Battelle Memorial Institute, *Richland, Washington* 99352

As one of several contractors for Oregon's ultimate needs study, BNW is developing recreation water demands for the years 2020 and 2070 utilizing population projections made by another contractor. The study identifies recreation demand for various activities, and associated water requirements including consumptive use at parks and camps and evaporation from the needed lakes and reservoirs. Demand and water use analysis techniques developed for this study have application in any area where water-based recreation is of significance. Factors utilized include income, mobility, education, leisure time, and local regional recreation habits.

SUPPORTED BY Oregon State Government

6.0613, COLUMBIA RIVER ECOLOGY

R.E. NAKATANI, Battelle Memorial Institute, *Richland, Washington* 99352 (AT(45-1)1830)

The comprehensive ecological study of the Columbia River has as its principal areas of interest, mineral cycling in the river ecosystem using reactor produced radionuclides as tracers, clarification of the role of the biota in river transport of radioisotopes, and study of the effects of physical and chemical factors on population dynamics and radionuclide cycling.

Highest levels of effluent isotopes in many river organisms are in the early fall when river conditions of light and temperature are most favorable and flow minimal. Zn-65 and P-32 are the dominant nuclides in most organisms, Cr-51 in plankton and algae. The 6-week reactor shutdown this summer markedly altered radionuclide patterns in the biota, a decrease of one to two orders of magnitude in lower trophic levels; loss by adult fish as well as uptake after startup was not so rapid. Zn-65 uptake was studied in peryphyton in the laboratory. The number of fall Chinook salmon nests was a 20-year high. Upstream dispersion of adult caddis flies labelled by reactor-produced Zn-65 was up to 16 km.

SUPPORTED BY U.S. Atomic Energy Commission

6.0614, EFFECT OF SUPERSATURATION OF DISSOLVED NITROGEN ON MIGRATING SALMONIDS

W.J. EBEL, U.S. Dept. of Interior, Biological Laboratory, *Seattle, Washington* 98102

Supersaturation of dissolved nitrogen in the Columbia River can be a significant factor in the survival of migrating salmonids. Measurements of nitrogen levels from the estuary to the upper Columbia River have indicated that highest levels were reached in the spring when large volumes of water were being spilled at dams. Nitrogen concentrations, which were sufficiently high to produce gas bubble disease in fish, did not equilibrate in reservoirs between dams. Migrant salmonids using fishways or passing through shallow areas that force them near the surface may suffer mortality from high nitrogen levels.

In conjunction with current fish behavior studies on the Columbia River, experiments are in progress to examine the effect of nitrogen levels on survival of migrating adult salmonids. Salmon in fishways are being inspected for evidence of gas bubble disease, and systematic searches of the river system are being made to obtain samples of moribund fish for clinical examination. Laboratory experiments are planned to determine the effects of nitrogen saturation at different pressures and temperatures on survival of young and adult salmon.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0615, FISH BEHAVIOR AND PHYSIOLOGY

A.B. GROVES, U.S. Dept. of Interior, Biological Laboratory, *Seattle, Washington* 98102

The essential purpose of this work is to acquire a knowledge of intrinsic physical and sensory abilities of fish which relate to specific environmental factors encountered in migration and fish passage situations: A broader purpose is to assess the adaptive ranges of these capacities in different migratory fish stocks. This information will be applied to help predict or anticipate the effects on migrant fish of various river and estuarine development programs which are creating numerous changes in the environments of native stocks of commercially valuable species.

Specifically the work is with salmonids and involves measurements of fish capacities against selected environmental variables. This includes measurements of swimming performance abilities of juvenile and adult fish and activity patterns and responses of salmonid species. Studies also are made of sensory responses which may relate to migration and homing behavior, of physical and hydraulic factors that can injure fish in power turbines, of responses that may aid in diverting fish away from dangerous areas in turbines, and of effects on migrants of thermal shock such as that encountered by passing through heated effluents from thermal power plants.

The work is now in the laboratory but is directed to the idea that the derived information can be applied directly to field problems.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0616, RELATION OF RIVER-RUN IMPOUNDMENTS TO SALMON PRODUCTION

A.J. NOVOTNY, U.S. Dept. of Interior, Biological Laboratory, *Seattle, Washington* 98102

This program seeks to develop a self-sustained, mobile field laboratory, designed for maximum flexibility, which will provide a working base for unlimited aquatic environmental studies in navigable impoundments, and eventually in marine bays and estuaries. Primary emphasis is being placed on studies related to changes in the environment induced directly or indirectly by human activities and the effects of these environmental changes on salmon. These studies will include on-site experimental control of water quality to determine the feasibility of 'carrying' salmon through critical phases of their life cycle in river-run impoundments. Parameters of control include temperature, filtration, sterilization, dissolved gases, and waste products.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0617, PREDICTION OF ENVIRONMENT

G.R. SNYDER, U.S. Dept. of Interior, Biological Laboratory, *Seattle, Washington* 98102

A chain of reservoirs is rapidly replacing the remaining free flowing areas of the Columbia and Snake Rivers. Freshets and floods which played a major role in the transport of fingerling salmonids to the sea are being controlled. Temperature regimes that govern rates of growth and maturation are being modified, and in the changed environment, new predator-competitor and disease relationships are being established that greatly affect the survival of the migrant salmon. Studies are in progress to predict future environments in rivers and reservoirs. Work is nearing completion on the prediction of the physical and biological environment of John Day Reservoir in the Columbia River.

Studies are under way and planned to determine the feasibility of lowering water temperatures in the Upper Columbia and Middle Snake Rivers by tapping cool waters at the bottom of lakes and reservoirs. If thermal controls carry into downstream areas of these rivers, environmental conditions for survival of salmon could be measurably improved during the hot summer months. Potential benefits from timed releases of stored waters also are being evaluated in the light of proposed thermal-nuclear power developments in the Columbia Basin.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0618, FISHWAY RESEARCH (BONNEVILLE LABORATORY)

C.R. WEAVER, U.S. Dept. of Interior, Biological Laboratory, *Seattle, Washington* 98102

These studies are designed to provide information applicable to the improved efficiency of fish facilities at Corps of Engineers projects in the Columbia Basin. The investigations are carried out in the Fisheries-Engineering Research Laboratory at Bonneville Dam. Financing is by the Corps and direction of research is under supervision of the Corps Technical Advisory Committee.

A large laboratory area permits construction of full-scale fish facilities for study of the performance and behavior of adult migrating salmon that can be diverted from an adjoining fishway at the dam. Current and proposed studies include examination of the responses of salmon to various jet velocities, submerged orifice flows, temperature conditions, and barrier facilities. Techniques for T.V. monitoring of fish passage are being explored and developed for use in remote control counting of fish at dams. Special aspects of the behavior of juvenile salmon in turbine intakes are also being examined.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0619, GRAVEL PERMEABILITY IN SALMONID SPAWNING BEDS

M.C. BELL, Univ. of Washington, Graduate School, *Seattle, Washington* 98122

Research on the effect of siltation on gravel permeability in salmonid spawning beds to determine cementation effects of the fine materials and the flows which would be required to remove such materials when deposited.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0620, ESTUARINE ECOLOGY

D.E. BEVAN, Univ. of Washington, Graduate School, *Seattle, Washington* 98122

The specific objectives of the current Estuarine Ecology Project are: 1. To develop a mathematical model of important physical and chemical processes of the Duwamish Estuary, including rates of dilution of pollutants. 2. To investigate the ecology of pelagic and demersal fishes in the estuary and nearshore marine environments affected by industrial and domestic waste discharges. This investigation includes studies of the estuarine and early marine life of immature chinook salmon (Oncorhynchus tshawytscha), including mortality, distribution, and growth; the estuarine life of migrant adult chinook salmon; and the ecology of resident demersal species of the Duwamish Estuary. 3. To record some of the parameters of the water quality in the Duwamish Estuary and compare them with the known environmental requirements of salmon and other fishes of economic importance.

Emphasis in the study is being placed on the Duwamish Estuary and Elliott Bay because a wealth of physical and chemical data has been collected. The Municipality of Metropolitan Seattle (METRO), a local organization concerned with sewage abatement, and the United States Geological Survey (USGS) have maintained three telemetry stations in the estuary and another station in the Duwamish River above saline influence since 1964. These stations record pH, dissolved oxygen, water temperature, conductivity, and turbidity every hour and send the data to the central station at METRO headquarters. The data, together with streamflow and other physical parameters, are transferred on magnetic tape for computer screening and subsequent analysis by Estuarine Ecology Project personnel.

SUPPORTED BY University of Washington
U.S. Dept. of Interior - F. Water Pol. Ctl

6.0621, VARIED RECREATIONAL USES OF FOREST LANDS FOR TIMBER PRODUCTION IN WESTERN WASHINGTON

C.F. BROCKMAN, Univ. of Washington, Graduate School, *Seattle, Washington* 98122

Objectives: Investigation of the compatibility and/or conflicts between: (1) relationships of the nature of public recreational uses and facilities to deterieratics of recreational interests. (2) different recreational uses of forest lands, (3) various recreational uses of forest lands with different silvicultural systems and current logging practices, and (4) study of methods of minimizing or eliminating conflicts between recreational use and timber production with a view to perpetuating maximum esthetic, cultural and economic returns.

Description of work proposed: The complexity of recreational research, together with the variety of information necessary to conclusions relating to the broad overall objective of this project, necessitates specific attention to various pertinent limited objectives as qualified workers are available. It is intended, first, to (1) measure relative increase of land values due to forest recreation focal points (lakes, streams, ski areas etc.) on forest lands and, based on trends and impact indicated from these data, develop a theoretic model for simulating recreation value implications in forest management and (2) determine, through ecological analysis of vegetative associations (using series of quadrate and/or transacts) the impact of public use on various types of recreational areas.

SUPPORTED BY U.S. Dept. of Agriculture

6.0622, STUDY OF RED SALMON IN THE NUSHAGAK DISTRICT

R.L. BURGNER, Univ. of Washington, Graduate School, *Seattle, Washington* 98122

Investigations of Wood River system red salmon have been in progress since 1946. Until 1959 funding was accomplished chiefly through the Alaska Salmon Industry. Since 1959 a portion of the work has been performed under contract to the Bureau of Commercial Fisheries.

The principal objective here, as in the other systems in Bristol Bay, is to determine optimum escapement levels. The Wood River program includes a variety of studies. Length measurements, scales, and otoliths are collected annually from spawning red salmon from several of the more important spawning grounds to determine racial differentiation. Detailed data concerning physical and chemical features of spawning areas are obtained regularly to ascertain spawning area requirements. Tow nets and echo sounders provide a means of indexing the abundance of young.

Limnological studies include: (1) determination of primary productivity; (2) chlorophyll determinations; (3) water analysis; (4) zooplankton identification and measurement of abundance.

Special studies recently instituted include: (1) a study of the life history of the Alaska blackfish; and (2) the effects of digestion after death on char stomach contents.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0623, OPTIMUM ESCAPEMENT STUDIES OF CHIGNIK SOCKEYE SALMON

R.L. BURGNER, Univ. of Washington, Graduate School, *Seattle, Washington* 98122

The Chignik River system, which consists of two physically and biologically dissimilar lakes, supports the largest run of sockeye salmon (Oncorhynchus nerka) on the south side of the Alaska Peninsula. Extensive analysis of historical records and preliminary studies conducted since 1955 have provided a basis for managing the runs to the two lakes separately. These studies have also led to the hypothesis that competitor species in the lake nursery areas are inhibiting return per sockeye spawner. Increased emphasis will now be placed on the ecological association of young sockeye and competitor species in the two lakes to evaluate the influence of sockeye year classes of different magnitude in control of the ecosystem. Studies will include: (1) Continuing beach seine and surface trawl sampling of both lakes to determine the growth, abundance, mortality, and distribution of juvenile sockeye salmon and associated species. (2) A study of the food supply and food habits of sockeye salmon and resident fishes to determine the manner in which the species compete for food. (3) Continuation of statistics of the adult salmon runs including age composition. (4) Preparation of a forecast for the 1969 sockeye run. The studies will be conducted in cooperation with the Alaska Department of Fish and Game.

SUPPORTED BY University of Washington
U.S. Dept. of Interior - Bu. Comm. Fish.
Alaska Packers Association

6.0624, FERN LAKE MINERAL METABOLISM PROGRAM

L.R. DONALDSON, Univ. of Washington, Graduate School, *Seattle, Washington* 98122 (AT(45-1)-2050)

Since 1958, Fern Lake and the surrounding watershed have been the object of a detailed ecological study to investigate the fundamental processes governing productivity in an undisturbed watershed.

Because of the size, type of soil, and climatological characteristics of the watershed, Fern Lake is flushed repeatedly every winter and thus kept in a mineral-deficient state. Terrestrial studies indicate the glacial till, high in sand and gravel content and low in organic matter, allows sufficient runoff to dilute the lake water during the rainy period. Consequently, steelhead trout production is low--approximately 22 pounds of fish per year per surface acre.

Results: To increase productivity a carefully planned addition of minerals was made to the lake in the summer of 1965. The responses to the fertilization in primary, secondary, and tertiary production were measured and the physical and chemical characteristics of the lake water and sediments were assessed. Production in the lake showed a marked increase. Heavy rains during the winter have differentially diluted the elements added; some minerals were completely flushed out, while others were retained. Work is now concentrated on the dynamics of the movement of phosphorus in the lake and the special problems of the measurement of the orthophosphates.

SUPPORTED BY U.S. Atomic Energy Commission

6.0625, AQUATIC COMMUNITIES

W.T. EDMONDSON, Univ. of Washington, Graduate School, *Seattle, Washington* 98122 (AT(45-1)-2044)

The object is to analyze the mechanisms that control productivity and population characteristics in aquatic communities. The first stage consists of improving our knowledge of conditions as they exist in natural communities. The basic data consist of measurements of abundance, population structure, rates of activity and relevant environmental features. Much of the work will be carried out in lakes that have been altered in distinctive ways; e.g., the saline lakes in the lower Grand Coulee which have been diluted with fresh water from irrigation projects. These field experiments will be backed up by appropriate experiments in the laboratory, as suggested by correlations found in the field data. Inevitably, considerable attention will have to be given to food relations.

A large body of information has already been obtained in previous investigations. Some has been published, and some is in advanced stages of preparation for publication. Much of the information concerns the way the fauna of the saline lakes has changed with dilution, and measurements have been made of the osmostic pressure of blood of invertebrates held in different concentrations of the lake water.

SUPPORTED BY U.S. Atomic Energy Commission

6.0626, THE ANALYSIS OF THE WATER RIGHTS REGISTRATION ACT AND ASSOCIATED LEGISLATION OF THE 1967 WASHINGTON SESSION LAWS

R.W. JOHNSON, Univ. of Washington, Graduate School, *Seattle, Washington* 98122

The proposed project involves the analysis of the Water Rights Registration Act and related legislation enacted by the Washington Legislature in 1967. The study would provide a natural continuation and sequel to O.W.R.R. Project 0A-002-Wash., 'Uncertainty in Washington Water Rights,' which influenced the 1967 Legislation. The analysis would involve a review of the problems that the 1967 legislation was designed to alleviate and a consideration of how effectively it is accomplishing its purposes. The legislation is unique and will be compared with the experiences of other states in attempting to solve the problems of unrecorded water rights. In addition the legislation should be related to the statutory water rights adjudication procedures. It is anticipated that one of the results of the study may be to suggest amendments to the 1967 legislation which would enable the legislation to better achieve its goals in this area. Further, the study would have an important bearing on the water rights problems common to all of the western states.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Washington

6.0627, STUDIES OF SOCKEYE SALMON, ONCORHYNCHUS NERKA, IN THE KVICHAK RIVER SYSTEM, ALASKA

D.A. MATHISEN, Univ. of Washington, Graduate School, *Seattle, Washington* 98122

The Kvichak project is a long-range study of the flow of energy between the tropic levels in a sockeye producing watershed, when the salmon runs exibit fairly regular oscillations within a period of five years. These field studies conducted in Bristol Bay, Alaska, commenced in Fiscal Year 1955 with no definite termination date.

SUPPORTED BY University of Washington
U.S. Dept. of Interior - Bu. Comm. Fish.
Association of Pacific Fisheries

6.0628, OBSERVATIONS ON RED SALMON IN THE KVICHAK RIVER SYSTEM

O.A. MATHISEN, Univ. of Washington, Graduate School, *Seattle, Washington* 98122

The Kvichak studies are funded in part by the Bureau of Commercial Fisheries via contractual arrangements with the Fisheries Research Institute. Additional support for the program is received from the Alaska Salmon Industry and the University of Washington.

While the red salmon runs to the Kvichak system have undergone marked cyclic fluctuations in abundance, the Kvichak drainage has led and continues to lead all other systems in the production of red salmon. The principal objective of the research on the Kvichak has been to determine optimum escapement levels. The overall program consists of a variety of studies designed to establish the carrying capacity of spawning and/or nursery areas and to determine what factors limit production in each environment.

Surveys are conducted annually to determine the distribution and racial differentiation of spawning groups. Indices of young fish abundance through use of tow nets and echo sounders have been developed to provide a measure of the success of reproduction. Determinations are made regularly of zooplankton abundance and distribution, the quantity of dissolved nutrients, and primary productivity. Currently, emphasis is directed upon comparison and evaluation of survival rates in off and peak years of the cycle.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0629, ECOLOGICAL STUDIES OF CHUM AND COHO SALMON AT BIG BEEF CREEK

E.O. SALO, Univ. of Washington, Graduate School, *Seattle, Washington* 98122

Although long range objectives of this University field station are to study the natural ecology of chum and coho salmon, preliminary investigations will be concerned with the effect of an artificial water impoundment in the stream.

A cabin on the site has been remodeled into living quarters and office. The studies of 1966 centered on enumeration and distribution of the smolt and adult populations and growth of the fingerlings throughout the stream system. The newly formed lake allowed for the examination of transition, plants, changes in water chemistry and alteration of streamflow patterns. Limnological studies are being continued.

SUPPORTED BY Washington State Government
University of Washington

6.0630, STUDIES IN OYSTER PATHOLOGY

A.K. SPARKS, Univ. of Washington, Graduate School, *Seattle, Washington* 98122

All oysters collected in the mortality investigations of the Washington Department of Fisheries and the Oregon Fish Commission are processed for histological examination in our laboratory. Three slides are prepared from each oysters; the slides are examined in our laboratory for the presence of disease organisms or pathological conditions. One slide is retained in our collection, one returned to the initiating agency along with the diagnosis, and one sent to the Bureau of Commercial Fisheries Shellfish Laboratory at Oxford, Maryland for confirmatory examination.

SUPPORTED BY University of Washington
U.S. Dept. of Interior - Bu. Comm. Fish.

6.0631, EPIZOOTICS IN EXPERIMENTAL MARINE SHELLFISH POPULATIONS

A.K. SPARKS, Univ. of Washington, Graduate School, *Seattle, Washington* 98122

Maintenance of experimental populations of Pacific oysters, native oysters, and bay mussels in float and bed stations will be continued in California, Oregon and Washington for determination of mortality and growth rates in the various species at the different locations. Living and dying bivalves will continue to be fixed and processed for microscopic examination for the presence and pathological effects of possible pathogenic organisms and a more sophisticated computer program will be utilized to determine the relationships of possible pathogens and mortalities.

Attempts will be made to culture in vitro the microorganisms, probably Vahlkampfia sp., responsible for heavy mortalities of Pacific oysters in Humboldt Bay, California to elucidate its life history, facilitate specific identification, and enable us to initiate infection experiments. Life history studies, through in vitro culture, of Mytilicola orientalis will be continued, particularly to determine the infective stage.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

6.0632, A COMPARATIVE ANALYSIS OF AMERICAN AND CANADIAN GOVERNMENTAL DEVELOPMENT OF REGIONAL WATER POLICY IN THE COLUMBIA RIVER BASIN

R. WARREN, Univ. of Washington, Graduate School, *Seattle, Washington* 98122

This study will have four main objectives: 1. To gather information in order to identify, compare and evaluate the governmental structures by which policies concerning the use and development of water resources are determined in the American and Canadian portions of the Columbia River Basin. 2. To specify and compare the national and international linkages of the American and Canadian regional systems in the Columbia River Basin which effect regional organization and policies. 3. To develop hypotheses about the relationship of the formal structure of government within a region concerning water policy, the behavioral tendencies of water related public enterprises within a region, and external regional linkages to the performance of the regional system for developing and administering water policy, i.e., the degree to which: social, economic and political consequences of a regional scale can be taken into account in policy choices on the part of regional decision makers; innovative policies can be developed; and plans can be developed with appropriate time horizons for the development and utilization of regional water resources. 4. To develop criteria for choosing among alternative formal regional governmental arrangements and/or externally determined incentives as means of producing policies and behavior within a region which will respond to regional and national values.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Washington

6.0633, FORECASTING WATER DEMAND - AN INTER- AND INTRA-COMMUNITY STUDY

R.J. SAUNDERS, West Va. University, Graduate School, *Morgantown, West Virginia* 26506

The three primary objectives of this study are:: 1. Identify those factors which are most closely associated with, or 'determine', the level of demand for water, both in an inter community and intra community context. 2. Construct several predictive models which will be of use in the forecasting of water demand in urban areas. 3. Examine the projected degree of sensitivity of urban area water demand to changes in both the magnitudes of the individual explanatory factors and in the parameters of the resulting models (parameter variations based on assumptions about changes in consumer taste, area development, technology, etc.).

It is proposed that the results of this study will provide a specific analytical framework which can be used to project specific urban area and intra area demand for water allowing for specified degrees of latitude in the assumptions concerning the probable future economic, demographic, and sociological structure of the urban community.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

6.0634, AN INTEGRATED RECREATION AND NATURAL AREA PRESERVATION PLAN FOR OHIO AND MARSHALL COUNTIES, WEST VIRGINIA

F.R. SWAN, West Liberty State College, Undergraduate School, *West Liberty, West Virginia* 26074

The purpose of this project is to develop an integrated plan for recreation areas and for the establishment of natural areas for scientific study in Ohio and Marshall Counties, West Virginia. This plan would show existing and proposed scientific areas, locations of reservoirs, camping sites, picnic areas, public hunting and fishing areas and hiking trails.

6. WATER RESOURCES PLANNING

SUPPORTED BY Southern Regional Education Board

6.0635, MONITORING FISH STOCKS AND ENVIRONMENTAL CONDITIONS

M.M. BAILEY, U.S. Dept. of Interior, Research Station, *Ashland, Wisconsin*

Optimum utilization of the fishery resources of Lake Superior can be achieved only through a knowledge of the biological characteristics of the various stocks and their environment. Systematic collections of basic data on stocks of Lake Superior fish should provide information on changes in distribution and abundance as related to environmental factors.

Current research is confined to systematic sampling of environmental conditions at pre-selected locations in western Lake Superior and the collection of data on size, age, maturity, and sex composition of commercially landed species and of associated species taken in experimental gear fished by the Bureau's research vessel Siscowet. Analyses of the data are kept current to detect changes in the biological community which may signify needs for special inquiry.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0636, ASSESSMENT OF LAKE SUPERIOR LAKE TROUT

R.L. PYCHA, U.S. Dept. of Interior, Research Station, *Ashland, Wisconsin*

Control of the sea lamprey and large-scale plantings of lake trout in Lake Superior have brought about a rapid buildup of lake trout stocks. Close surveillance of the changes in the juvenile, legal sized, and spawning stocks is required for rational utilization in the future. Data currently utilized are collected by contract fishermen using conventional commercial gear and by the Bureau's research vessel Siscowet using experimental gill nets and trawls.

Present research, designed to assess the rehabilitation of the lake trout, includes inquiry into: changes in abundance of the size groups of the commercial portion of the artificially propagated lake trout to the commercial catch and the relative success of various hatchery plants; changes in age structure and growth rates of the populations; comprehensive evaluation of the effect of hatchery-reared fish on the juvenile and spawning populations; differences in the habits and distribution between hatchery-reared and native lake trout; the identities and biological features of discrete offshore populations; and the relationship between lamprey predation and the size of the lamprey population. Data on food habits and other features of the life history are collected incidentally to other studies.

Techniques and findings of research on lake trout in Lake Superior should aid similar studies on Lakes Michigan and Huron.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

6.0637, IMPACT OF LAGOONS AND SAND BLANKETS ON FISH, AQUATIC LIFE AND WATER QUALITY

D.A. BRATLEY, State Dept. of Nat. Resources, *Madison, Wisconsin* 53701

Phase one, nearly complete, involvles assembling Public Service Commission records on characteristics and extensiveness of lagoons and sand blankets in inland Wisconsin lands. Phase two will involve field research on Lake Winnebago and southeastern Wisconsin lakes to determine the effects of encroachments upon species composition, density, and dominance of aquatic vegetation, fish, bottom organisms and plankton. Water Quality stations will also be monitored in connection with this work. Lakeshore encroachments are presently being checked to determine their potential as study areas for the second phase of the project.

SUPPORTED BY Wisconsin State Government

6.0638, WILD RIVERS ECOLOGY STUDIES

J.W. MASON, State Dept. of Nat. Resources, *Madison, Wisconsin* 53701

The Wisconsin State Legislature in 1965 designated the Pine, Popple and Pike Rivers in northeastern Wisconsin as wild rivers. In 1966, a project was developed to study the ecology of these three wild rivers, in order to inventory the resource, document its current status, and provide a guide for planning and management in the future. Work now in progress includes fish population studies (species present and relative abundance, growth rates and reproductive success of game fish, evaluation of fish management techniques, harvest and angling pressure on opening weekend); an aquatic plant survey (species composition, relative abundance, and relationship to environment); and a study of the invertebrate fauna (species composition, relative abundance and ecological significance). Water quality and quantity is being measured in cooperation with the United States Geological Survey (temperature, flow, Do, pH, conductivity, alkalinity, major nutrients and major elements).

SUPPORTED BY Wisconsin State Government

6.0639, WATER QUALITY MONITORING STUDIES

J.W. MASON, State Dept. of Nat. Resources, *Madison, Wisconsin* 53701

A statewide program is under way to detect and document changes in water quality which may occur in various lakes and streams as a result of changing use patterns (shoreline development, recreational development, dam construction, dredging, ditching, irrigation, etc.). In the waters selected for monitoring, the following parameters are measured four times yearly: temperature and oxygen profiles, pH, alkalinity, water clarity, resistivity, nutrient concentrations, and other elements. Biota changes, if any, are noted (fish populations, vegetation, etc.). Streams are also being monitored for any chemical changes that may occur, and in addition continuous temperature recordings are being made. In situations where fish populations are suspected to be affected by development they are studied intensively (dam constructing, ditching, irrigation, land cover changes). Lakes and streams which man-made changes are not expected to affect are being monitored as 'bench mark' waters.

SUPPORTED BY Wisconsin State Government

6.0640, WALLEYE FRY - ZOOPLANKTON RELATIONSHIPS IN SOUTHEASTERN WISCONSIN LAKES

UNKNOWN, State Div. of Conservation, *Madison, Wisconsin* 53701

Procedures: Walleye spawning runs are sampled by fyke nets to obtain information on the size of the run, dates of spawning, sex ratios, incidence of marked fish in the run, and to obtain fish for growth and maturity data.

Spawning grounds are observed to determine when eggs are laid, to follow their development, and determine time of hatching.

Plankton samples are collected, starting with the date of walleye hatching or fry stocking, and then at four-day intervals for the next three weeks. Two tows are made at both the 6 and 12-foot levels. The individual collections are diluted to known volumes, 1 cc. samples placed in a Sedgewick-Rafter cell, plankters identified and counted, the number determined for the collection, and the number per one revolution of the Clarke-Bumpus sampler determined. The four cellections for each date are combined and averaged to give a plankton abundance value per revolution for the date. This value is used to show fluctuation in abundance.

Data on dates of natural hatches, fry stockings, strength of year classes, and plankton abundance values are analyzed to see if a correlation exists between plankton abundance and year class strength.

The stocking rate is 2,000 per acre in LaBelle and 5,000 per acre in the other lakes. To determine if there is a substantial mortality of walleye fry soon after stocking, three lots of 100 fish will be placed in muslin enclosures at the time of stocking each study lake. One enclosure will be removed from each lake at regular intervals (24, 48, 72 hours) to learn of initial losses. Small numbers of walleye fry will be placed in aquaria and observed until all are dead, to yield information on how long the fish lives on the yolk sack and how long it will live before it starves to death. This information will be useful in developing the plankton abundance - year class strength relationship.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Wisconsin State Government

6.0641, FLOOD PLAIN DELINEATION - DRD - USGS, COOPERATIVE STUDY

T.M. LEE, State Div. of Env. Protection, *Madison, Wisconsin*

This cooperative project, provides for the U.S.G.S. to perform flood plain delineation studies with the aid of Division of Environmental Protection's water surface profile computer program for the Rock River in Rock and Jefferson Counties, Wisconsin. This project will: 1. Result in U.S.G.S. preparation of computer control cards for Division of Environmental Protection's encroachment studies needs, thus eliminating need for future D.E.P. duplication of this effort. 2. Provide basis for Rock River flood plain regulation in Rock and Jefferson Counties. 3. Provide model U.S.G.S. delineation report reflecting state flood plain criteria which would have state-wide use as an example.

SUPPORTED BY Wisconsin State Government
U.S. Dept. of Interior - Geological Survey

6.0642, LAW AFFECTING INSTITUTIONAL DESIGN FOR WATER QUALITY MANAGEMENT

P.N. DAVIS, Univ. of Wisconsin, Graduate School, *Madison, Wisconsin*

This is a tripartite legal study to investigate the legal and constitutional constraints on proposed broadening of powers of state agencies to regulate water quality and to operate pollution abatement works. The three areas of research are: (1) Common law of pollution in action - What influence if any does the common law riparian concept of 'reasonable use' have on the behavior of polluters? Field interviews will be conducted with riparian owners, and practicing attorneys. Local court records will be examined. Library research will determine the procedural and evidentiary problems in civil pollution actions. (2) Law affecting effluent charges -- Library research will determine the legal and constitutional limitations on various effluent charge schemes proposed by economists. (3) Operation of polluation abatement works by the State of Wisconsin -- Library research will determine the legal and constitutional constraints to broadening state agency powers to regulate water quality in a river as a single system and to operate pollution abatement works.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Wisconsin

6.0643, THE APPLICATION OF RADIOISOTOPES TO STUDIES OF AQUATIC ECOSYSTEMS

A.D. HASLER, Univ. of Wisconsin, Graduate School, *Madison, Wisconsin*

Studies will be continued to determine the amounts and relative nutrient value of trace elements and organic compounds of biological importance in water.

Investigations will be initiated to examine the changes that occur over a 24 hour period in the composition of benthos on a small section of substrate in Lawrence Creek, Adams Co., Wisconsin. Sections of substrate will be enclosed by metal frames and the organisms contained therein labelled with P-32. Qualitative and quantitative analyses will be made of drift samples collected downstream from the experimental areas in an attempt to elucidate the influence of such factors as changing light intensity, stage of development, and population densities, on benthic turnover and drift rates.

SUPPORTED BY U.S. Atomic Energy Commission

6.0644, BIOLOGICAL FACTORS IN THE MANAGEMENT OF LAKE FLIES

W.L. HILSENHOFF, Univ. of Wisconsin, Agricultural Experiment Sta., *Madison, Wisconsin*

The ecology of the bottom fauna of Lake Winnebago and 14 other Wisconsin lakes, and the chemical and physical properties of these lakes are being studied to determine the factors that are responsible for nuisance population of midges. The biology of the Lake Fly, Tendipes plumosus, in Lake Winnebago is being intensively studied in the field and in the laboratory. The parasites and predators of T. plumosus are being investigated to determine their potential for biological control. Lakes treated by the Wisconsin Conservation Department with toxicants to remove undesirable fish populations are being studied to determine the effects of the toxicants on the bottom fauna and the effect of fish predation on this fauna.

SUPPORTED BY Wisconsin State Government

6.0645, IRRIGATION TRENDS AND POTENTIALS IN THE NORTH CENTRAL STATES

D. MASSEY, Univ. of Wisconsin, Agricultural Experiment Sta., *Madison, Wisconsin*

Objectives: To indicate the extent to which irrigation will compete for available water supplies and must be considered an integral element of water resources planning in the North Central States.

Approach: Information from past and current studies and Census reports will be analyzed and correlated to complete a regional appraisal of irrigation trends and potentials for major resource regions and subregions within the North Central States. Historical trends in irrigated acreage will be estimated using appropriate time series techniques including such factors as sources of water and methods of application. Corresponding data on rates of water use per irrigated acre will also be derived, analyzed, and evaluated for possible intertemporal change resulting from improved irrigation technology, weather variations, and changes in crops irrigated. Physical limits to irrigation potential will be estimated on the basis of soil suit- ability and water availability. Projections of future irrigation development will be made for specific dates in the future, considering future technology of irrigation, long-term drought probabilities, and costs and returns from irrigation activities. Water rights and other legal restrictions will also be considered in this role of either restricting or permitting irrigation development.

SUPPORTED BY U.S. Dept. of Agriculture

6.0646, ECONOMIC AND LEGAL FACTORS IN PROVIDING, USING AND MANAGING WATER RESOURCES IN AGRICULTURE

R.J. PENN, Univ. of Wisconsin, Agricultural Experiment Sta., *Madison, Wisconsin*

Objectives: (1) To determine the economic considerations that affect use and management of water in agriculture and competing uses (2) To identify and describe rights in water and the administrative arrangements that regulate water use in the several states.

Procedures: Multiple regression analysis of data collected from 60 artificial lakes in Wisconsin and an analysis of consumer behavior relating recreation to income, size of family, age of family, place of residence, occupation and other selected characteristics. Update an existing bibliography of publications concerning water rights and related topics which will serve as a reference source for related research efforts. Provide a method by which economic effects of state and federal water-based recreation projects on the economies of local political subdivisions can be determined; and illustrate the use of the model developes to analyze the adequacy of present and proposed public decision-making institutions relating to the development and expansion of water-based recreation areas from the viewpoint of economic considerations. (Predictive inputoutput model for a selected case county in Wisconsin.)

SUPPORTED BY U.S. Dept. of Agriculture
Wisconsin State Government

6.0647, PHYSICAL TECHNIQUES AND INSTITUTIONAL MECHANISMS FOR INTEGRATED ADJUSTMENT IN THE FLOOD PLAIN THROUGH SOIL SURVEYS

D.A. YANGGEN, Univ. of Wisconsin, School of Agriculture, *Madison, Wisconsin*

The major thrust of this project is to develop practical and relatively inexpensive methods for public control of flood plain occupancy in rural areas. The proposed research would be done through a series of interrelated steps as follows:

A. Development and Testing of New Techniques for Delineation and Description of Flood Plain Characteristics.

Detailed soil surveys made as a part of the National Cooperative Soil Survey appear to be resource inventory with high potential for use in delineation of flood plain boundaries in non-urbanized areas. A determination will be made of the correlation between soil mapping units and an array of flood flow values ranging from low volume events which occur frequently through the maximum flood of record and the standard project flood to the maximum probable flood. The resulting product will be a delineation of flood plains into areas of various intensities of flood hazard by standard methods which can then be compared with soil mapping units to determine degrees of correlation.

B. Analyze Alternative Public Methods for Influencing Flood Plain Development.

C. Prepare Model Provisions for Local Flood Plain Regulations.

D. Develop Economic Guidelines for Evaluating Alternative Uses of Flood Plain Lands.

E. Evaluate the Techniques Developed After Testing in a Pilot County.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Wisconsin

6.0648, RELATIONSHIP OF CERTAIN BIOLOGICAL, CHEMICAL AND GEOLOGICAL PARAMETERS TO THE ENVIRONMENT OF THE BOISE BRULE WATERSHED, WISCONSIN

A.B. DICKAS, Wisc. State University, Graduate School, *Superior, Wisconsin* 54881

Functioning under an interdisciplinary format, a research team will conduct studies to determine qualitative and quantitative interrelationships of the vegetative cover, geology, soil and bedrock type, bedload sediment evaluation, and water chemistry, on the total environment of the Boise Brule watershed and their effect as a system on the quality of Lake Superior.

The investigation within the project will follow four major phases: 1. Ecological - Vegetation types will be studied by selecting from the communities as delineated on maps in Fassett (1944), from aerial photographs, and from field surveys. Vegetation types will also be selected with reference to drainage patterns of the total watershed. 2. Chemical - A relationship of the water properties to the surrounding environments of the river will be investigated by the sampling and analysis of selected water quality parameters. 3. A comparative study will be undertaken following the comprehensive geological survey of 1942 by Bean and Thompson (1944) to quantitatively define the changes that have occurred during the past 26 years. 4. Geographical - Information resulting from the above three phases will be collated and mapped to provide a unified view of the study area. Aerial photographs will be used to aid in the interpretation and correlation of the data.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Wisconsin State University

6.0649, DETERMINATION OF THE MAGNITUDE AND AGE COMPOSITION OF THE HARVEST, HABITAT PREFERENCES AND FOOD HABITS

F.M. EISERMAN, State Game & Fish Commission, *Cheyenne, Wyoming*

Procedures: 1. To measure sportsman harvest. 2. To correlate habitat type with numbers of fish present, by age, group and season. 3. To correlate relative abundance of specific food organisms in (1) the habitat and (2) fish stomachs, by season.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Wyoming State Government

6.0650, VALUE OF THE GAME AND FISH RESOURCES IN RELATION TO THE FUTURE UTILIZATION OF THE WATER OF THE GREEN RIVER DRAINAGE IN WYOMING

G.T. BAXTER, Univ. of Wyoming, Graduate School, *Laramie, Wyoming* 82071

The evaluation of the game and fish resources of the Green River, and their potential value under different types of future water utilization, particularly as anticipated under either the Wild Rivers Act or prospective State or Federal developments including irrigation, industrial, trans-basin diversions, etc. This study will be essentially a refined inventory of the Green River, to include lengths of stream, water surface areas, stream classification, fish and game populations, general productivity, land ownership status, review of flow records as they pertain to fisheries, and present utilization of sportsmen. Various aspects of water quality - present and anticipated - will be analyzed. A prediction of the effects of various types of water utilization on the game and fish resources will be made on the basis of the data obtained during the course of the study.

Field work will be undertaken near Pinedale, Wyoming. All other portions of the study will be on the campus of the University of Wyoming.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Wyoming

6.0651, THE ECONOMICS OF WATER RESOURCE DEVELOPMENT

R.I. CLARK, Univ. of Wyoming, Agricultural Experiment Sta., *Laramie, Wyoming* 82071

Objectives 1 and 2 -- Data on supplies of water will be compiled from secondary sources, and note will be taken of areas where increased competition for such supplies appears imminent. Attention will be given to shifts in use as these relate to economic growth.

Objective 3 -- Legal and institutional arrangements or processes presently governing transfer of water rights will be examined.

Objectives 4 and 5 -- Adequacy of the above arrangements and processes will be appraised, with goals of efficiency, economic growth, equity; etc. as criteria, and alternative arrangements will be recommended where such appear to be in order.

This study will be both descriptive and analytical. It will be descriptive in that present water uses will be noted as well as arrangements relating to transfer of water among uses. It will be analytical in that it will investigate the relation of water use to efficiency and to equity.

SUPPORTED BY Wyoming State Government

6.0652, WATER RESOURCE OPERATIONS STUDY

P.A. RECHARD, Univ. of Wyoming, Water Resources Research Inst., *Laramie, Wyoming* 82071

The basic purpose of the research is to learn more about the relationships among the many kinds and aspects of water resource operations, including how better to accomplish such multidisciplinary research.

As initial objectives, four study areas have been selected for investigation: (1) Criteria for Water Resource Planning, by studying the basic problems relating to 'Trans-basin Diversions in Wyoming'; (2) Bio-Physical Relationships in the Hydrologic Cycle, by implementing the 'Multiple Use of the Water Resource Observatory'; (3) The Impact of Weather Modification, with a legal-engineering study of 'Artificial Snow Pack Augmentation'; and (4) Principles of Analysis of Water Resource Operations.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Wyoming

6.0653, STATE WATER PLANNING FOR WYOMING

P.A. RECHARD, Univ. of Wyoming, Water Resources Research Inst., *Laramie, Wyoming* 82071

Prepare and maintain an up to date file of streamflow data for Wyoming in automatic data processing form. Have available programs for tabulating and analyzing the data.

Aid in the selection of proper hydrologic period for water supply study purposes.

SUPPORTED BY Wyoming State Government

7. RESOURCE DATA

Network Design; Instrumentation; Data Acquisition; Evaluation, Processing, and Publication.

7.0001, A GROUNDWATER QUALITY SUMMARY FOR ALASKA

C.E. BEHLKE, Univ. of Alaska, Inst. of Water Resources Res. , *College, Alaska* 99735

Presently available groundwater quality information for the State of Alaska is being centralized and punched on cards for data retrieval and analysis purposes. The punched information will be suitable for analysis in preparation of a ground water quality atlas for the State.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Alaska

7.0002, A WATER QUALITY COMPUTER MODEL OF COOK INLET (PHASE ONE - THE HYDRAULIC MODEL)

R.F. CARLSON, Univ. of Alaska, Inst. of Water Resources Res. , *College, Alaska* 99735

The proposed research will develop a computer model of the water quality behavior of Cook Inlet. Phase one of the study will develop the hydraulic portion of the overall study. The hydraulic model output is the solution of the two-dimensional equations of flow as specified by the velocity and water surface elevations as functions of time and location. Phase two will develop the water quality portion of the study as an extension of phase one.

The hydraulic model will furnish the main flow parameters to the water quality model. The solution of the water quality model is specified by the time and location history of the concentration of a substance. The solutions of both the hydraulic and quality models will be checked with field data. The results of the field check will be examined and used to indicate modifications of the model.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Alaska

7.0003, AERIAL MEASUREMENT OF HYDROLOGIC PHENOMENA

H.E. SKIBITZKE, U.S. Dept. of Interior, Water Resources Division, *Phoenix, Arizona*

Ways to accelerate and improve collection of data desperately needed in the analyzation of the roles of nature and of man in community problems involving floods, droughts, and water supply are constantly being sought. Recent and potential developments in aerial film, sensing devices and camera equipment, give evidence of heralding the long needed collection techniques.

Through the use of aircraft maximum advantage will be taken of natural light reflected from the earth, of heat radiated from the land surface, and of moisture vapor migrating through the air away from evaporation areas. Photography with black and white, color, in the right wavelength range, detect heat radiation in the temperature range of interest; and a thermistor-type sensing element responds electrically to the moisture vapor present in the atmosphere along the path of the aircraft.

The object of this project is to procure, design, construct, and assemble the sensing and recording equipment necessary for the aerial measurement of hydrologic factors, or the aerial collection of data pertinent to such factors. To evaluate, through preliminary field trials and demonstration, the utility to the hydrologist of aerial measurement and data-collection techniques.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

7.0004, EFFICIENCY OF DATA COLLECTION SYSTEMS IN HYDROLOGY AND WATER RESOURCES FOR PREDICTION AND CONTROL

C.C. KISIEL, Univ. of Arizona, Graduate School, *Tucson, Arizona* 85721

The overall objective of this research is to contribute to our methodology for determining the worth (in the economic and information- theoretic sense) of hydrologic and water resource data for prediction and control of water resource systems. A hybrid computer will be employed to simulate a range of hydrologic situations in Central Arizona where data is available. The simulation model is to be formulated in the spirit of recent developments in stochastic and parametric hydrology and will employ operations research techniques as necessary. Data analyses requisite to such modeling include time series analysis (power spectra, coherence, phase, frequence response, stationarity, and probablistic character of input and output sequences, linearity and stationarity of the system behavior) and regional analyses (multivariate analysis, space-time ergodicity). The time series include precipitation, streamflow, ground water levels and evaporation. By simulation the efficiency of current streamflow forecast procedures and ground water models will be studied on single and multiple-watershed systems. To this end, probablistic models of precipitation, snow-melt, ephemeral streamflow, natural recharge and ground water fluctuations will be investigated. The cost of data collection and analysis (cost of thinking) will be related to the benefits assignable to the data.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Arizona

7.0005, DIGITAL SYSTEMS FOR ON-SITE DATA COLLECTION FOR WATER QUALITY ANALYSIS

M.K. TESTERMAN, Univ. of Arkansas, Graduate School, *Little Rock, Arkansas* 72005

The proposed work is concerned with the development of an electronic digital system for on-site data collection in water resources research and control programs. System design objectives include (1) data recordings directly readable by computer input devices, (2) a selectable number of measurement channels within a design maximum, (3) system operation either independent or in synchronism with other equipment of the same type, (4) provisions for interfacing with telemetry packages or data modems for transmission over communication networks (e.g. Bell System Dataphone).

The work would involve establishing data acquisition requirements and sources of error, data system requirements and performance constraints, and system equipment design.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Arkansas

7.0006, A CONTINUOUS MULTIPARAMETER WATER QUALITY MONITOR

M.K. TESTERMAN, Univ. of Arkansas, Graduate School, *Little Rock, Arkansas* 72005

The object of this investigation is to study, perform necessary research and develop an unattended portable, self-contained unit capable of measuring and recording parameters of interest in the study of water pollution. Concurrent measurement and recording of at least four parameters of flowing streams, such as pH, conductivity, temperature, and dissolved oxygen, by a single station should be feasible.

Consideration will be given to weight, time of operation, required cost, and accuracy. For those parameters to be considered, suitable methods of measurement must be developed and studied. Modular design will be used to provide the possibility of changing transducers in order to allow recording of different parameters while using the same basic electronic and recording unit. In order to allow unattended operation for considerable periods of time, very careful consideration must be given to the question of power sources and the power drain required by the electronic, programmer, and recorder units. Provisions for internal standardization and validity checks, in so far as possible, should also be included.

A versatile instrument, capable of recording a number of stream parameters at a minimum cost per recording station, would make available long-term data defining general aspects of water quality and the extremes of particular chemical constituents of interest. Without a device of this type, it is impossible to study pollution transients by current techniques.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

7.0007, INDUCED ELECTRICAL POLARIZATION AND GROUND WATER

S.H. WARD, Univ. of California, School of Engineering, *Berkeley, California* 94720

Applications of an electric field to rock or soil containing clay minerals leads to electrical polarization in the rock or soil. This polarization may be detected by measuring the change in apparent resistivity of the subsurface as the frequency of electrical excitation is changed. This measurement can be of value in location and evaluation of natural ground water reservoirs.

We have investigated the applicability and limitations of the induced electrical polarization method in the location and evaluation of natural ground water reservoirs in the State of California.

Clay horizons and other clay-bearing unconsolidated sediments are potential sources of induced polarization anomalies. If such anomalies may be detected above system noise, then the induced polarization method may be of value for in-situ classification of unconsolidated sediments encountered in hydrological projects. One such project exists in Santa Clara County where near-surface unconsolidated sediments are frequently considered as potential recharge areas. Of four areas surveyed with induced-polarization apparatus in Santa Clara County, only two yielded significant frequency-effect anomalies, and in each of these two the frequency effects were of the order of 3 percent. These anomalous frequency effects may be related to clayey gravels. The dipole-dipole array, with spreads of 10 ft. and 20 ft., was typically used in the study.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of California

7.0008, SACRAMENTO-SAN JOAQUIN DELTA ANALOG MODEL STUDIES

C.A. WERNER, Univ. of California, School of Engineering, *Berkeley, California* 94720

Problem: Simulate the hydraulics of the complex estuarine system of an inverse Delta (Sacramento-San Joaquin Delta) composed of over 700 miles of meandering interconnected sloughs and waterways.

Solution: Construct and verify an electrical analog model of the system: Analogy; tidal stage; discharge; water surface area; cross sectional area with gravitational acceleration; frictional resistance; voltage above ground; current; capitance; inductance per unit length of channel; resistance.

Special square law resistor units are employed to simulate nonlinear characteristics of the hydraulic system. Direct current simulates 'net' flows. The tidal effect is duplicated by using alternating current at different frequencies corresponding to the solar and lunar components of the tide.

The analog model has been verified and is operational for normal hydrology conditions, and is now in the verification stage for flood conditions. It is located in Sacramento, California. For information write Department of Water Resources, P.O. Box 388, Sacramento, California, Attention: Wayne Haas.

SUPPORTED BY California State Government

7.0009, THEORY FOR THE DESIGN OF PRECIPITATION NETWORKS FOR HYDROLOGIC ANALYSIS

J. AMOROCHO, Univ. of California, School of Agriculture, *Davis, California* 95616

The purpose of the investigation is to establish criteria for the design of precipitation gage networks based on consideration of the physics of precipitation as well as on the principles of sampling theory.

It is proposed to establish a special recording gage network which will permit the study of trend surfaces describing the instantaneous precipitation patterns over a catchment during a series of storm events. Whth these data, the minimum gage spacing necessary to characterize significant areal distribution trends for various catchment sizes will be studied.

SUPPORTED BY University of California

7.0010, HYDRAULIC STUDIES AND RESEARCH ON CALIFORNIA WATER FACILITIES

J. AMOROCHO, Univ. of California, Agricultural Experiment Sta., *Davis, California* 95616

Objective: The objective of these studies is to investigate the phenomena of fluid flow in complex structures of the type used in large irrigation and other water conveyance systems. Specific application of this work will be the optimization of a number of features of the California Water Plan for final design.

Description: Laboratory scale models of structures designed by the State Department of Water Resources will be constructed in the laboratories of the Department of Irrigation. The theories of hydraulic similitude will be applied for the analysis of the results and for their application to the prototype. Special installations and instrumentation have been developed for these purposes and some new theoretical studies have been performed in the past and will be advanced in the future.

SUPPORTED BY California State Government

7.0011, OPERATIONAL HYDROMETEOROLOGICAL DATA MANAGEMENT SYSTEM

J. SCHIEFER, North Amer. Rockwell Corp., *Downey, California*

The objective of this project is to obtain technical assistance in the orderly development of automation of the federal multipurpose river control and power system operation in the Pacific Northwest.

The area pertinent to hydrology is to develop and plan for a joint Pacific Northwest Federal Agencies Data Management System for collecting, transmitting, storing, retrieving, processing and displaying hydrometeorological data.

SUPPORTED BY U.S. Dept. of Interior - Bonnvl. Pwr. Adm.

7.0012, PLANNING ALGORITHMS FOR REGIONAL WATER RESOURCE SYSTEMS

W.G. KECKLER, Stanford Research Institute, *Menlo Park, California*

The size, complexity, and expense of regional water resource systems have made computer-based decision techniques of central importance. Methods are being sought to provide planners with the capability of determing the least costly means of providing water to meet system demands at a specified future date within prescribed physical, legal, financial, and contractual constraints. Methods providing the optimal sizing, sequencing, and timing of system additions from the present to the termination of the planning interval are also being developed.

The primary emphasis of this research is the development of computer algorithms capable of meeting the above objectives. Thus far dynamic programming and its extensions have been successfully applied to the optimal operation and planning of natural-gas pipeline networks, electrical power planning, and the short-term optimal dispatching of a multipurpose reservoir system. These methods and other specialized dynamic programming techniques, such as branch compression and absorption, k-best trajectories, and successive approximations, will be used to obtain the required algorithms.

SUPPORTED BY Stanford Research Institute

7.0013, SPECIFIC YIELD RESEARCH AND PERMEABILITY RESEARCH

W.E. STEINER, U.S. Dept. of Interior, Geological Survey, *Menlo Park, California*

The U. S. Geological Survey, Water Resources Division, on a matching fund basis with the California Department of Water Resources, performs research on specific yield and permeability of California water-bearing sediments. Specific yield and permeability of California are directed toward establishing uniform laboratory testing procedures, and developing definitive values of specific yield and permeability in order to determine storage capacity of ground water reservoirs, and rates of movement of ground water.

SUPPORTED BY California State Government
U.S. Dept. of Interior - Geological Survey

7.0014, NUMERICAL MODELING OF GENERAL CIRCULATION OF EARTHS ATMOSPHERE

A. KASAHARA, Natl. Center For Atmosph. Res. , *Boulder, Colorado* 80302

A mathematical model of the general circulation of the earth's atmosphere is being developed for studying the various processes at work, for experiments in prediction and for simulation of atmospheric modification. A computer is used to solve by numerical methods the equations governing the motions and processes of the atmosphere. The current version of the model uses a grid network of seven height levels reaching from the earth's surface to the top of the atmosphere and covering the entire globe with a horizontal spacing of 5 degrees in both latitude and longitude. The surface friction layer is included by incorporating the horizontal and vertical eddy exchange processes for momentum, water vapor, and heat. Heating due to incoming solar insolation and cooling due to long-wave radiation are included. Distribution of sea-surface temperature is taken from climatological records but land temperature distribution is computed, based on a balance condition of heat flux at the ground. The distribution of orography is taken into account through lower boundary conditions. As the initial approximation, the effect of release of latent heat of condensation is included by assuming the atmposphere to be saturated by water vapor. However, the amount of latent heat release is adjusted by a factor determining the rate of condensation. Next, the hydrological cycle will include vertical and horizontal transports of water vapor, precipitation, runoff and evaporation. At present many short-term (10 to 30 days) and long term (80 to 100 days) integrations are being made on the Control Data 6600 computer by changing the magnitudes of parameters within their reasonable limits. The results of integration are compared with climatological data of the atmosphere. The response of the model to varying parameters is studied and the model is adjusted accordingly.

SUPPORTED BY National Center For Atmospheric Research
U.S. National Science Foundation

7.0015, REMOTE SENSING OF WATER VAPOR

R.E. MCGAVIN, U.S. Dept. of Commerce, Wave Propagation Laboratory, *Boulder, Colorado* 80302

The variability of received electromagnetic signals is a function of the variations of the refractive index which is in turn controlled mainly by temperature and water vapor fluctuations. Radio distance measuring equipment, an auxiliary optical probe and standard weather instruments will be used to measure the turbulence of water vapor over arbitrary paths and surfaces to determine the nature of water vapor transport.

A radio phase measuring system with an auxiliary optical probe has been developed and tested.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

7.0016, INSTRUMENTATION FOR ENERGY BUDGET EVAPOTRANSP STUDIES

C.R. DAUM, U.S. Dept. of Interior, Water Resources Division, *Denver, Colorado*

A means for measuring the diurnal flow characteristics of water within the trunk of a tree would aid in determining the atmosphere plant-soil relationship. This method measures the radial heat entering or leaving the water stream from the outside of the tree, the heat lost or gained by the water from the inactive xylem, and the vertical temperature differential of the stream. From these data, the water flow may be calculated.

A detailed study of natural heat flow as evidenced by temperature gradients within the trunk of a tree along with its physiology provides the basis for this project. The temperatures are measured and recorded using small copper-constantan thermocouples (size 30 wire) embedded within the tree. The depth is determined by the physiological section to be studied, i.e., the active or inactive xylem. Commercial heat flow plates are embedded under the bark of the tree and outside the cambium layer, to provide a measurement of incoming or outgoing heat.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

7.0017, TECHNIQUES FOR USE OF RADIOISOTOPES IN TRACING RESERVOIR LEAKAGE

R.L. HANSEN, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The Bureau is vitally concerned with developing new methods of investigations of reservoir sites where the problem of leakage from reservoirs might exist. Investigations and actual tests by others have shown that definite advantages can be attained by the use of radioisotopes for detecting and tracing such leakage. In many cases where contamination by ground water or ancient water has occurred, the radioisotope method, at this time, is the only practical means of deriving volumetric and directional flow information. For tracing leakage in complex and faulted or cavernous strata such as may occur in foundations and abutments, the radioisotope method is an excellent method as it can be adapted to continuous reading by detecting the actual movement of the tracer past the point of measurement.

This is a program, in part, funded by a contract with the Atomic Energy Commission.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

7.0018, BOREHOLE GEOPHYSICS AS APPLIED TO GEOHYDROLOGY

W.S. KEYS, U.S. Dept. of Interior, Water Resources Division, *Denver, Colorado*

Borehole geophysics is one of the most important techniques for deriving information from drill holes. It can provide accurate in situ data on the geometry and physical characteristics of aquifers and adjacent rocks, and chemistry and movement of the contained fluids, in both cased and uncased holes. Exploratory drill holes constructed to investigate a ground-water environment are often very costly. Means of improving the quality and increasing the quantity of data obtained are necessary if full use of these drill holes is to be realized.

Geophysical techniques currently in use in the petroleum industry, e.g., gamma-gamma, neutron, and sonic logs and in-hole tracer tests will be applied to ground-water investigations. The conventional gamma ray, electric, temperature, caliper and flowmeter logs will be evaluated in a variety of geologic terranes. Procedures for improving log interpretation as related to geohydrology are being investigated and recent advances in equipment technology will be utilized. Considerable progress can be made in all of these phases of borehole geophysics by utilizing knowledge available in the petroleum industry.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

7.0019, INSTRUMENTATION, DATA ACQUISITION, AND COMPUTER TECHNIQUES

J.C. SCHUSTER, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Modern instrumentation is studied to find how the quality and quantity of data acquired from laboratory investigations can be improved. The study emphasizes a continuous review of the instruments offered by various manufacturers. Information is assembled to aid in providing instrument groups conpatible with computer methods of analysis at a reasonable cost. The study includes transducers for pressure, temperature, velocity, vibration, and acceleration to match the data recording and computing systems. Each system is designed for use in the laboratory but made adaptable as required for field use.

Hydraulics Branch personnel are being trained in the efficient use of computer systems and in the utilization of these systems in the solution of routine hydraulic problems. Application is being made of both digital and analog computers.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

7.0020, PHYSICAL CHEMISTRY OF RADIOELEMENTS - RADIOMETRIC METHODS OF ANALYSIS

L.L. THATCHER, U.S. Dept. of Interior, Water Resources Division, *Denver, Colorado*

The objective of this project is to improve existing analytical methods and develop new analytical methods for the determination of trace concentrations of natural and synthetic radionuclides in water. Also, to make preliminary studies of determinations of trace concentrations of stable elements by activation analysis. Analytical techniques such as alpha and gamma spectrometry are used extensively. Frequently used chemical processes include ion exchange, solvent extraction, coprecipitation, and electrodeposition.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

7.0021, ELECTRONIC EQUIPMENT DEVELOPMENT

J.E. EDDY, U.S. Dept. of Interior, Water Resources Division, *Washington, District of Columbia*

The objective of this project is to design and develop equipment (largely electronic) for use in ground water studies. Included in the plans are the development of a magnetic switch and counter for the deep well current meter, equipment for measuring differential head of aquifers using pressure sensitive transducers, and an angular measurement device to determine the direction of current flow by the use of potentiometers.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

7.0022, BLACK CANYON OF THE GUNNISON, COLORADO

W.R. HANSEN, U.S. Dept. of Interior, Geologic Division, *Washington, District of Columbia* 20242

Detailed geologic mapping of 4 - 7 1/2-minute quadrangles along the Gunnison River in Southwestern Colorado. The geology consists of Precambrian granite, gneiss and schist, Triassic red beds, Jurassic Morrison formation, Cretaceous Dakota sandstone, Mancos shale, Mesa Verde sandstone, and Tertiary volcanic rocks. The Morrison formation contains uranium deposits in this general area. Tuff breccias and tillites of the area may be aquifers.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

7.0023, PHOTOMAPPING

J.W. PUMPELLY, U.S. Dept. of Interior, Topographic Division, *Washington, District of Columbia* 20242

Purpose: To develop published maps which, by using orthophotomosaics in areas of steep terrain or controlled mosaics in areas of low relief, show the detail contained in aerial photographs and portray this detail in colors representative of the ground, vegetation, water features, etc., and to overprint such standard map information as is required to facilitate use of the map.

Procedure: Three lithographically reproducible continuous tone negatives are prepared to print the photographic imagery.

A tint representative of the ground color is printed first. By masking technique the various portions of one negative (low contrast) are next printed in color appropriate for the type of feature. Over these an accent image (edge-isolated) negative is used to accentuate all line- type features contained on the photographs. Selected maps lettering and certain line symbols are added to facilitate the identification of important roads, places, or other features.

Results: Orthophotomaps have been processed through publication. Results are sufficiently satisfactory that 16 photomaps covering the Florida-Georgia Okefenokee Swamp have been prepared for public sale. Research and experimentation in the production of similar maps for numerous other areas is progressing rapidly.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

7.0024, TAXONOMY AND ECOLOGY OF INSHORE MARINE MICROBIOTA

J.B. LACKEY, Individual Grants, *Florida*

This envisages publication of an illustrated account, with keys, of inshore marine and brackish water protozoa and microscopic algae, both planktonic and benthic. Their commonness or rareness, cosmopolitan or restrictive distribution will be covered by ecology, especially with reference to pollution, nutrient richness and water poor in nutrients. Regions covered to date are the Atlantic Coast, Florida to Woods Hole, Massachusetts; The Florida Gulf Coast, the California coast, the Island of Oahu and Guanabara Bay, Brazil.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

7.0025, A METHOD OF DETERMINING AND MAPPING THE HYDROLOGIC RESPONSE OF UNGAGED WATERSHEDS IN THE SOUTHEAST

J.F. WOODRUFF, Univ. of Georgia, Graduate School, *Athens, Georgia* 30602

The research will determine the quantitative relation between hydrologic response of small watersheds (20 square miles or less) and a selected small number of geomorphic and land use factors. Hydrologic response is defined as the ratio direct runoff/gross precipitation, averaged over a season or year. Direct runoff is defined quantitatively by an equation developed and tested in a previous study. The derived relation will be used to map a test area in detail, showing the source and volumes of potential flood waters produced by different areas in an average year.

Drastic differences in hydrologic response of various terrains and regions is generally concealed in records of precipitation and streamflow published by the Weather Bureau and the U. S. Geological Survey. Gaging stations are too far apart to map response accurately and methods are needed to convert hydrologic, soil, topographic and serial maps into response maps, revealing at a glance the varying capacity for land areas to produce storm flows. This project will attempt to show the ungaged areas can be mapped and that hydrologic response maps are potentially valuable tools in water resources education, planning and management.

Response ratios will be calculated according to methods already developed by one of the investigators. The ratios will be related by multivariate analysis to certain precipitation and watershed factors. Data will be secured from government publications and from various maps and recorded data. Analysis will be chiefly by 7094 computer.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Georgia

7.0026, TELEMETERING OF HYDROLOGIC DATA FROM REMOTE AREAS

C.C. WARNICK, Univ. of Idaho, Engineering Experiment Station, *Moscow, Idaho* 83843

This program is in cooperation with the University of Idaho Experiment Station. The program develops and tests scientific equipment for the telemetering of hydrological data from remote mountainous areas which provide a source of water supply for power and irrigation.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation
Idaho State Government

7.0027, DEVELOPMENT OF MULTIPLE-USE PRODUCTION/OUTPUT INFORMATION FOR OWNERS OF SMALL WOODLANDS IN THE CENTRAL HARDWOOD REGION

R.I. BEAZLEY, Southern Illinois University, Graduate School, *Carbondale, Illinois* 62903

Analysis of the need for physiical input/output information concerning water in all its aspects except navigation and irrigation. Of particular interest is input-output information as to erosion control effects in this region.

SUPPORTED BY Southern Illinois University

7.0028, EXPERIMENTAL INVESTIGATION OF HYDROLOGICAL PARAMETERS OF AQUIFERS THROUGH ELECTRICAL RESISTIVITY MEASUREMENTS

H. PFANNKUCH, Southern Illinois University, Graduate School, *Carbondale, Illinois* 62903

Fundamental concepts of resistivity measurements of saturated porous rock are investigated. They will be applied to the geophysical determination of hydrological parameters of aquifers by electrical measurements in the well or bore hole.

Complete equations are developed containing terms for conductance of the saturating pore fluid, the solid matrix, and the double layer at the solid-liquid interface. In normal operations, developed from oil field practices, the two last terms are neglected. This is not warranted, however, for high resistivity liquids such as ground water of high purity.

The proposed equations will be tested experimentally in the laboratory and empirical relations will be derived from the analysis of field samples.

SUPPORTED BY Southern Illinois University

7.0029, THE DEVELOPMENT OF COMMERCE IN THE UPPER MISSISSIPPI BASIN IN THE PERIOD PRIOR TO THE CIVIL WAR (ABBREV)

W.A. PITKIN, Southern Illinois University, Graduate School, *Carbondale, Illinois* 62903

Considerations: 1. Questions of Sovereignty 2. Explorers and Travellers 3. Expeditions sponsored by the U.S. Government; Utilization of Scientists and Engineers 4. The Role of the War Department 5. The War of 1812. Its Outcome The Signal for Expansion 6. The Great Migration 7. Impact of the Erie Canal 8. The Indian; The Black Hawk War 9. The Origin of Traffic on the Upper Mississippi 10. The 'Spirit of Commerce.' (See James Hall) 11. The Founding and Development of 'key' communities (e.g. Galena) 12. Production for a Market; Exploitation of Natural Resources 13. Domestic Trade 14. Foreign Trade 15. The Mississippi's Tributaries 16. The Illinois and Michigan Canal (Impact of Chicago's growth on Mississippi River Traffic, and Vice Versa) 17. Types of River Craft 18. The Great Age of the Steamboat on Inland Waters 19. Persistence in Utilization of the Flat Boat and the Keel 20. Regulation of Commerce by the U.S. Government 21. Impact of Science and Technology; the Industrial Revolution 22. The Men of Initiative and Imagination Responsible for the Phenomenal Expansion of the Mississippi Basin 23. The Dark Cloud on the Horizon; the Approach of the Civil War 24. The Question of a Northwest Confederacy 25. A Traffic Study, 1860-1861 --trade with the East --trade with the South 26. The Historian's Task: Sources; Synthesis; Interdisciplinary Considerations

SUPPORTED BY Southern Illinois University

7.0030, SOUTHERN ILLINOIS REGIONAL ECONOMIC DATA SYSTEM

A.E. PRELL, Southern Illinois University, Graduate School, *Carbondale, Illinois* 62903

This project involves the establishment of data banks on important industrial variables. One of the variables to be analyzed, evaluated and catalogued is the water resources of the area as they relate to business and industry. This would include the industrial requirement for water, the possibilities of developing water resources into recreation industries and the relationship of water as a factor in the development and growth of business and industrial communities.

SUPPORTED BY Southern Illinois University

7.0031, A REGIONAL STUDY OF THE CHANGING OCCUPANCY AND DEVELOPMENT OF AN ALLUVIAL LOWLAND

T.H. SCHMUDDE, Southern Illinois University, Graduate School, *Carbondale, Illinois* 62903

The purpose of the study has been to analyze the present occupancy of a portion of the Mississippi alluvial lowland and the agricultural system by which the area has been developed and is being developed. Special emphasis was focused on the space organizing aspects of this development. From such an analysis the attempt will be to construct a model of regional development in this area. Such a model could be expected to have important implications for guiding development in other areas.

Relevant to water resources research the occupancy of the Lower Mississippi alluvial lowland can be viewed as a struggle toward better water resource management. Fundamental to the development of this area for agricultural as well as other forms of settlement has been the need to organize spatially institutions and individual enterprises in order to manage the problems of too much water on the land (drainage organization), too little water on the land at critical times (irrigation organization) and the Mississippi River itself (flood control and improved navigation). Spatial organization is an inherent part of water management since the control over movement of quantity and quality of water horizontally is the essence of water management. Once such organization is established, however, the institutions can serve either directly or indirectly for other forms of spatial organization, which is so essential for area development. Thus an appreciation of the spatial dimension of water resource management problems in the area is an important result of the study.

An atlas of relevant distributions concerning water resources, land resources and agricultural and economic factors is nearing completion and could be published if funds were available.

SUPPORTED BY Southern Illinois University

7.0032, DEVICE FOR FIELD DETERMINATION OF HEAVY METALS IN NATURAL WATERS

R.E. VANATTA, Southern Illinois University, Graduate School, *Carbondale, Illinois* 62903

The proposed investigation involves the design, construction, and testing of a simple, portable, self-contained device suitable for in situ analysis of natural waters for copper, lead, cadmium, nickel, chromium, and zinc; simultaneous determination of dissolved oxygen may also be feasible. A modification of a conventional DC polargraphic device is proposed.

Laboratory investigations would involve the following: (1) Development of fundamental electrical circuitry for simplicity of field operations, while permitting the desired accuracy. (2) Development of suitable electrolyte and electrode systems for field application. (3) Adaptation of circuitry and electrolyte-electrode systems to concentration levels present in natural waters.

Field studies would include testing of the proposed device through the analysis of various types of natural waters, i.e., lakes, rivers, ground water, wells, etc. Confirmation of performance would be made through appropriate laboratory analysis of the same waters with modern laboratory techniques and facilities.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Southern Illinois University

7.0033, ELECTRICAL EARTH RESISTIVITY SURVEYS

M.B. BUHLE, State Geol. Survey, *Urbana, Illinois*

From 75 to 140 electrical earth resistivity surveys are conducted each year in search of water-bearing sand and gravel deposits. This activity has been a public service function by the State Geological Survey since 1932. It is also used in research projects where warranted. Surveys are conducted for municipalities, industries, public agencies, and private citizens, using instruments whith Gish- Rooney AC circuits and Wenner electrode configuration. Interpretation of results is based on empirical methods that have proved to be applicable in Illinois.

SUPPORTED BY Illinois State Government

7.0034, GROUND-WATER GEOLOGY OF OGLE COUNTY, ILLINOIS

J.E. HACKETT, State Geol. Survey, *Urbana, Illinois*

The geology of Ogle County is under study relative to the occurrence and availability of ground water. The county contains favorable aquifers within the glacial drift and to depths of more than 1000 feet in the bedrock. Information on the character of the aquifers is being obtained from well records and from extensive outcrops of bedrock in the county. Aerial photographs are yielding information on possible fracture traces that may be useful in well siting.

011 015

SUPPORTED BY Illinois State Government

7.0035, STATE GRAVITY SURVEY

P.C. HEIGOLD, State Geol. Survey, *Urbana, Illinois*

A gravity study of the state is being conducted by regions. Gravity measurements are made at all section corners and at bench marks. Bouguer and residual gravity contour maps are prepared as each region is completed. To date field work has been completed in the northern third, the southern third, and the east-central part of Illinois. The regional maps are interpreted relative to basement and sedimentary structure as they are completed. Deep seismic reflection studies have been used to complement gravity studies in some regions.

SUPPORTED BY Illinois State Government

7.0036, GEOLOGY OF VALLEY FILL DEPOSITS IN THE MIDDLE ILLINOIS RIVER VALLEY

M.R. MCCOMAS, State Geol. Survey, *Urbana, Illinois*

This study of the Middle Illinois River Valley in Bureau, Marshall, Woodford, Peoria, and Tazewell Counties undertakes to define the geological and hydrogeological characteristics of the valley fill deposits. The initial investigation is primarily an examination of the glacial drift in order to define the limits and character of the sand and gravel aquifers, especially the thick basal aquifer, the Sankoty Sand. A textural, mineralogical, and possibly electron microscopic examination of the Sankoty Sand will be performed in order to determine its history of deposition and physical properties. The Sankoty Sand is the principal aquifer for the cities of Peoria, Pekin, Henry, Hennepin, and Princeton.

SUPPORTED BY Illinois State Government

7.0037, STATISTICAL ANALYSIS OF WATER CONSUMPTION

S. CSALLANY, State Water Survey, *Urbana, Illinois*

Purpose of this study is to determine the influence of various factors on municipal water consumption in Illinois.

To collect the basic data questionnaires were sent to all public water works (incorporated places) in Illinois. The questionnaire was designed to obtain information on the date of daily pumpage metered, average daily pumpage subdivided by number of persons served by the water works, and percent of total pumpage treated. The collected basic data were tabulated and grouped according to source (groundwater, surface water). The effects of these factors on water consumption were studied. Outside of the Chicago region the most important factors influencing water consumption are percent of public distribution, persons per service, population, and commercial and industrial water use. In the Chicago region the most factors are the percent of services used by commercial and industrial firms; percent of water used for commercial and industrial purposes, and the age of the water works.

SUPPORTED BY Illinois State Government

7.0038, PERMEABILITY OF UNCONSOLIDATED AQUIFER MATERIALS

T.A. PRICKETT, State Water Survey, *Urbana, Illinois*

The statistical analysis of the permeability of unconsolidated aquifer materials versus geohydrologic controls is continuing. All hydrologic and geographic data have now been put on punch cards and several correlations made with geologic parameters.

A special study is being made of the valley train and alluvial deposits contained in the bedrock valley coincident with the present Mississippi River from Alton to Cairo. Data are available from approximately 2500 measurements of permeability along this valley system. With this data it is hoped to determine to what limits permeability variation can be predicted. The results of this special study will form the basis for determining the reliability of other valley system predictions.

SUPPORTED BY Illinois State Government

7.0039, AUTOMATIC RECORDING OF SHORT TERM B.O.D.

R.M. ARTHUR, Rose Polytechnic Institute, School of Engineering, *Terre Haute, Indiana* 47803

The project objective is to demonstrate the ability of the automatic respirometer to produce accurate and precise measurement of BOD of waste waters within a one or two hour time period with batch or continuous operations. Automatic respirometers will be fabricated and installed in two sewage treatment plants. Daily tests of 5-day BOD will be run on the plant influent and effluent. The same samples will be tested in the automatic BOD respirometer. Correlation analysis will be performed on the results.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Rose Polytechnic Institute

7.0040, LIMNOLOGY OF DESOTO BEND LAKE, IOWA AND NEBRASKA

R.W. BACHMANN, Iowa State University, Iowa Coop Fishery Unit, *Ames, Iowa* 50010

Investigations of physical, chemical and biological characteristics of DeSoto Bend Lake were begun in June, 1967 and will continue until the spring, 1968. Analysis of plankton, benthos and bottom sediment samples has been initiated. Temperature and oxygen records indicate partial stratification in mid-summer. M. S. thesis will be completed in 1969.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Iowa State University
Iowa State Government
Nebraska State Government

7.0041, THE FEASIBILITY OF COLD WATER FISHES FOR LAKE SHARPE, SOUTH DAKOTA

R.W. BACHMANN, Iowa State University, Iowa Coop Fishery Unit, *Ames, Iowa* 50010

Under normal flow conditions, Lake Sharpe is a single dominant water mass warming between 1 and 9 degrees C. Maximum temperature encountered during 1966 and 1967 was 24.3 degrees C. Bottom sampling from June through November, 1967 indicated little season variation in the numbers or types of bottom organisms.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Iowa State University

7.0042, A LIMNOLOGICAL INVENTORY OF IOWA LAKES AND STREAMS

R.W. BACHMANN, Iowa State University, School of Agriculture, *Ames, Iowa* 50010

The purpose of this project is to review, analyze and summarize the existing information dealing with the distribution, water supply, water chemistry, flora and fauna, and limnological cycles of Iowa lakes and streams. Limnological surveys are being conducted on selected lakes and streams.

SUPPORTED BY Iowa State Government

7.0043, AGRICULTURAL AND INDUSTRIAL DEVELOPMENT IN RELATION TO IOWAS ECONOMIC GROWTH

W.R. MAKI, Iowa State University, School of Agriculture, *Ames, Iowa* 50010

Prepare econometric models for development planning in Iowa, particularly in relation to the Missouri and Upper Mississippi Basin Development programs; prepare analyses of investment opportunities in selected Iowa industries; estimate labor and water resource requirements of projected agricultural and industrial development in Iowa and contiguous areas; collaborate with Iowa Development Commission, Iowa Natural Resources Council, and Missouri Basin Inter-Agency Committee in preparation of area economic projections.

SUPPORTED BY Iowa State Government

7.0044, COMPUTER SIMULATION AND EVALUATION OF CLIMATOLOGICAL MODELS

J.R. EAGLEMAN, Univ. of Kansas, Graduate School, *Lawrence, Kansas* 66045

The climatic variables if viewed in terms of long period means for a particular location can be combined in various ways to obtain indices to the average climate for this location. One way of combining climatic elements is through the water balance. Monthly differences between evapotranspiration and precipitation can be compared. This static climatological model becomes more dynamic with the inclusion of fluctuations about the mean values. These fluctuations are being investigated in terms of standard deviations and certain percentages of the area under the Gamma distribution.

SUPPORTED BY University of Kansas

7.0045, R.I.-LIQUEFACTION OF SAND DUE TO LONG TERM, SMALL AMPLITUDE VIBRATIONS

V.P. DRNEVICH, Univ. of Kentucky, School of Engineering, *Lexington, Kentucky* 40506

The objective of this research will be to study liquefaction of saturated cohensionless soils under restricted drainage conditions due to long term, relatively small amplitude vibratory shearing strains. The number of load repetitions necessary to cause liquefaction will be determined as a function of ambient effective stresses, relative density, and shearing strain amplitude. For this study, a special torsional resonant column device will be used. It applies essentially uniform vibratory shearing strains to a hollow cylindrical specimen acted upon by static confining pressures. Shear modulus and energy dissipation will be measured as a function of the number of cycles of vibration.

SUPPORTED BY U.S. National Science Foundation

7.0046, AUTOMATION OF GROUND-WATER RECORDS

W.E. WEBB, Johns Hopkins University, State Geological Survey, *Baltimore, Maryland* 21218

The objective is to organize and prepare a feasible operating system of ground-water data storage and retrieval. The approach used is to identify the types of data to be stored, assign priorities for their entry into the system, determine the storage media and format, and finally enter data accumulated into the system.

SUPPORTED BY Maryland State Government
U.S. Dept. of Interior - Geological Survey

7.0047, SIMULATION OF WATER RESOURCE REGIMES

T.W. CADMAN, Univ. of Maryland, School of Engineering, *College Park, Maryland*

Water Resource regimes will be simulated for analysis with analog computers. Typical of the regimes to be studied are those such as the surface flow in a watershed, an estuarine system, or ground water supply and waste disposal. Initially, emphasis will be on the training of faculty members in the analog simulation and application. Subsequently, faculty members will utilize this knowledge in broader water resources research problems.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Maryland

7.0048, TEST AND EVALUATION OF TELEMETERING STORAGE PRECIPITATION GAGE

K.W. DAVIS, U.S. Dept. of Commerce, Weather Bureau, *Silver Spring, Maryland* 20910

Test and evaluation of a telemetering storage precipitation gage for use at inaccessible heavy snow areas during the winter months.

The Equipment Development Laboratory prototype will be subjected to a series of controlled laboratory tests to determine its ability to meet its functional and engineering requirements.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

7.0049, FISHER AND PORTER INSTALLATION METHODS

K.W. DAVIS, U.S. Dept. of Commerce, Weather Bureau, *Silver Spring, Maryland* 20910

To evaluate the Fisher and Porter precipitation gage installations methods, oils for use as evaporation suppressors and the effect of the windshields on the F and P precipitation gage.

Comparative evaluations will be conducted on precipitation gage foundations of different designs, oils recommended by oil companies for use as evaporation suppressors and the effect of the windshield at various elevations.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

7.0050, IMPROVE COMPONENTS OF THE DATA ACQUISITION SYSTEM - SATELLITE COMMUNICATIONS EQUIPMENT

F.V. KOHL, U.S. Dept. of Commerce, Weather Bureau, *Silver Spring, Maryland* 20910

Continue current experimental collection of river and rainfall reports from remote sensor sites via VHF relay through ATS-1 satellite to determine feasibility and optimum equipment inventory required for a large scale data collection program by this method. Investigate techniques for low signal level and for signal reception under difficult signal/noise conditions.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

7.0051, IMPROVE PRECIPITATION MEASURING EQUIPMENT - HYDROLOGIC EQUIPMENT IMPROVEMENT

F.V. KOHL, U.S. Dept. of Commerce, Weather Bureau, *Silver Spring, Maryland* 20910

This task is concerned with the improvement of hydrologic equipment for the purpose of bettering hydrological data collection.

This work will take one of two directions depending on the outcome of the hydrologic equipment analysis of the D111 Precipitation Gage Analysis or the Pressure Transducer Analysis.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

7.0052, PRECIPITATION-FREQUENCY MAPS FOR WESTERN UNITED STATES

J.L. PAULHUS, U.S. Dept. of Commerce, Off. of Hydrology, *Silver Spring, Maryland* 20910

Physiographically adjusted precipitation-frequency maps of 6- and 24 hour-precipitation for return periods of 2, 5, 10, 25, 50 and 100 years are being prepared for 10 western States. Relationships developed between precipitation-frequency station, or point, data and topographic and climatic parameters are used to estimate point data where none is available. Maps thus produced depict precipitation-frequency regimes more accurately than those based on station data only. Two sets of maps are prepared for those regions with high elevations where snow contributes significantly to annual series data. For those regions, one set of maps is based on precipitation data throughout the year; and the other, on data for the May-October season only, when practically all heavy precipitation is rain. The maps, which are printed on a 1:1,000,000 topotraphic base, are issued as completed on a State-by-State basis.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

7.0053, DEVELOP PROTOTYPE PRECIPITATION OCCURRENCE SENSOR - DEVELOP AMOS III-70 (AUTOMATIC WEATHER STATION)

R. RUTH, U.S. Dept. of Commerce, Weather Bureau, *Silver Spring, Maryland* 20910

An outside contractor will be engaged to package as a prototype, a precipitation occurrence sensor. The type of sensor, either 'rotating disc' or 'peck' will be determined by the results obtained through tests and evaluation.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

7.0054, SOME ASPECTS OF THE MARINE SPORT FISHERY OF MASSACHUSETTS WITH SPECIAL EMPHASIS ON SURVEY DESIGN AND BASIC ECONOMIC ATTRIBUTES

J.A. MCCANN, Univ. of Massachusetts, School of Agriculture, *Amherst, Massachusetts* 01003

Federal and state agencies have recently realized the importance of collecting reliable marine sport fishery statistics and of determining the impact of the marine sports angler on local economy. A study has recently been undertaken to obtain data on the identity of the marine sport fisherman, his needs and preferences, and his impact on the economy of Massachusetts.

Major emphasis thus far has been upon literature review and method evaluation. Data will be collected this summer (1968) which should provide some insight into problems related to survey design and division of labor in future work. These data will be solicited from certain business establishments and captains of sport fishing vessels, as well as the fishermen themselves, and will deal primarily with fishermen residences, preferences as to methods, localities, and fish species, and average daily expenditures. Questionnaires in post-card form will be made available to fishermen at randomly selected bait and tackle shops, and some limited personal interviewing is anticipated. A large- scale fisherman interview program is planned for 1969 and will follow some type of stratified design.

These preliminary observations will provide a foundation for the principal survey of 1969, especially with regard to nonresident sampling. A tentative statistical scheme employing several survey methods is being considered for in-state sampling. This may take the form of a latin square whereby treatments (survey methods) are assigned randomly to cells within the overall pattern. Several assumptions underlying this method will have to be tested prior to its actual implementation.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Massachusetts State Government

7.0055, DATA COLLECTION ECONOMICS FOR WATER POLLUTION STUDIES

A.S. GOODMAN, Northeastern University, School of Engineering, *Boston, Massachusetts* 02115

The research will employ operations research and other techniques to critically review existing data collection and processing programs. The programs studied will be selected from those of the pollution control agencies in the New England area. A principal objective of the research will be the improvement of the economic efficiency of such programs, to make them as responsive as practicable (within budget constraints) to the planning and operation requirements of water pollution control agencies.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

7.0056, HYDROLOGIC MEASUREMENT SYSTEMS

P.S. EAGLESON, Mass. Inst. of Technology, School of Engineering, *Cambridge, Massachusetts* 02139

Use of concepts from information theory to develop generalized criteria for the design and evaluation of hydrologic instruments, networks and measuring programs. Conventional, tipping-bucket raingages are shown to be inadequate for many problems of urban hydrologic analysis. When estimating long-term average areal rainfall the error of estimate is often quite insensitive to the use of more than two point measuring stations.

SUPPORTED BY Massachusetts Institute of Technology

7.0057, RAIN SCAVENGING STUDIES - DATA ANALYSIS, SYNTHESIS AND INTERPRETATION

A.N. DINGLE, Univ. of Michigan, Graduate School, *Ann Arbor, Michigan* (AT(11-1))

The proposed work has for its objective the collection and interpretation of fundamental data on the scavenging of atmospheric particulate matter by rain systems and investigation of the rain systems themselves.

This work is basic to the understanding of the natural mechanisms by which the air is cleaned and to the intelligent use of our atmospheric reservoir.

Our procedure is to use the natural and artificial chemical content of rain water to trace the natural cleansing processes. This is done through the collection and analysis of sequential rain samples from individual storms and observations of rain to the detail of raindrop size distributions and tipping bucket rainfall rates. The data collection is located and timed for maximum benefit from the extensive facilities of the National Severe Storms Laboratory, Norman, Oklahoma.

A new and potentially valuable technique, now in the pilot phase, is the investigation of convective storm and precipitation processes through the introduction of artificial tracers.

Results to date indicate that the techniques developed over the past few years are capable of yielding new knowledge in such areas as natural air cleansing mechanisms, convective storm circulations and structure, weather modification by cloud seeding, and the efficiency of convective precipitation.

SUPPORTED BY U.S. Atomic Energy Commission

7.0058, CHARACTERISTICS OF RIVER BANKS RELATED TO VEHICLE PERFORMANCE WHEN ENTERING & EXITING STREAMS

W.L. HARRISON, Univ. of Detroit, Graduate School, *Detroit, Michigan* 48221

The current study will investigate or establish the following: a. Definition of the Problem: This will be established by collecting statistics on river characteristics such as : frequency of accuracy of streams and specific stream characteristics. This will determine if the problem to be solved is one of modifying the vehical or the stream and which part of the problem area should receive emphasis. b. Mathematical Models: Establish mathematical functions which will predict vehicle thrust developed and a vehicle moves from a totally buoyant state through the soil-water transition area to a totally soil supported state. c. Experimental Tests: Scale model tests will be used in the establishment of vehicle-river exit equations and full scale tests will be conducted to verify the final equations.

The studies are being conducted under contract with the University of Detroit using the River Simulator located at the Land Locomotion Laboratory, ATAC.

SUPPORTED BY U.S. Dept. of Defense - Army

7.0059, RESEARCH IN SEDIMENT SAMPLING EQUIPMENT

J.V. SKINNER, U.S. Dept. of Interior, Water Resources Division, *Minneapolis, Minnesota* 55414

Equipment developed under this project permits collection of suspended-sediment samples, bed-material samples, and determination of particle size of both suspended- and bed-material sediments. Current work includes the following: (a) Design of an improved bed-load discharge sampler, (b) Development of a volume-recording pumping sampler, (c) Testing of nuclear gages for measuring suspended sediment, (d) Experimentation with direct electronic sensing of suspended sediment concentration, and ultrasonic and turbidity sensing instruments.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

7.0060, COOPERATIVE GULF OF MEXICO INVENTORY AND STUDY (AUDIO-VISUAL FILM)

J.Y. CHRISTMAS, State Marine Conserv. Comm. , *Biloxi, Mississippi*

OBJECTIVES: (1) To prepare an audio-visual film of environmental characteristics, resources and problems of the Gulf of Mexico estuaries. (2) To cooperate with the Gulf States, Marine Fisheries Commission and the Bureau of Commercial Fisheries in the preparation of such a film.

PROCEDURES: An audio-visual film presenting the importance of the estuaries of the Gulf States Marine Fisheries Commission and the Bureau of Commercial Fisheries. The work will be performed under a contract, with the Bureau of Commercial Fisheries providing production supervision. All such production supervision expenses will be State financed as agreed at the April 28, 1966 meeting of the film sub committee of the Estuarine Technical Coordinating Committee, Gulf States Marine Fisheries Commission.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.
Mississippi State Government

7.0061, COOPERATIVE GULF OF MEXICO INVENTORY AND STUDY (AREA DESCRIPTION)

J.Y. CHRISTMAS, State Marine Conserv. Comm. , *Biloxi, Mississippi*

OBJECTIVES: (1) To determine the physical characteristics of Mississippi Estuaries. (2) To develop a state atlas describing these estuaries. (3) To make the state atlas available, in cooperation with the other Gulf States and the Bureau of Commercial Fisheries, for inclusion in an atlas of Gulf of Mexico estuaries.

PROCEDURES: (1) Locate and compile existing data describing physical, geological and industrial features of Mississippi estuarine areas. (2) Acquire necessary additional data using techniques and procedures recommended by the Estuarine Technical Coordinating Committee of the Gulf States Marine Fisheries Commission. (3) Collect, analyze and prepare data in a state atlas in a form which will be available for incorporation as a section in an atlas of the estuaries of the Gulf States in cooperation with members of the Gulf States Marine Fisheries Commission and the Bureau of Commercial Fisheries. (4) Prepare and publish additional notes and papers as necessary.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.
Mississippi State Government

7.0062, INSTRUMENTATION IN EMBANKMENTS AND FOUNDATIONS

C.R. FURLOW, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to collect and study instrumentation practices for earth dams and foundations by all USAE Divisions and other agencies. Selected devices are subjected to laboratory and field investigations to determine their precision and reliability in regard to their use by Corps of Engineers' offices. The results of these studies will be disseminated in a series of reports and will eventually culminate in an Engineer Manual.

SUPPORTED BY U.S. Dept. of Defense - Army

7.0063, HYDRAULIC INSTRUMENTATION

J.E. GLOVER, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to develop special laboratory and field measuring equipment or techniques to increase the accuracy and efficiency of measurements. Current efforts are concerned with turbulence meters, model hawser stress transducers, water level indicators for prototype lock tests, water-surface measuring equipment for model use, and miscellaneous model and field testing equipment.

SUPPORTED BY U.S. Dept. of Defense - Army

7.0064, DEVELOPMENT OF HYDROLOGIC EQUIPMENT

F.P. HANES, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to develop an adapt instruments an equipment for hydrologic purposes, including raido facilities, when such needs cannot be satisfactorily met through normal procurement methods. This project will also assemble information regarding characteristics and cost of equipment available for hydrologic use, and conduct certain investigations and studies to improve or adapt such equipment to best serve the requirements of the Corps of Engineers.

It is the intent of this project to provide qualified professional personnel within the Corps to act as consultants in planning, designing, and installation of telemetering networks. Progress and accomplishments are reported on an unscheduled basis, but usually once a year, by means of Project Bulletins issued by USAE Waterways Experiment Station.

SUPPORTED BY U.S. Dept. of Defense - Army

7.0065, EFFECTS OF SCALE AND OPERATING TECHNIQUE ON HARBOR MODELS

R.Y. HUDSON, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to determine the effects of model scale and the techniques of model operation on the accuracy of model results. Tests will be conducted to establish the bases of model design, operation, and analysis of test results. Studies to be made are wave filters for harbor models and wave flumes, wave attentuation due to bottom friction, and design of ripple tank and appurtenances.

SUPPORTED BY U.S. Dept. of Defense - Army

7.0066, DESIGN OF RUBBLE WAVE ABSORBERS

A.M. KAMEL, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this study is to investigate the wave reflecting and transmitting characteristics of rubble-mound breakwaters, rubble wave absorbers, sand beaches, wave traps, and resonators.

SUPPORTED BY U.S. Dept. of Defense - Army

7.0067, EVALUATION OF SOIL MECHANICS LABORATORY EQUIPMENT AND TESTING PROCEDURES

B.N. MACIVER, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to develop and evaluate laboratory equipment for use by USAE Division Laboratories and to investigate laboratory testing procedures to determine beneficial improvements.

Under this continued study, evaluations have included consolidometers, pore pressure devices, procedures for performing direct shear tests, etc. During FY 68, work included evaluation of the back-pressure consolidometer and investigations of the methods for preparing test specimens of cohesive soils and the effect of strain rate on R triaxial shear strength. The study of strain rate will be continued in FY 69 and several new studies will be initiated, including evaluation of the direct simple-shear apparatus, investigation of the effect if various apparatus features on the results of triaxial tests, and development of methods for performing undrained annular shear tests.

7. RESOURCE DATA

SUPPORTED BY U.S. Dept. of Defense - Army

7.0068, VIBRATION OF LOW-CREST SPILLWAYS

E.B. PICKETT, U.S. Army, Waterways Experiment Sta., *Vicksburg, Mississippi*

The objective of this project is to investigate low ogee spillway crest vibrations resulting from flow instabilities occurring with operating heads exceeding design heads. The study includes determination of intensity and dominant frequencies of possible fluctuations in the hydrodynamic load in the fixed spillway and consideration of the elastic and inertial properties of the vibratory system.

SUPPORTED BY U.S. Dept. of Defense - Army

7.0069, THE USE OF LIGHT-WEIGHT SPHERICAL PARTICLES FOR DISCHARGE MEASUREMENT IN OPEN CHANNELS

H. LIU, Univ. of Missouri, Water Resources Research Ctr., *Columbia, Missouri* 65202

Experimental results of the current project study have indicated that accurate flow measurement in open channels for velocities below 0.1 ft/sec is feasible through the use of light-weight spherical particles (the integrating-float method). More studies are planned in this proposal. These include an extension of the present study to uniform flows of higher velocities, a study of the technique under nonuniform-flow condition and a study of the influence of turbulence on the accuracy of the technique. All proposed tests will be conducted in a 2 ft x 1 ft laboratory flume.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Missouri

7.0070, INFORMATION PROCEDURES IN ENVIRONMENTAL CONTAMINATION

M.L. PETERSON, Comm. For Environ. Information, *Saint Louis, Missouri* 63108

This is a project for developing and evaluating methods for communicating technical information on environmental contamination to scientists and interested laymen. The problems of environmental contamination encompass such a wide range of scientific disciplines, and are in such rapid change, that it is increasingly difficult for individual scientists not professionally concerned with these problems to acquire a grasp of their general significance amd scientific background. It is correspondingly difficult for scientists, generally, to transmit such information to the interested public.

We expect to develop methods for collecting and distributing objective information about a series of specific problems in air pollution, water pollution and other environmental contamination such as pesticides, noise, etc.

The CEI Scientific Division reviews relevant scientific journals and reports, prepares continuing bibliographies, staus reports, and the articles for publication in the journal 'Scientist and Citizen' relevant to each of the indicated topics. The close collaboration between the scientists and a Readers Advisory Board ensures both objectivity and readability.

Coordinated publication, radio and news coverage, and school or other public lectures are continually being used and evaluated as effective ways for scientists to impart necessary information to the public. Study of the best means to involve larger number of scientists, reaching a wider citizen audience is in progress.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

7.0071, AIRBORNE RADIOMETRIC SNOW SURVEY

P. JORDAN, Montana State University, School of Engineering, *Bozeman, Montana* 59715

This program is to design and fabricate an operationally reliable system of measuring snow water contents from an aircraft by measuring the degree of attenuation of gamma radiation from a radioactive source of known strength pre-placed under the snowpack.

SUPPORTED BY U.S. Dept. of Interior - Bonnvl. Pwr. Adm.
U.S. Atomic Energy Commission

7.0072, DIGITAL INSTRUMENTATION AND TELEMETRY FOR WATER RESOURCES RESEARCH

D.K. WEAVER, Montana State University, School of Engineering, *Bozeman, Montana* 59715

This study is concerned with Digital Instrumentation Systems and Digital Telemetry Systems for use in remote areas. The study will review current practice, current developments and current and future requirements. A design philosophy and specifications will be established for reliable, flexible and low cost digital systems. Models will be constructed for test and demonstration. The Bridger Hydro-Meteorological Research Area will be used as a proving ground.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Montana State University

7.0073, EVALUATION OF HYDROLOGIC INSTRUMENTATION ON MAYNARD CREEK WATERSHED

T.T. WILLIAMS, Montana State University, School of Engineering, *Bozeman, Montana* 59715

This study involves the evaluation of automated equipment for the recording and transmission of hydrologic phenomena. The Electronics Research Laboratory at Montana State University has developed (as a separate project) a centrally located data acquisition facility which will receive information via radio or dataphone, and convert it into a form suitable for input to a digital computer. The research conducted herein is aimed at evaluating, testing, and calibrating a variety of new types of automated equipment for measuring, transmitting, and recording hydrologic phenomena.

The study began in July 1965. Data collection is scheduled to terminate on December 1, 1967, with completion of the project scheduled for June 1968.

SUPPORTED BY Montana State University

7.0074, GENERAL STUDIES RELATED TO CODING GROUND-WATER APPROPRIATIONS & BASIC DATA FOR INFORMATION, STORAGE & PROCESSING SYSTEMS

S.L. GROFF, Montana Coll. of Min. Science, Graduate School, *Butte, Montana* 59701

The objective of this research project is a basic study of the coding of all ground water data on IBM type cards and the development of an actual system for filing and retrieval of ground water legal data.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Montana College of Mineral Science & Tech.

7.0075, HYDROLOGICAL DATA ACQUISITION THROUGH REMOTE RECONNAISSANCE SYSTEMS

F.L. GERLACH, Univ. of Montana, Graduate School, *Missoula, Montana* 59801

This research is a continuation of work conducted during 1965-66. The purposes include (1) testing the apparent relationship between surface soil moisture and middle-range infrared radiation using ground data and airborne sensor imagery of selected areas, (2) applying multi- sensor image analysis in the preparation of soil moisture maps of selected areas, (3) observing radiation-temperature characteristics of selected terrain features for ground verification of these characteristics, and (4) testing the application of multi-sensor image analysis to the acquisition of hydrologic data. Study areas have been located containing a variety of terrain features. Ground data including surface soil moisture, surface reflectance, and surface radiation temperature will be related to aerial photographic and thermographic imagery during selected diurnal periods. Supplemental environmental data will be obtained.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Montana

7.0076, A COMPREHENSIVE ANALYSIS OF THE TULAROSA BASIN SALINE WATER RESOURCES - THEIR AVAILABILITY AND POTENTIAL ECONOMIC DEVELOPMENT

H.R. STUCKY, New Mexico State University, Water Resources Research Inst. , *Las Cruces - University Park, New Mexico* 88001

The objectives of this study are: (1) to assemble pertinent information on the saline water resources of the Tularosa Basin and make a summary report on the quantities, qualities and depth by locations. (2) develop a prospectus on the potential industry, recreation and agricultural uses of the basin's saline water, and (3) to outline further investigations which may be required to develop these resources.

The Geological Survey, Office of Saline Water, and the Office of Water Resources Research are cooperating with the New Mexico State Engineer Office, and the New Mexico Water Resources Research Institute in the conduct of the various phases of this research effort. A group of electrical generating companies are interested in these saline water resources for a large scale generating plant, possibly in combination with a desalinization plant powered by coal or atomic fuel.

One phase of this project will be an investigation of the resources by the U. S. Geological Survey, a second will be research on the hydrology of the Lucero Lake area and its relation to the resources of the area, while a third with the economic analysis of the potential users.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
New Mexico State University

7.0077, HYDRAULICS OF WELLS

M.S. HANTUSH, New Mexico Inst. Min. & Tech. , Graduate School, *Socorro, New Mexico* 87801

Theoretical development and experimental verification, using viscous- flow models, of several well-flow problems. Some of these problems are: 1) Unsteady drawdown distribution around wells of constant discharge in stratified aquifers. 2) Unsteady drawdown distribution around wells of constant discharge in aquifers separated by semipervious layers. 3) The unsteady drawdown of the water table in a semipervious layer drained by pumping wells in an underlying artesian aquifer. 4) The unsteady drawdown in an artesian semipervious layer drained by pumping wells in an underlying artesian aquifer.

SUPPORTED BY New Mexico State Government

7.0078, TO EVALUATE THE UTILITY OF EXISTING AUTOMATIC CHEMICAL ANALYSIS EQUIPMENT FOR WATER QUALITY SURVEILLANCE UNDER COMPUTER CONTROL

J.E. OBRIEN, Health Research Incorporated, *Albany, New York*

The utility of existing automatic equipment designed to collect and analyze water samples for 12 specified parameters of water quality will be evaluated. The equipment will be capable of analyzing samples on a continuous or intermittent basis, and will include atomic absorption spectrophotometry. An electronic 'memory' system for storage and retrieval of data output of the automatic chemical analysis equipment, a system for periodic data scanning and a system for computer control of the instrument will be provided and evaluated.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
New York State Government

7.0079, THE ROLE OF FOOD IN THE MORTALITY OF LARGEMOUTH BASS LARVAE

C.A. CARLSON, State University of New York, School of Agriculture, *Ithaca, New York* 14850

The objectives of this project are 1) To determine how long the caloric content of yolk supplies enough energy to meet the requirements of developing largemouth larvae, 2) To establish the exact age and size of larvae at onset of feeding, 3) To establish feeding rates of larval bass on mixtures and pure cultures of plankters at different temperatures, light conditions, and population densities, and to determine importance of specific plankters in larval bass diets, and 4) To study starvation of largemouth larvae. Two energy budget and metabolism experiments have been conducted. In one, oxygen consumption was used as a measure of catabolism, and the ratio of larval tissue to remaining yolk was used as a measure of catabolism, in the other. Condition factor was determined in groups of larvae fed at three different densities of plankton and in a group of starved larvae. An experiment to determine the effect of dissolved organic matter on the survival and development of embryos and larvae through the yolk-sac period was also conducted. A swimming speed experiment was used to obtain a quantitative measure of starvation in largemouth bass larvae. Data from these experiments are currently being analyzed. Experience has been gained in use of radioisotopes which will be used in future determinations of food preferences and feeding rates. This project was begin in 1968 and is expected to continue until 1971.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Cornell University
New York State Government

7.0080, PREDATION ON LARGEMOUTH BASS DURING THEIR FIRST YEAR OF LIFE

C.A. CARLSON, State University of New York, School of Agriculture, *Ithaca, New York* 14850

Objectives of this project are 1) to observe behavior of and predation on largemouth bass larvae under natural conditions, 2) to observe effectiveness of suspected predators in aquaria, and 3) to identify and quantify predation on larvae by use of radioactive tags. During the summer of 1967, preliminary experiments on marking of young largemouth bass with radioisotopes were conducted at Cornell's Radiation Biology Field Laboratory (New York State Veterinary College). Initial attempts to study uptake of 85Sr by newly-hatched larvae met with little success because of difficulty in handling larvae. New methods employed in a temporary radioisotope lab at the Fishery Laboratory during the 1968 spawning season were successful, and preliminary data on 85Sr uptake by newly-hatched bass larvae were obtained. Uptake of 85Sr by larger young-of-the-year bass was studied in the summer of 1967, and acceptable methods and preliminary data were generated. Experiments on uptake by green algae (food for cladocerans) have also been initiated as the first step in studies to determine food preferences and feeding rates of largemouth larvae. A scintillation counting system was recently acquired, and a permanent radioisotope laboratory to house this research is under construction at the Fishery Laboratory. Experiments to obtain information about predation on bass larvae by aquatic insects were begun during the 1968 spawning season. Larval bass of various ages have been placed in aquaria with suspected insect predators, and feeding rates at different predator and prey densities have been observed. This project was initiated during 1968 and will continue indefinitely.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Cornell University
New York State Government

7.0081, DEVELOPMENT OF MARKING METHODS FOR SMALL FISH

A.W. EIPPER, State University of New York, School of Agriculture, *Ithaca, New York* 14850

The objective of this research is to devise and evaluate methods of marking small fish. Investigation of effectiveness of fin cautery, dye-marking, and four types of tags for marking young largemouth bass was continued in F.Y. 1968. Fish were held in 1/5-acre man-made ponds after marking. Fin tips removed with a high-frequency electro cauterizing iron had completely regenerated after four months. Use of a jet injector to inject dye (National Fast Blue) into fins apparently did not affect survival or growth and produced marks recognizable a year after marking. Marks on anal and pectoral fins were retained better than marks on mandibles or dorsal or caudal fins. Four types of tags consisting of a small plastic pennant connected to a stainless steel device anchored between the interneural bones below the spinous dorsal fin were evaluated. Tags similar to the 'Sphyrion' tage of Scarratt and Elson, but containing a soft-temper stainless steel wire between anchor and pennant, showed best retention. Tagging mortality was not appreciable with any of the tags. Rigid filaments produced less external tissue irritation than semi-flexible filaments. Experiments with dye marks and tags on smaller bass and on other fishes are planned for the future. This project was begun in 1964 and will continue indefinitely.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Cornell University
New York State Government

7.0082, FOOD HABITS OF LARGEMOUTH BASS LARVAE

A.W. EIPPER, State University of New York, School of Agriculture, *Ithaca, New York* 14850

The objectives of this research are 1) to determine food habits of largemouth bass in their first ten weeks of life in man-made ponds and 2) to compare food habits with composition of pond plankton to identify any food selectivity which might exist. Following is a brief summary of Mr. Mathur's M.S. thesis which is in final stages of preparation. Stomach contents of larvae collected from three ponds at the Cornell Fishery Laboratory during the summer of 1966 were analyzed. Zooplankton abundance was determined for each pond and compared to food of larval bass. Cladocerans (including Chydorus, Daphnia, Bosmina, and Ceriodaphnia) and Cyclops and Diaptomus were the most abundant organisms in stomachs of larval bass. Copepods and immature insects were more common in stomachs of older larvae. Rotifers and copepod nauplii were the most abundant constituents of the pond zooplankton. Electivity indices indicated that Chydorus and Daphnia were consistently preferred by the bass larvae. Since these were the smallest and largest available cladocerans, there appeared to be no selectivity on the basis of size. Copepods were consistently rejected by bass larvae. Ivlev's electivity index was found to be rather unrealistic when forage organisms were present in very small quantities in the plankton or in larval stomachs, but not in both, and when changes in plankton abundance occurred during sampling periods. This project was initiated in 1966 and will be terminated in 1969.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Cornell University
New York State Government

7.0083, CONTINUATION OF WORLD DATA CENTER A - GLACIOLOGY

W.O. FIELD, Amer. Geographical Society, *New York, New York*

It is proposed to continue the operation of IGY World Data Center A: Glaciology, along its present lines of activity. The World Data Center has as its principal tasks 1) the collection, exchange among other relevant World Data Centers, and the archiving of data with a suitable cataloguing to make the collection effectively known to the scientific community, 2) serving of the scientific community by providing copies of glaciological and related data on request, and 3) serving as a source of information about glaciological research in progress around the world. In order to make known new data in the files of the Data Center, a quarterly bulletin, Glaciological Notes, will continue to be published, listing new acquisitions. Some increase in the cataloguing function is required. For example, many of the photographs taken of areas affected by the great Alaskan earthquake of 1964 have not yet been integrated into the Data Center files.

Maintenance of World Data Center A is essential to many long range as well as short range studies in glaciology. The records of events which change with time are basic to such a large number of glaciological and related studies that the need for photographic and other documentation goes without question. In particular, the global nature and possible world-wide cause-effect relations in glaciology demand records that can best be obtained and maintained by the World Data Center.

SUPPORTED BY U.S. National Science Foundation

7.0084, LAKE EFFECT SNOW SITUATIONS, EASTERN LAKE ONTARIO AREA

R.B. SYKES, State University of New York, Graduate School, *Oswego, New York* 13126

So far activity has primarily concerned gathering of information relating to snow situations particularly identified with circumstances to the lee (southeast and east) of Lake Ontario. This comparatively small scale effort began in the winter of 1962/63 with a trial meso- scale network of microbarographs for air pressure records. During the next three years network was expanded in area to include the land peripheral around eastern Lake Ontario and inland 30 to 40 miles to the east of the lake. Wind and temperature instrumentation was included; detailed surface and reconnaisance observations were added. Since winter of 1965/66 the meso-network has been largely one for atmospheric pressure with about 65 microbarographs located within the land arc around the eastern third of Lake Ontario. Data are filed and cataloged by days. Data have been used in conference presentations and for preparation of status reports except that one major publication was produced in 1966 based upon a 1965 locally heavy snow situation to the lee of the Lake. Such snows appear to be complex composites of air mass temperature and stability, moisture content, flow at 4000 feet and below, orography, temperature of the lake, water-ice relations, nuclei, and electrical charge factors to mention the more obvious.

The main surface weather observations are made near the College, but the recorded data are acquired over an area of a couple thousand square miles.

Activities started in FY 1963 under funding auspices of SUNY ASRC with termination of current data collection phase expected by the end of FY 1971; except operations will phase into FY of the International Hydrological Decade for Lake Ontario.

SUPPORTED BY State University of New York
Individual Support
U.S. Dept. of Commerce - E.S.S.A.

7.0085, WATER RESOURCES OF NORTH CAROLINA - AN INVENTORY OF INFORMATION AND DATA

F.E. MCJUNKIN, Univ. of North Carolina, School of Public Health, *Chapel Hill, North Carolina* 27514

The objective of this work is to prepare and analyze, in a single publication, a comprehensive inventory and index to all significant printed information and data of specific relevance to North Carolina's water resources.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of North Carolina

7.0086, EXPLORATORY STUDY ON THE APPLICATION OF NEUTRON ACTIVATION ANALYSIS TECHNIQUES TO WATER RESOURCES RESEARCH AND MANAGEMENT

J.R. BOHANNON, Univ. of North Carolina, School of Engineering, *Raleigh, North Carolina* 27600

Objectives: The major objectives of this research program are to determine the applicability of the use of neutron activation analysis in water monitoring and investigation of specific water and pollution problems.

Perspective: Once the applications of N.A.A. in this area of research are clear, a report to and contacts with North Carolina Industry and agencies will be made. In doing this, the areas of N.A.A. that prove feasible and practical to water resource centrol and in the implementation of present programs of analysis, will be outlined.

Procedures: 1. Complete extensive literature survey on present research of N.A.A. along lines of project to determine local and national levels of involvement. 2. Visit with State agencies, laboratories and industry to establish objectives, extent and priority of their present programs to insure future co-operation in confirmation of N.A.A. techniques. 3. Based on identity of areas of known or potential use of N.A.A. begin laboratory check and confirmation of methods and techniques by working in close liaison with Pesticide Research Lab and N.C. Water Resources Laboratory.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

7.0087, DESIGNING AND TESTING A WATER MONITORING SYSTEM FOR PESTICIDES IN NORTH CAROLINA

T.J. SHEETS, Univ. of North Carolina, School of Agriculture, *Raleigh, North Carolina* 27600

General pesticide use patterns in North Carolina will be determined and related to river drainage systems. Procedures for sampling rivers and estuaries for pesticides will be outlined and tested on one major river and estuarine system in North Carolina (Tar-Pamlico River and Pamlico Sound). Testing of sampling procedures will include location and number of sites, position of sampling in the river and sound, and frequency of sampling.

Extraction and cleanup procedures will be selected from the literature and adapted for use on this project. Electron capture gas chromatography will be employed for detection. Two chlorinated hydrocarbons p,p'-DDT and endrin) will be measured routinely, but concentrations of other pesticides will be recorded when convenient. At the completion of one year's work, judgement will be made of the need for additional research on sampling and of the adaptability of the procedures to routine monitoring by another State Agency.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
North Carolina State University

7.0088, BIBLIOGRAPHY ON FLUORIDATION OF PUBLIC WATER SUPPLIES

I.R. CAMPBELL, Univ. of Cincinnati, School of Medicine, *Cincinnati, Ohio* 45221

The primary purpose of the project is the publication at such intervals as are deemed desirable, of evaluated summaries of selected, scientifically reliable literature bearing on the safety, effectiveness and significance of fluoridation of public water supplies. The first of these publications, 'The Role of Fluoride in Public Health: The Soundness of Fluoridation of Communal Water Supplies,' was published in 1963. The publications for inclusion in these reviews are chosen, with the assistance of an Advisory Editorial Board, from a continuing comprehensive survey of the world literature. Informative abstracts are prepared of publications dealing with the following aspects of inorganic compounds of fluorine: occurrence, biochemistry, physiologic and pharmacologic observations on man and animals; all aspects; methods of analysis and pertinent chemical properties. The abstracts, together with author and subject indexes, are made available on a limited basis and at nominal cost to interested scientists and libraries.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

7.0089, INSTRUMENTATION DEVELOPMENT FOR HYDROLOGIC DATA COLLECTION

H. WIRES, U.S. Dept. of Interior, Water Resources Division, *Columbus, Ohio.*

New developments in equipment and instrumentation suitable for use in water resources investigations, surveys and research need to be evaluated. Advancements in electrical, electronic, and mechanical devices and components should be investigated. Designs for new devices to improve, supplement or replace present equipment are needed.

The purpose is to design, develop, and test new equipment and instruments for use in field, laboratory, or office studies. Specifications, drawings, and test procedures for procurement use will be prepared. Manuals for installation and service of new equipment will be assembed as necessary.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

7.0090, ACCUMULATION OF CLIMATOLOGICAL DATA

J.B. JONES, Ohio Agric. Res. & Dev. Ctr., *Wooster, Ohio* 44691

1. To determine daily maximum-minimum air temperature, precipitation and maximum-minimum temperature in the plow layer. 2. To determine weekly soil temperature and moisture at specific depths below plow layer. 3. To observe and record the date of first leaf and flower emergence, last date of flowering and last date of leaf drop of Chinese lilac plants (to conform to NC Regional Weather Project, NC-26).

Moisture blocks, thermistors, and soil thermometers were installed at Canfield, Carpenter, North Baltimore, Ripley, Wooster, and Columbus in order to gather weekly and daily soil moistures and soil temperatures. Blocks and thermometers are to be installed also at South Charleston later this year. Lilac plants are at Carpenter, North Baltimore, Ripley, Wooster, and Columbus. Data taken from these plants are to be forwarded to the Nebraska Station for evaluation.

SUPPORTED BY Ohio State Government

7.0091, SUBSURFACES BRINES CONTAINING VALUABLE AND STRATEGIC MINERALS

A.G. COLLINS, U.S. Dept. of Interior, Petroleum Research Ctr., *Bartlesville, Oklahoma*

The analytical data of subsurface brines from selected areas are subjected to automatic data processing using techniques such as principal component analysis or cluster analysis. The results are interpreted to determine the potential value of the brines which their geochemical relationships to the environment from which they were obtained.

SUPPORTED BY U.S. Dept. of Interior - Bureau of Mines

7.0092, STUDY SOCIAL VALUE OF RECREATIONAL FACILITIES RESULTING FROM IMPROVED WATER QUALITY

P. DAVIDSON, Univ. of Pennsylvania, Graduate School, *Philadelphia, Pennsylvania* 19104

Specific Aims and Expected Results: The proposed research would utilize data from the Michigan Survey Research Center, from the National Recreation Survey conducted by the Bureau of the Census, and from other sources such as the Corps of Engineers and the Tennessee Valley Authority to extend and improve the previous study in several ways.

One addition will be to explore the way people respond to an improvement in recreational opportunity. As improvement takes place, recreational experts have found that the number of users and kinds of use increase as people have to learn how to engage in the new activities and acquire the necessary equipment. The ordinary projections of recreation participation neglect this dynamic aspect and often underestimate the demand which improved water quality will bring forth. A second aspect of recreation demand which has not been studied previously and which will be investigated is the possibility that an 'option' demand may be important. People may place a value on the fact that facilities are there to use should they want them even though they rarely if ever use them. The previous study revealed that such a demand does exist and that conventional means of recreation evaluation miss it completely. The proposed study would utilize the newly available data to shed light on this problem. Several journal articles or a book length study should result from this project.

SUPPORTED BY Resources For The Future Incorporated

7.0093, FEEDING PATTERNS OF THE FRESHWATER ISOPOD LIRCEUS BRACHYURUS

E. COOPER, Penn. State University, Graduate School, *University Park, Pennsylvania* 16802

Reason for Study: Animals considered to be scavengers, such as Lirceus brachyurus, are uniquely important in the energetic relationship of ecosystems, particularly when they represent a significant portion of the biomass. This species represents a major component of polluted portions of some streams in central Pennsylvania. There is a wide variety of possible foods available and much uncertainty as to the exact nature and quantities of these that are actually consumed. It is also probable that the effeciency of the isopod in utilizing the various foods consumed may vary from one food type to another. A study of its feeding patterns will clarify the nature of this species as a scavenger, expand the knowledge of energy flow pathways and add to our understanding of the biotic response to water pollution.

Objectives: 1. To rate preference for the various food types naturally available to the isopod. 2. To determine the rate of consumption of each food type for a 24-hour period and variations of the consumption rate during a 24-hour period. 3. To determine the growth rate of L. brachyurus on each food type. 4. To correlate laboratory studies on food selection with the relative abundance of the isopod on each food type in a polluted stream.

Design of Project: To study food selection, the response of the isopods to different combinations of food types fastened to specific locations in a chamber will be observed. To determine growth rates, radioisotopically labeled food materials will be used. To determine feeding rates, isopods will be grown for several weeks on single food types and their ash free dry weight increase during this interval will be calculated.

To correlate laboratory studies on food selection with the relative abundance of the isopod on each food type in a polluted stream, samples will be taken from stream locations having a predominance of each of the food types.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Pennsylvania State University

7.0094, RELATIONSHIPS BETWEEN DRIFT DENSITY AND PRODUCTION, GROWTH, CROPPING EFFICIENCY AND CONSUMPTION IN A NATURAL BROOK TROUT POPULATION

E. COOPER, Penn. State University, Graduate School, *University Park, Pennsylvania* 16802

Reason for Study: Production within a fish population is largely dependent upon the quantity and availability of food. Basic information is needed on how changes in feeding opportunity influence cropping efficiency and ultimately production of natural populations of fish. So little is known about this aspect of production that such information may go far in increasing or understanding of natural production. The emphasis of this study will be placed on differences in prey density and how it relates to fish growth, production and cropping efficiency.

Objectives: 1. Measure differences in growth and production of brook trout in two streams having different prey densities. 2. Determine cropping efficiency at different levels of prey density. 3. Estimate total consumption of two populations of brook trout. 4. Compare field studies with feeding experiments conducted in the laboratory.

Design of Project: Sections of two small Pennsylvania brook trout streams differing in productivity will be isolated with weirs. Fish will be captured and individually marked. Prey density will be measured with stationary drift nets. Diurnal and seasonal fluctuations in drift will be recorded.

The drift will be sampled at both ends of the study area at approximately 10-day intervals for two consecutive days. During the first day fish will be in the stream. The second day the fish will be removed and held in live boxes. Percentage changes in drift will be recorded. Additional studies will be conducted to determine the amount of drift added per unit area and the total estimated consumption in the study sections. The trout will be weighed, measured and sampled live for stomach contents. Separate studies will be conducted in the laboratory to determine growth rate with a range of known catch sizes.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Pennsylvania State University

7.0095, WATER RESOURCES SITUATION IN PUERTO RICO - A BIBLIOGRAPHY OF PUBLISHED INFORMATION

A.S. VAZQUEZ, Univ. of Puerto Rico, School of Engineering, *Mayaguez, Puerto Rico*

This study will be primarily centered on collection and organization of past and current information in conjunction with the preparation of a comprehensive report of the present water resources situation in Puerto Rico.

The objectives of the study are to: (1) Collect all published information on water resources of Puerto Rico. (2) Classify and organize the said information in respect to areas of study related to Water Resources. (3) Compile a list of references accompanied by a summary of the procedure, objectives and findings of the respective references. (4) Prepare a report of the current water resources situation in Puerto Rico based on the collected and compiled information.

Data for this project will be collected from all federal, insular and private organizations on the island. The results of this study will be of immeasurable benefit upon completion to all water resources institutions in Puerto Rico.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Puerto Rico

7.0096, AUTOMATIC VHF RADIO HYDROLOGIC DATA REPORTING SYSTEM

R.A. ELDER, U.S. Tennessee Valley Auth. , *Knoxville, Tennessee*

Information on rainfall, streamflow, and related data required to operate the TVA system of 32 reservoirs must be collected and transmitted daily to the operating staff. To provide rainfall and streamlevel data from stations in remote areas of the Tennessee Valley, an automatic VHF radio hydrologic data reporting system has been operated and maintained for the past 13-14 years. However, this equipment is approaching the end of its useful life.

During the past two years, a new system has been redesigned to replace the old system. The new system which will be completely operational by December 1968 is designed to:

1. Increase system dependability through the use of solid state components, 2. Make station operation independent of commercial power, 3. Decrease data transmission time, and 4. Provide narrow band system operation, as required by the Federal Communications Commission (FCC) by 1967.

With the new system, each station will report automatically every two hours, but any station may be called on at any time for additional reports. A complete report takes from seven to ten seconds per station. The new system can be easily expanded to a larger number of stations, can be coupled directly to the digital computer for data processing, and can be modified easily to report other variables such as temperature, wind speed, etc.

Because of the use of solid-state electronics, the average power required by a gaging station is so small that the power from thermoelectric generators using LP gas will be sufficient for many months of operation.

SUPPORTED BY U.S. Tennessee Valley Auth.

7.0097, REGIONAL CORRELATIONS IN HYDROLOGIC VARIABLES

J.E. CAFFEY, Univ. of Texas, School of Engineering, *Arlington, Texas* 76010

Collection, reduction and assembly of basic hydrologic data of rainfall, runoff and evaporation sufficient to support the teaching endeavor and provide base data for hydrologic research investigations. After sufficient data has been processed more detailed research into the character of inter-station correlations in annual precipitation and in annual river flows is to be done. Attempts will be made to identify local factors affecting the general patterns in inter-station correlation coefficients. If sufficient evaporation data is available, a first look will be taken at regional patterns in interstation coefficients for evaporation. Patterns are defined by fitting three dimensional surfaces to observe inter-station correlation coefficients.

SUPPORTED BY University of Texas

7.0098, ENVIRONMENTAL GEOLOGY STUDY OF DALLAS-FT. WORTH METROPOLITAN REGION

R.L. TUCKER, Univ. of Texas, School of Engineering, *Arlington, Texas* 76010

A preliminary study of environmental and engineering geological aspects of the Dallas - Fort Worth Metropolitan Area is being conducted. The first phase includes obtaining and assembling data available from numerous agencies and firms. Needs of potential users of survey results are being determined. Special purpose maps and reports will be developed in the future. It is expected that the results of the project will be useful in delineating regions of possible foundation problems, natural resources and groundwater sources.

SUPPORTED BY University of Texas

7.0099, STREAMFLOW TEMPERATURE INVESTIGATION, TEXAS

J. RAWSON, U.S. Dept. of Interior, Water Resources Division, *Austin, Texas*

This research is part of the program of water resources investigations conducted by the U. S. Geological Survey in cooperation with the State of Texas.

Purpose: To determine whether the temperature being collected at gaging stations is representative of the stream temperature. To determine the range of fluctuations of temperatures, particularly in pools and riffles, between gaging stations in the lower reaches of the Colorado and Guadalupe Rivers.

Methods: Profiles will be measured at stream cross sections using the thermistor thermometer at 13 gaging stations. The surveys will be repeated six times during the year so that seasonal and rate of flow differences will be observed.

An investigation will be made of the thermal changes in the Colorado River from Austin to the mouth and in the Guadalupe River from near Gonzales to the mouth. A pilot study will first be made by boat on the Colorado between Austin and Bastrop. Temperature measurements will be made along this reach to determine the range of fluctuations, particularly in riffles and pools. The results of the pilot study will be used to determine the details of the remainder of this phase of the study, specifically whether it will be necessary to continue with the surveys by boat or whether surveys made at each road crossing will be sufficient.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey
Texas State Government

7.0100, TEXAS GEOLOGIC ATLAS PROJECT

V.E. BARNES, Univ. of Texas, Bureau of Economic Geology, *Austin, Texas* 78712

This project, which was undertaken with the support and cooperation of various professional geological societies and oil companies of Texas, is the compilation of a new geologic map of Texas. The map will be issued as a geologic atlas consisting of 37 individual sheets. Geologic information from published sources, unpublished theses and dissertations, oil company files, aerial photographs, and current field mapping is being compiled on Army Map Service base maps, drawn on a scale of 4 miles to the inch (1:250,000). The areas of outcrop of various rock units indicated on the map sheets will provide basic information for ground water studied.

The Tyler, Texarkana, Lubbock, Sherman, Palestine, Beaumont, Houston, Plainview, and Van Horn-El Paso sheets have been published and color separation has been finished for the Amarillo sheet. Scribing has been completed for the Texas portion of the Tucumcari sheet and is in progress for the Abilene, Beeville-Bay City, and the Texas portion of the Perryton and Dalhart sheets. Field checking has been completed on the Dallas, Waco, and Brownsville sheets and is in progress on the Austin, Seguin, Brownwood, Big Spring, and Texas portion of the Clovis, Brownfield, and Hobbs sheets.

SUPPORTED BY University of Texas

7.0101, GEOLOGY OF THE CAVE CREEK SCHOOL, MONUMENT HILL, AND YEAGER CREEK QUADRANGLES, GILLESPIE, BLANCO, AND HAYS COUNTIES, TEXAS

V.E. BARNES, Univ. of Texas, Bureau of Economic Geology, *Austin, Texas* 78712

This project, geologic field mapping in central Texas, is a continuing project which has resulted in publication of 24 7.5-minute geologic quadrangle maps including the 3 listed in the title. At least 6 others will be published as U. S. Geological Survey topographic bases become available. The maps so far published have been widely used to guide drilling in development of ground water resources.

SUPPORTED BY University of Texas

7.0102, DEVELOPING COMPUTER PROGRAMS FOR SOLUTION OF HYDROLOGIC PROBLEMS RELATED TO SMALL WATERSHEDS

L.J. GLASS, Texas A & M University System, Agricultural Experiment Sta., *College Station, Texas* 77843

Objectives: 1. Develop procedures whereby hydrologic data from experimental watersheds can be quickly analyzed by electronic computers giving correlation of the effects of various physiographic and climatic characteristics. 2. Develop computer programs for predicting hydrographs for small watersheds based on probabilities of any combination of physiographic and climatic factors existing at any given time.

Description of Work Proposed: Computer programs will be developed for analysis of hydrologic data from small watersheds. Also, computer methods will be developed to make predictions of watershed yields at future dates if possible. This is not an experimental research project, but instead a project for development of procedures for rapid systematic handling of hydrologic data to obtain the greatest and most general use of the physical data possible. The project does not require the collection of additional experimental field data.

SUPPORTED BY U.S. Dept. of Agriculture
Texas State Government

7.0103, DEVELOPMENT AND EVALUATION OF IMPROVED TECHNIQUES TO MEASURE WATER-CONTENT OF SNOW

D.G. CHADWICK, Utah State University, Utah Ctr. For Water Resour., *Logan, Utah* 84321

Snow pressure pillows used for determining water-content of snow are both large and expensive. A new type of snow pressure pillow is being designed which holds about 1 percent of the alcohol commonly used in the conventional pillows. This newly designed low-displacement type pressure pillow, if successful, could cut pillow acquisition and installation costs to 15 percent of present costs.

Several types of the low-displacement pressure pillows will be evaluated. Also, several types of electrical pressure sensors will be evaluated by aid of a telemetering system which will remotely monitor and transmit hydrologic data on command.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Utah State University

7.0104, SEDIMENTATION METER

D.G. CHADWICK, Utah State University, School of Engineering, *Logan, Utah* 84321

Development of a sediment meter that operates unattended and automatically records sediment in a stream.

SUPPORTED BY Utah State Government

7.0105, ELECTRONIC ANALOG SIMULATION OF THE SALINITY FLOW SYSTEM WITHIN THE UPPER COLORADO RIVER BASIN

J.P. RILEY, Utah State University, Utah Water Research Laboratory, *Logan, Utah* 84321

Efficient management of water resources involves a consideration of interacting quantity and quality variables, and therefore, requires an examination of the system as a whole. The overall approach being applied under this project requires the integration of the many system components, and to this end the electronic analog computer is well suited. In addition, through analog simulation of a complete flow system, this project will demonstrate a means of better understanding the various parameters involved in describing water quality.

Briefly, the major objectives of the research study are to: (1) Simulate the complex hydrologic and salinity flow systems of a river basin, and (2) Evaluate various management possibilities for a water supply of a given quantity and salinity.

Fundamental equations which describe the joint hydrologic and salinity system of a drainage area will be programmed on the analog computer. The demonstration unit selected is the Upper Colorado River Basin, and a computer model of the hydrologic and salinity system within this basin is being developed. When verified, the applicability of the model as an aid in water resources management will be demonstrated.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Utah State Government

7.0106, APPLICATIONS OF ANALOG COMPUTER SIMULATION TECHNIQUES FOR RUNOFF PREDICTIONS WITHIN THE REYNOLDS CREEK WATERSHED

J.P. RILEY, Utah State University, Utah Water Research Laboratory, *Logan, Utah* 84321

The overall objective of this cooperative study is to examine the applicability of analog computer simulation techniques for investigating basic hydrologic processes and for establishing runoff predictions. Data will be obtained from the Reynolds Creek experimental watershed near Boise, Idaho. As far as possible, models will incorporate basic, fundamental expressions for describing the various hydrologic processes. Large and small increments in both the space and time dimension will be applied, with the range site being considered as a minimum space unit.

It is anticipated that it will be possible to examine the influence upon the model of each of the hydrologic parameters included as input quantities to the system. In addition, the study will help to indicate a direction of emphasis for the continuing data collection program on the Reynolds Creek Watershed.

SUPPORTED BY U.S. Dept. of Agriculture

7.0107, FEASIBILITY OF RATING CURRENT METERS IN A VELOCITY FIELD

G.V. SKOGERBOE, Utah State University, Utah Water Research Laboratory, *Logan, Utah* 84321

The Towing Tank method of rating current meters is widely accepted. The primary disadvantage of this technique is the length of time, and consequent cost of this time, required to establish the rating for a current meter.

The advantage of rating current meters in a velocity field is the rapidity with which the ratings can be acquired. Once the velocity field is established, one current meter after another can be placed in the moving fluid.

The primary objective of this study is to investigate the feasibility of rating current meters by placing them in a submerged jet emanating from a contracting cone section. Model cones will be constructed based upon both published design criteria and theoretical analysis. The model cones will be evaluated for uniformity of the velocity field and the effects of placing a pygmy meter in the jet. The results of the model studies will form the basis for designing a prototype system, which will also be evaluated.

SUPPORTED BY Utah State University

7.0108, STATISTICAL INFERENCE AND MODELS

E.J. GILROY, U.S. Dept. of Interior, Water Resources Division, *Arlington, Virginia*

An investigation is being made to determine the effect of the geometry, cross-sectional areas and volumes, of tree growth on time trends in sequences of annual ring widths. A statistical model for the time trend is needed to facilitate computer operations for trend removal in an observed sequence of ring widths.

The application of spectral analysis to describe the fluctuations of ground-water levels as they respond to storms and such factors as barometric pressure and earth tides is being investigated. The analysis is aimed at determining the response function of an aquifer and as a tool for filtering out frequencies for certain causative factors.

A Markov binomial model is being used to determine the probability distribution and the associated moments for the number of peaks in a partial duration series. The use of a Markov model provides a simple and direct means of accounting for the lack of independence among the peaks.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

7.0109, INSTRUMENTATION FOR RESEARCH

G.F. SMOOT, U.S. Dept. of Interior, Water Resources Division, *Arlington, Virginia*

The general objective is to develop instrumentation for use in investigations in fluid mechanics.

Specific attention is being given to developing instrumentation for measuring and characterizing the scale and intensity of turbulence, utilizing the Doppler-shift principle to measure velocity, and designing a reliable system for recording variables other than stage on a Fischer- Porter digital recorder.

SUPPORTED BY U.S. Dept. of Interior - Geological Survey

7.0110, TEST AND EVALUATION OF FLASH FLOOD ALARM SYSTEM

K.W. DAVIS, U.S. Dept. of Commerce, Weather Bureau, *Sterling, Virginia* 22170

To conduct sufficient test and evaluation of the flash flood alarm system to determine its suitability for field implementation.

The Equipment Development Laboratory prototype will be subjected to a field test by a series of controlled laboratory tests.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

7.0111, COOPERATIVE STUDIES WITH FEDERAL AND STATE AGENCIES

W.J. BECK, U.S. Dept. of Hlth. Ed. & Wel. , Pac. Nw. Marine Hlth. Sc. Lab. , *Gig Harbor, Washington* 98335

Assistance will be provided to the Washington State Health Department on hydrological and microbiological surveys associated with sanitary surveys of Willapa Bay and Grays Harbor estuarine areas. Assistance will be provided to the Alaska Health Department in assaying shellfish for paralytic shellfish poisons.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

7.0112, OCEANOGRAPHIC DATA COLLECTION - MIDDLE PUGET SOUND

W.J. BECK, U.S. Dept. of Hlth. Ed. & Wel. , Pac. Nw. Marine Hlth. Sc. Lab. , *Gig Harbor, Washington* 98335

Collection of oceanographic data for temperature, salinity and bacteriology at future laboratory site in Middle Puget Sound will be continued. Continuous recordings of temperature and salinities will be continued. Pacific oysters will be used to determine the potential uptake of metals by bivalves at this location.

SUPPORTED BY U.S. Dept. of Hlth. Ed. & Wel. - P.H.S.

7.0113, WETLANDS ECOLOGY LITERATURE REVIEW

S.J. KLEINART, State Dept. of Nat. Resources, *Madison, Wisconsin* 53701

To develop a bibliography on wetlands in the categories of hydrology, biology, ecology, management and economics. This bibliography will be used in determining gaps in knowledge about wetlands values which must be filled by future research and will form the basis for a statewide wetland ecology program which will include research and planning.

The bibliography will be published in 1968. This bibliography will be kept current each year as part of the Wisconsin Wetland Ecology program.

SUPPORTED BY Wisconsin State Government

7.0114, BIOPOTENTIAL OF NATURAL WATERS

J. KOONCE, State Dept. of Nat. Resources, *Madison, Wisconsin* 53701

Objectives: A research program will be initiated to explore various modifications of techniques of measuring primary productivity to find a method suitable for acid bog lakes. While most of the methods (14C assimilation, O2 evolution and CO2 uptake) have been applied to oligotrophic and eutrophic lakes, the dystrophic lakes have neither been adequately explored, nor have reliable methods been developed to measure their primary productivity. In conjunction with this major emphasis, seasonal variation of phytoplankton biomass and major nutrient levels (phosphate, nitrate, and the cations: calcium, iron, manganese, and sodium) will be observed. This study will, therefore, develop methods for and provide useful data on the primary trophic level of acid bog dystrophic lakes.

Procedures: At intervals during the summer, water samples from selected stations in the study lakes will be taken for chemical analysis and biomass determination. If the techniques prove fruitful, year round observations may be initiated. Productivity measurements will also be made in situ using a modified 14C assimilation method and CO2 uptake rate method. Water samples will be returned to the Trout Lake Laboratory where colorimetric analysis of phosphate and nitrate will be conducted. Some samples will be fixed and returned to Madison for atomic absorption spectrophotometric determinations of calcium, iron, manganese, and sodium content. Phytoplankton biomass will be determined with the Uttermohl sedimentation technique and major species will be identified to the species level.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Wisconsin State Government

7.0115, DEVELOPMENT AND IMPROVEMENT OF INSTRUMENTATION AND SAMPLING GEAR FOR USE IN LIMNOLOGY AND FISHERY BIOLOGY

J. MAGNUSON, State Dept. of Nat. Resources, *Madison, Wisconsin* 53701

Objectives: To increase the accuracy, precision, and ease of use of new and traditional instruments and sampling gear where a need is indicated.

Background: Relatively little attention has been paid to the improvement of instrumentation and standard sampling gear which has been traditionally utilized in limnological and fisheries research for biological sampling and data recording. Such improvements are needed and recent development in electronics technology suggest that they are entirely feasible.

Procedures: Experimentation will be initiated to design and construct a towable plankton counter for in situ measurements of zooplankton distribution and abundance. Work will continue on the development of an electronic scale reader. New circuitry will be developed for the ultrasonic white bass tag which will allow monitoring the depth of swimming and swimming movements. One study will center on the effects of this internal tag on fish behavior. The larger ultrasonic tags will be modified to reduce weight while maintaining greater range for use in tracking fishes such as the salmon or trout. A rolling vertical gill net will be designed and developed for use in Pallette Lake and other oligotrophic lakes to investigate distributions of the pelagic fishes. Field aquaria will be developed for in situ measurements of oxygen tolerances of fishes in bog lakes during the winter.

SUPPORTED BY U.S. Dept. of Interior - Bu. Sport Fish.
Wisconsin State Government

8. ENGINEERING WORKS

Design; Materials; Construction and Operation.

8.0001, VERIFICATION OF HYDRAULIC DESIGN OF BRIDGES IN ALABAMA

UNKNOWN, State Highway Department, *Montgomery, Alabama*

Objective - Investigation of the water resources of Alabama, with special reference to the collection and analysis of information on floods.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Alabama State Government

8.0002, EVALUATION AND CONTROL OF SEEPAGE FROM WATER STORAGE AND CONVEYANCE STRUCTURES

L.E. MYERS, U.S. Dept. of Agriculture, *Phoenix, Arizona*

Objective: Develop and evaluate principles, methods, materials, and design criteria for measurement, evaluation, control of seepage losses from channels and reservoirs.

Plan of Work: Design math models, electrical analogs, soil columns, sand tanks and hydraulic flumes to test new principles or methods for metering seepage and hydraulic conductivity of soil. Correlate with field tests of materials for seepage control with emphasis on sprayed asphalts, emulsions, dispersants, flocculants, chemicals, films, and membranes.

SUPPORTED BY U.S. Dept. of Agriculture

8.0003, IRRIGATION SYSTEMS FOR EFFICIENT WATER USE

L.E. MYERS, U.S. Dept. of Agriculture, *Phoenix, Arizona*

Objective: To develop and evaluate principles, methods, and design criteria for irrigation systems that will facilitate efficient water use.

Plan of Work: Develop physical and mathematical models to define hydraulic characteristics of irrigation system components, including control and metering devices. Include data on evapotranspiration and soil moisture movement, obtained by other investigators, to develop comprehensive models describing functioning of complete systems. Conduct field studies to test models under actual operating conditions and make necessary corrections. Develop procedures for utilizing mathematical models and physical model data to design complete, efficient irrigation systems.

SUPPORTED BY U.S. Dept. of Agriculture

8.0004, OPEN CHANNEL TRANSITIONS

E.M. LAURSEN, Univ. of Arizona, School of Engineering, *Tucson, Arizona* 85721

Both contractions and expansions in canal sections are being studied, looking toward improvement in design methods. For the contractions various shapes ranging from the abrupt through circular ellipsoidal walls to the free stream line form will be used. Flow patterns, water surface profiles and head losses are being measured. For the expansion, standard warped sections veined expansions and other shapes are being studied. Flow patterns, water surface profiles and head losses will be measured.

These studies are being carried on as masters' theses.

SUPPORTED BY University of Arizona

8.0005, SCOUR AT RELIEF BRIDGES

E.M. LAURSEN, Univ. of Arizona, School of Engineering, *Tucson, Arizona* 85721

Laboratory investigation to find the effect of sediment size and velocity of flow on the limiting depths of clear-water scour in simple relief-bridge geometries. Long contractions and abrupt contractions will be studied. The experimental data will be compared to an approximate solution of the problem previously published by the principal investigator.

SUPPORTED BY University of Arizona

8.0006, SHEAR CHARACTERISTICS OF UNDISTURBED WEAK CLAY

H.B. SEED, Univ. of California, School of Engineering, *Berkeley, California* 94720

The objective of this project is to investigate the influence of pore water pressure on the strength characteristics of undisturbed weak clays with particular reference to the applicability of the results to the design of embankments resting on such clays.

Prior to FY 68, emphasis in this project was placed on the methods for measuring the shear strength of weak clays. The effects of sampling disturbance were evaluated as were the influences of anisotropy, plane strain versus axially symmetric strain conditions, reorientation of principal stresses, cap and base restraint of test specimens, etc. In FY 68, finite elements methods of stress analysis were developed to permit application of strength and stress-deformation characteristics of weak clays to stability analyses of embankment foundations.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0007, CHARACTERISTICS OF SOILS UNDER SUSTAINED STRESS

H.B. SEED, Univ. of California, School of Engineering, *Berkeley, California* 94720

From a review of literature, it is apparent that the creep and creep strength behavior of soils is dependent on a large number of inter-related factors. We need more information on this subject to insure that the strength of soil, at least under some conditions may not be less than that determined by current procedures. This has led to a program of research to identify and clarify the factors of controlling response of artificially prepared sand-clay mixtures and of natural disturbed clays to the action of sustained stress, with particular reference to time-dependent deformation, pore-water pressures, and the phenomenon of rupture at stress levels lower than required to cause failure in normal strength tests.

After a thorough critical review of all available literature on this subject, a detailed experimental test program will be conducted with the following variables: clay type, size distribution and texture of the granular phase, relative proportions of sand and clay, water content, density, and structure. Also, the following test variables will be included: age of specimen, preconsolidation pressure, confining pressure, deviator stress intnesity, duration of creep, and type of loading in strength test.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0008, MODEL STUDY OF DISSIPATING STRUCTURES

UNKNOWN, Univ. of California, Graduate School, *Berkeley, California* 94720

OBJECTIVE - A model study of Hook-type energy dissipators (or aerodissipators) for the performance of specific designs and for the development of general design criteria.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
California State Government

8.0009, CALIFORNIA AQUEDUCT, NORTH SAN JOAQUIN DIVISION, FISH PROTECTIVE FACILITY

A.R. GOLZE, Univ. of California, Graduate School, *Davis, California* 95616

Work consisted of hydraulic model studies to evaluate the hydraulic performance of various features of the Fish Protective Facility located on the California Aqueduct intake channel from the Sacramento-San Joaquin River Delta. Reasonably uniform flow throughout the absence of nonflow areas in the structures is necessary to assure efficient fish collection by this louvered guidance principle facility.

Model tests were conducted to determine the length of inlet and outlet training walls required to attain uniform velocities of flow in separate 21-foot channels and various combinations of channels across a 160-foot-wide, 200-foot-long reinforced concrete waterway at depths varying from 20 to 25 feet and with velocities varying from 1.5 to 3.5 fps.

Another phase of model testing was to determine the most feasible configuration to achieve uniform velocity of flow through a transition from two 4-foot-diameter pipes to a l0-foot-wide reinforced concrete channel at depths from 4 to 10 feet with velocities varying from 1.5 to 3.5 fps. The 1:7.5 scale model included 6-inch clear plastic pipes with simulated gate and butterfly valves and flexiglass walls and roof on the transition to permit visual observation of flow. An acceptable flow was achieved by alteration to the slope of the transition roof.

The final phase of model testing determined the need for and the required positioning of flow guide vanes in a fish bypass intake structure. This structure transitions flow from a 25-foot-deep, one- foot-wide intake into a 4-foot-diameter pipe. University of California at Davis Water Science and Engineering Papers Nos. 1012 and 1019 have been published giving the results of the above tests.

SUPPORTED BY California State Government

8.0010, DRAINAGE DESIGNS AS INFLUENCED BY CONDITIONS IN THE VICINITY OF THE DRAIN LINE

J.N. LUTHIN, Univ. of California, School of Engineering, *Davis, California* 95616

Exit gradients causing movement of sands and silts into drain pipes will be determined for a variety of conditions including: drain pipe diameter, size and geometry of gravel envelope, condition of backfill, relative hydraulic conductivity of the gravel envelope with respect to the surrounding soil, depth to impermeable layer, soil stratification. Theoretical analyses utilizing existing equations and with solutions prepared by the computer for cases not covered by present theory will be used to study conditions affecting the flow into the drain pipes. Experiments will be run on field scale laboratory models and on smaller models for the purpose of determining the optimum size of the gravel envelope. The effect of crack width on the flow into conventional drains will be studied. The optimum spacing of perforations in plastic drains will also be studied.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of California

8.0011, THE MECHANICS OF OPEN-CHANNEL FLOW SYSTEMS

T.S. STRELKOFF, Univ. of California, Agricultural Experiment Sta., *Davis, California* 95616

Objectives: (1) Develop standard computational methods of maximum efficiency for the prediction of hydraulic transients in canal systems with controls for cases of prismatic and non-prismatic configurations; (2) Develop a more rigorous theory and supporting experimental data for representation of the phenomena of steady and unsteady-state flow past complex control structures; (3) Provide mathematical foundation for the automatic control and optimum programming of the operations of complex open-channel distribution systems.

Description: (1) A comprehensive analytical and experimental study will be made of specific phenomena encountered in operation of complex open-channel systems that are presently poorly understood and quantitatively unpredictable; (2) Unsteady surface profiles in trapezoidal prismatic reaches will be investigated experimentally; (3) Detailed studies will be made of flow phenomena for assessment of certain equations for unsteady flow in non-prismatic channels; (4) Theoretical determinations will be made of surface profiles and discharge coefficients for free flow under gates and over weirs; (5) Detailed studies would be made of flows in the neighborhood of submerged radial gates to obtain discharge coefficients for gates under motion and stationary, with gradually varying heads and a more accurate description of flow patterns, so that mathematical linkages can be established between adjacent canal reaches for prediction of transient flow conditions.

SUPPORTED BY California State Government

8.0012, FACTORS GOVERNING EVAPOTRANSPIRATION OF WATER IN COASTAL REGIONS

P. NIXON, U.S. Dept. of Agriculture, *Lompoc, California*

Objective: Relationships between evapotranspiration and various climatic, soil, and plant influences. Develop improved methods of predicting evapotranspiration of cropped fields and native vegetation.

Plan of Work: Continue metering evapotranspiration from electronically instrumented lysimeters at Lompoc Hydroclimate Station. Complete installation of data of logger instruments to record energy budget. Obtain backlog of data representative of coastal environment. Conduct duplicate research and/or compare data with similar cooperative research under (a) hot humid; (b) cool humid; (c) hot desert arid; and, (d) cool desert arid energy regimes. Describe processes involved in transformation of energy in soil -plant-atmosphere system. Develop predictive equations which utilize easily measurable variables.

SUPPORTED BY U.S. Dept. of Agriculture

8.0013, THE EFFECT OF HIGH CONFINING PRESSURE ON THE DEFORMATION OF SOIL

K.L. LEE, Univ. of California, School of Engineering, *Los Angeles - U.C.L.A.*, *California* 90024

The present trend in the design and construction of earth dams is toward dams of progressively increasing heights with correspondingly increasing stress on elements of soil in and near the foundations. The satisfactory performance of these structures requires a clear knowledge of the engineering properties of soil at these high confining pressures. Preliminary investigations have produced data which suggests that some of the important design properties may be adversely affected to a considerable degree by high confining pressures but present knowledge does not allow definite conclusions to be made. This study is intended to supply sufficient basic fundamental data to clarify the effect of high pressures on the strength and deformation properties of soil to guide the detailed design investigations for future major earth dams.

SUPPORTED BY U.S. National Science Foundation

8.0014, PROTOTYPE ANALYSES - STRUCTURAL BEHAVIOR

W.L. BERTSCH, U.S. Army, Engineer District, *Sacramento, California* 95814

Purpose is to determine if use of a 'Linemeter' will improve accuracy of measurement of concrete dam alignment at Corps dams. The 'Linemeter' is a new surveying instrument in which a beam of light can be projected between monuments at ends of dam. This beam of light serves as a reference axis from which deviation of any point along the axis may be measured. Only piece of equipment that is moved is device which measures distance of intermediate markers from light beam. Device must be set on each marker in much the same fashion as the micrometer caliper target must be in present system. By use of 'Linemeter', entire reference line is fixed for duration of particular survey, enabling deviations to be read from line at any point.

District completed, by contract, one precise alignment survey on Pine Flat dam in FY 1967 and tentatively scheduled second survey at Table Rock Dam, Little Rock District, for FY 1969. Contracts include adaptation of instruments for use with present type of monuments at dams. 'Linemeter' surveys to coincide as practical with appropriate district's regularly scheduled precise alignment surveys. District will prepare a report on accuracy, characteristics, costs, and suitability of new method.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0015, ADHESIVE PROTECTION FOR CONCRETE

E.J. BOYD, U.S. Army, Engineer District, *Sacramento, California* 95814

Location: Pine Flat Dam, Kings River, California. Objective: Determine effect of epoxy resin applications in reducing erosion, or damage from cavitation in concrete conduits subject to high velocity flows. Applications were made in November 1957. Following types of epoxy resin foundations were used: 1. Epoxy adhesive, consisting of 100 parts of epoxy resin to 27 parts reactive catalytic agents. 2. Epoxy mastic coating, consisting of 100 parts epoxy resin, 27 parts inert filler and 25 reactive catalytic agents. 3. Epoxy mortar, consisting of 100 parts epoxy resin, 300 parts sand and 54 parts reactive catalytic agents.

Tests of epoxy applications were made in 1958, 1961, 1963, 1964, and 1967. Reservoir water surface elevations and demand for irrigation water did not produce conditions suitable for further testing in 1965, 1966, or 1968. Applications have been tested at full gate opening under heads from 334 feet to 379 feet and at partial gate openings under heads from 71 feet to 250 feet.

Partial gate opening tests will be continued at progressively higher heads until damage to conduits occurs or until a head of approximately 400 feet has been reached.

None of the areas treated with epoxy resin mastic has been damaged during periods of testing or normal operation.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0016, SHEAR STRENGTH OF ROCK FILL

G.E. BERTRAM, U.S. Army, Engineer Division, *San Francisco, California* 94111

The purpose of this study is to determine the shear strength, stress- strain, and volume change characteristics of materials such as crushed rock, quarry-run gravels, siltstones, sandstones, limestones and mixtures of such materials used to construct rockfill dams. These granular materials will be compacted by vibration to expected placement densities and at varying gradations and sheared under triaxial compression using 12‘ and 5‘ diameter specimens. Confining pressures generally range from 60 to 500 psi and maximum particle size in the 12‘ specimen is 3‘ and in the 45‘ specimen is 8‘. Specimens are also loaded in one-dimensional consolidometers having a diameter of 12‘ to determine volume change characteristics under extremely high pressures.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0017, ACCESSIBILITY OF PORES IN POROUS MEDIA

F.A. DULLIEN, Univ. of Waterloo, School of Engineering, *Waterloo - Ontario, Canada*

Systematic determination of the accessibility of pores, i.e., the fraction of pore space occupied by relatively large pores that is accessible only through narrower ones.

If Alpha, which is a function of delta, is the pore size distribution function, then the accessibility, alpha prime, which is a function of delta and delta sub e, gives the fraction of alpha, which is a function of delta, that is accessible through pores having diameters between delta sub e and delta sub e plus the differential of delta sub e.

SUPPORTED BY Amer. Chemical Society

8.0018, DRAINAGE SYSTEMS - PIPE AND FILTERS

A.J. AISENBREY, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Research work has been and is being conducted for pipe drainage systems for irrigated agricultural lands by many different agencies throughout the world.

A need exists for an assembly and evaluation of this work culminating with a presentation in a form for use by designers.

Filter materials, efficiency, and gradation limits for granular filters performing under various hydraulic gradients with various soil base materials will be investigated. Materials used for pipe, size, and location of apertures, friction factor, and structural strength, are also of special interest.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0019, SITE TESTS TO DETERMINE STRUCTURAL PROPERTIES OF ROCK FOUNDATIONS

F.A. ANDERSON, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

In order to gain useful information on the characteristics of foundation rock in the area of large dams, underground powerplants and tunnels, and the means of stabilization of this rock, the Bureau of Reclamation is working in the following areas:

Equipment has been designed and fabricated and procedures have been developed to determine the in situ shear strength of foundation rock. Tests have been conducted utilizing foundation rock from Morrow Point damsite, and further tests will be conducted at Glen Canyon Dam utilizing this equipment.

Development of a lightweight assembly for field jacking tests is underway to allow earlier testing in remote areas where large hydrostructures are planned. This basic considerations of the design are the unit weight of the components and the loading capacity.

Tests of various proprietary rock bolt anchorage types have been conducted to determine those types which are most effective in varying types of foundation rock. Further testing will be done as additional anchorage systems become available. The results should provide the basis for rational design criteria of underground structures.

Status: shear tests have been completed at Glen Canyon, light weight field jacking tests have been completed at two Forks damsite, Colorado, and radial jacking tests are to be done at Two Forks Colorado, and at Auburn damsite, California, future work will be done at project sites as needed.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0020, STRUCTURAL ANALYSIS

H.W. ANDERSON, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Since electronic computers are available for use in solving complex structural analysis problems, new and different methods of structural analysis compatible with computer usage should be considered.

The following investigations shall be continued: 1. search of scientific literature for new ideas and methods and serious study given to their applicability in solving particular design problems. 2. Some of the particular solutions being considered and used are: a. Elastic frame analysis; b. Stability analysis; c. Slab analysis d. Stress analysis by finite elements method; e. Trial load method of analysis; f. Concrete beam design; g. Concrete column design; h. Concrete volume computations

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0021, DETERMINATION OF IN SITU STRESSES BY STRAIN-RELIEF METHOD

W.G. AUSTIN, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Test methods, instrumentation, and procedures for measurement of 3-dimensional stress within structures will be developed to evaluate structural conditions. This research also provides a means of determining when and if rehabilitation is necessary on older structures such as concrete dams.

Currently used methods for in situ combined stress determinations using the 3-dimensional bore hole gage will be improved. Also, other types of instrumentation and procedures for obtaining strain-relief measurements will be investigated for later inclusion in the research program to increase accuracy and economy of in situ stress determinations.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0022, POURBAIX DIAGRAM FOR CORROSION EVALUATION

T.E. BACKSTROM, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The use of the Pourbaix diagram for evaluating the corrosivity of soils and waters will be studied, with the view of developing a standard test for corrosivity evaluations. This application could provide a suitable soil or water parameter for determination of corrosivity.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0023, CORROSION OF METALS IN CONCRETE

T.E. BACKSTROM, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The object of this program is to determine the effects of the common parameters such as chloride concentration and steel stress level on the corrosion of steel embedded in concrete. To be studied are the effects of chloride ion concentration, prestressing levels, and concrete composition on the corrosion process. Tests will be pointed toward problems of immediate interest to the Bureau.

The effect of crack width in concrete on the corrosion of embedded steel is the area of immediate concern to the Bureau.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0024, NEW DEVELOPMENTS IN CATHODIC PROTECTION AND CORROSION STUDIES

T.E. BACKSTROM, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

This is a continuing study of corrosion and corrosion control. Current projects are (1) determination of the influence of cathodic protection on protective coatings, and (2) investigation of the use of platinized titanium anodes for cathodic protection.

Standard Bureau protective coatings are being evaluated for resistance to various levels of cathodic protection. The use of platinized titanium wire for providing cathodic protection to the interior of wells and well metalwork is being studied. Further applications will be found in protection hydraulic structures in which commonly used anodes are not practicable due possibly to geometrical, size, or safety considerations.

Standard Bureau protective coatings are being evaluated for resistance to various levels of cathodic protection. The use of platinized titanium anodes for providing cathodic protection to the interior of wells and to radial gates is being studied. Further applications will be found in protection of hydraulic structures in which commonly used anodes are not practicable due to the geometry of the structure, size, or other considerations.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0025, ALLOY SELECTION FOR CAVITATION RESISTANCE

T.E. BACKSTROM, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The program is designed to determine a suitable test procedure for alloy selection for cavitation resistance; a new parameter for evaluating the order of alloys as to cavitation resistance has been developed. Testing will be performed to determine the applicability of the parameter to cavitation in hydroturbines.

Tests will be made to evaluate the cavitation intensity levels experienced in turbines and in accelerated test devices, and tentative recommendations for a suitable turbine materia made.

A field test program to determine the applicability of the laboratory test results to operating turbines will be made.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0026, DRAFT TUBE SURGES

C.G. BATES, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

A large percentage of hydraulic turbines have draft tube surges which cause noisy operation, vibration, and power surges. These problems are usually overcome by the admission of air and/or by the installation of baffles on the draft tube liner. However, occasionally a tube will not take air, or baffles do not help. Additional research on the phenomena is desired to assure sucess of original and modified designs.

Several venting schemes recommended by manufactures and one scheme recommended by this office have been tried with only partial success. Vented splitters installed in the draft tube have stopped surging but not without loss of capacity and efficiency. Further attempts will be made to find corrective and preventive designs.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0027, GLASS FIBER REINFORCED PLASTIC MORTAR PIPE FOR PRESSURE IRRIGATION DISTRIBUTION SYSTEM

B.P. BELLPORT, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The 1/2-mile-long experimental test section using 15-inch-diameter glass reinforced plastic mortar (Techite) pipe in Lateral 7-9.5S of Westlands Water District will be instrumented in part to record strains and deflections. In addition, 10-foot long sections will be removed at 6-month intervals for tests and evaluation. The studies are part of a program for determining service, charac-

teristics, suitability, and possible benefits of using this new type of pipe for Bureau work. The Westlands installation will provide severe conditions and will indicate the direction for possible future studies of much larger sized pipes.

This research program will consist of monitoring the field test instruments and recording the results, removing and examining the 10- foot sections and recording the results, making engineering evaluations based on these results, and preparing reports that discuss the tests test results, and the conclusions and recommendations reached. The program will be integrated with studies being made in Denver.

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8.0028, SEDIMENTATION AND WATER SALVAGE STUDIES-SOIL AND MOISTURE PROGRAM

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Sedimentation Studies. In a continuation of sedimentation studies, field data collected on the aggradation and degradation upstream and downstream from existing diversion dams will be analyzed; studies based on this data and observed conditions will be utilized to gain a better understanding and provide a solution to the problem, and on-site field observations and studies of stream channels will be made toward (1) predicting the maximum scour at siphon structures and (2) recommendations for the stabilization and protection of channel banks.

Transportation by Phreatophytes and Other Nonbeneficial Vegetation. This study is for the purpose of developing reliable methodology for evaluating the transpiration of the phreatophyte growth and the water savings that can be salvaged by eradication, control, or conversion by determining importance of depth to water table and density of growth on rate of use, and effectiveness of existing and potential eradication projects, and establishing criteria for selection of eradication methods, resulting costs and effectiveness. Data obtained from areas in Arizona and New Mexico and eradication projects on the Rio Grande and Pecos Rivers will be analyzed using the newly developed Jensen and Haise solar radiation consumptive use method for establishing transpiration rates and indexes.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0029, STRENGTH OF ROCK MASSES

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Strength of rock mass studies include, in part, the effect of shear and joint planes on the rock mass stability. To investigate this problem, shear tests on rock samples are required.

To accomplish the above, a three phase undertaking is proposed: (1) developing shear testing equipment at U. S. Bureau of Reclamation laboratories, (2) University of Illinois will study effect of shear stresses on lubricated and grouted shear planes and joints, (3) Colorado School of Mines will develop a theoretical and experimental approach to a bolted rock structure to see what effect joints and shear planes have on a rock mass restrained by bolts or other means.

Phase (1) design completed - equipment to be fabricated FY 69 if funds available, (2) and (3) to continue into FY 69 under contracts if funds available.

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8.0030, ULTIMATE STRENGTH DESIGN

***H.O. BROUGHTON*, U.S. Dept. of Interior, Structural & Arch. Branch, *Denver, Colorado* 80225**

Numerous changes were made in the latest revision of the ACI Building Code and serious consideration should be given to use of all these revisions on the heavy construction used in hydroelectric structures.

Preliminary investigations indicate that load factors specified in 'Building Code Requirements for Reinforced Concrete, ACI 318-63' for ultimate strength design are satisfactory for small pumping plant structures.

Further investigations will be restricted to study of the recommended load factors for ultimate strength design when applied to heavily loaded massive structures.

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8.0031, DESIGN OF UNDERGROUND POWERPLANTS

***G.L. BROWN*, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225**

The following investigations have been undertaken in the field of rock mechanics: 1. Determine the torque-tension relationship in rock bolting. Development of a lightweight hydraulic ram for true tension installation. 2. Determination of in situ stresses by bore- hole gage technique. Unidirectional bore-hole gages are adequately covered in Bureau of Mines publications-Bulletin 587 and RI-5881. Presently working on development of a three-dimensional bore-hole gage and will ultimately extend this to development of a three-dimensional bore-hole gage. 3. Development of 'finite element' solutions for stress problems and programmed for electronic digital computer. The two dimensional analysis of the stress concentration around an underground opening including effects of jointing, altered zones due to blasting, faults, variation of rock type and rock properties, and other physical features of the rock mass is reported in the paper 'Morrow Point Underground Powerplant' by W. H. Wolf et al, Proceedings ASCE Power Division Specialty Conference, Denver, Colorado, August 13- 20, 1965, pp. 493-534 and is to be further reported by the papers 'The Influence of Discontinuities on the Stability of an Underground Opening' by I. G. Taylor and 'The Finite Element Solution Applied to Rock Mechanics' by H. W. Anderson and J. S. Dodd, in the forthcoming First International Congress of the International Society of Rock Mechanics to be held in Lisbon September 25 through October 1, 1966.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0032, STRUCTURAL RESPONSE, DYNAMIC LOADS

***G.L. BROWN*, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225**

The paramount dynamic load considered for hydroelectric plants is an earthquake loading. With the availability of electronic computers, characteristics of vibration can be computed for structures and typical dynamic load patterns applied. The following investigations should be made.

1. Continue review of current literature on the following subjects:

a. Methods of analysis for computer application. b. Effects of geology and foundation on earthquake response spectral. c. Damping factors for heavy concrete rigid structures such as powerplants.

2. Determine the number of modes of vibration which should be considered to insure adequate design for the structure. Study is complete. Results are summarized in final designs for visitor facilities at San Luis Pumping-Generating Plant.

3. Investigate the effects of the extreme stiffness inherent in the main body of hydroelectric powerplants. Study complete, see San Luis final designs.

4. Have adopted methods of analysis using response spectra adjusted for a particular site and actual dynamic properties of the structure.

Write a computer program for analysis of structural dynamic properties and application of response spectrum curves to analysis of structures for earthquake damage resistance.

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8.0033, STRUCTURAL PROBLEMS ASSOCIATED WITH CONCRETE PIPE

***L.H. BURTON*, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225**

As outlined in Report No. CB-3, 'Study of Earth Pressures on Rigid Pipe,' field tests of buried rigid pipe are proposed. Results of these tests will be studied and revisions in design criteria, if indicated, developed and reported. Studies have been underway to find a better approach to watertightness in concrete pipes. An ap-

proach involving width-of-crack criteria is being pursued. A large number of hydrostatic tests, on various head classes of concrete pipe, are necessary to improve the validity of data used in this study. As results of these tests become available they will be evaluated and design criteria developed and reported.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0034, FACTORS AFFECTING STABILITY OF ARTIFICIAL AND NATURAL CHANNELS

***E.J. CARLSON*, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225**

These studies are concerned with field and laboratory investigations of stable channel shapes as well as boundary shear (critical tractive forces) for cohesive soils.

Field tests at lower than design discharge have been made on experimental reaches of trapezoidal channels with 1-1/2:1 side slopes constructed on less than critical, critical, and greater than critical hydraulic slopes for stability. These test reaches are all in cohesive soils. The boundary shear is measured with a Preston tube. Tests will be concluded with a set of field measurements in the experimental reaches at design discharges and will include velocity distribution, boundary shear, water surface slope, and vane shear tests on the soil.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0035, INVESTIGATION OF EROSION AND TRACTIVE FORCES ON CANALS--OPEN AND CLOSED CONDUIT RESEARCH PROGRAM

***E.J. CARLSON*, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225**

The purpose of the investigation is to correlate performance of soils in unlined and earth-lined canals with soil characteristics and hydraulic conditions. Based on criteria developed in the study of about 50 Bureau canals, three field test sections on a new unlined canal in a loessial soil area have been established to check the criteria. One section was designed with a slope sufficient to cause erosion, the second with a slope to cause the soil to be on the point of eroding, and the third section with a slope such that the canal would not be expected to erode. Laboratory tests to determine soil characteristics have been conducted on representative soil samples from the field test sections. During the 1965 irrigation season it is expected that hydraulic measurements will be made on the field test sections. A correlation of the soil and hydraulic properties and the performance of the test sections with respect to erosion will be made so that an adjustment of the present criteria for erosion can be made, if required.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0036, FIELD TESTS OF POWER TRANSMISSION EQUIPMENT

***G.W. CLEAVELAND*, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225**

By means of the main mobile power systems laboratory and its smaller mobile auxiliary, tests are made of basic power system parameters, the characteristics and adequacy of prototype power system apparatus, the requirements of future designs, and the characteristics of limitations of existing apparatus. The work that is currently proposed for investigation includes tests of coordination of transmission line protective relaying on the Colorado River Storage Project. Other work for investigation includes tests of EHV system switching surges, line reclosing capability, adequacy of excitation control including time constants of control components and capability of circuit interruption.

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8.0037, GATES, VALVES, AND ORIFICES

***D. COLGATE*, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225**

The objective of this project is to study the hydraulic features of control devices with the view of improving their design and operating characteristics. The seating, sealing, and extrusion properties of rubber gate seals under prototype heads to 600 feet are being investigated. Comparative operational data on several different seal designs have been obtained and tests are continuing. The basic parameters for air requirement relationships in gate structures using prototype and model measurements are being studied. An analytical study of the air requirements of an emergency penstock gate was completed. The discharge coefficients for orifice plates located in unusual settings and for circular openings in pipe walls are being measured and evaluated.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0038, FLOW SURFACE PROTECTION

***D. COLGATE*, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225**

The objective of this study is to determine the cavitation potential of surface roughnesses or misalinements subjected to high velocity flow. Misalinements or roughnesses can take several forms, including offsets, waviness, depressions, protrusions, bug holes, and surfaces that slope or curve too rapidly away from the flow.

Laboratory tests have been completed for the design of an aeration slot to admit air into the stream in a tunnel spillway to prevent cavitation erosion. Selected hydraulic structures in which cavitation damage has occurred will be observed as opportunities arise.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0039, TRANSIENT FLOW IN OPEN CHANNELS

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When the flow in an open channel is suddenly changed, surges are set up in the channel. These surges may be caused by starting and stopping pumps, operation of turnouts and checks, or operation of siphons. Currently available methods of analysis of such open channel transients need refinement and further development in order to provide the design engineer with better analytical tools. Methods of analysis should be able to account for shape of channel cross-section, bottom slope, surface slope, changes in cross-section, branch connections, dead ends, and side channel spillways.

Presently available methods of computing open channel transients will be reviewed and evaluated. The method of characteristics adapted for digital computer will be pursued.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0040, PROTECTION OF ERODIBLE CHANNELS AND SURFACES WITH GRAVEL OR RIPRAP

***M.E. DAY*, U.S. Dept. of Interior, Canals Branch, *Denver, Colorado* 80225**

The protection of erodible channels by gravel or riprap is essential to reduce scour and for the protection of structures. The study of channel protection is necessary to insure the use of sufficient material at minimum cost, since protective materials are expensive and often difficult to obtain. The collection of data on the field performance of gravel and riprap will continue. Information desired for various types and sizes of structures on canals and cross-drainage channels and at diversion dams, and for various flow conditions, includes location, extent, size, number of layers, bedding and foundation material. Field and laboratory data will be compared and existing design procedures and instructions will be examined to improve design criteria and to establish standards where appropriate. Related areas of study include underseepage control, reverse filter design, integration with various types of lining, hydraulic action of flowing water, ground water and waves, energy and the protection of earth fills.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0041, EXPLOSIVE EXCAVATION IN THE DEVELOPMENT OF WATER RESOURCES

***M.E. DAY*, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225**

The Plowshare Program of the U.S. Atomic Energy Commission is established to develop the technology required for the peaceful applications of nuclear energy. Excavation by nuclear explosions is one phase of the Plowshare Program. Among the primary purposes are the development of design data and the improvement of related investigative techniques. The Bureau is interested in this program as it relates to the current rapid excavation research devoted to finding ways to speed up excavation work and reduce the cost. Test and research includes the use of chemical explosives. Possible uses of excavation by explosion include: Canal excavation, reservoir excavation, construction of earth and rockfill dams including cofferdams, development of underground water supply and storage, and conversion of tunnel schemes to open cut excavation. Design research by the Bureau will include the following activities: (a) Study the literature to keep abreast of developments; (b) establish and maintain contact with other agencies to determine new developments in related fields and possible applications to Bureau work; (c) observe tests by other agencies.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0042, PIPELINE AND TUNNEL HYDRAULICS

R.B. DEXTER, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The studies are concerned with surges in pipelines and friction losses in various types of pipes and tunnels. Frequently, long pipelines are separated into sections by pipe checks or pipe stands which eliminate the need for high pressure piping. This type of system has the disadvantage that, unless properly proportioned, excessive surging will occur. With the aid of a hydraulic model of a pipeline that included seven pipe checks in series and a flow control valve that provided uniform increments of discharge change with respect to time, an ADP program has been developed to compute surges for various pipeline operations. A hydraulic performance test of a 115 mile-long portion of the Canadian River Aqueduct, Texas, has been performed to define pressure surges in the system in relation to discharge changes. Data were also obtained to define hydraulic frictional resistances in long reaches of precast concrete pipe with diameters of 72 inches, 66 inches, and 54 inches. Analytical and experimental studies were made to investigate the type and magnitude of surges which can develop with steady inflow into a pipe system containing a series of check structures.

The performance of previously constructed conduits is a reliable guide for predicting the performance of new designs. Therefore, a field testing program is being continued to evaluate hydraulic resistance coefficients of large water conduits. Installation of test facilities is in progress in large diameter concrete-lined pressure and free flow tunnels to permit measurements of hydraulic friction heads.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0043, FACTORS INFLUENCING THE DURABILITY OF CONCRETE

J.T. DIKEON, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Work has been conducted on (1) correlation of freeze-thaw data obtained from field and laboratory concrete specimens; (2) correlation of tests for sulfate resistance and uncombined calcium hydroxide with performance of cement-asbestos pipe. The study of silicons, epoxies, and other agents as surface treatments for improving the durability of concrete is active. Investigation of maximum permissible sulfate content of curing water for concrete is underway. Results of tests with concentrations of sulfate in mixing water for concrete are in Report C-1258. Data are collected from longtime, outdoor storage specimens to determine the effect of pozzolan on the durability of concrete. An extension of initial tests, which have been reported are scheduled to investigate the effect of freezing fresh concrete on its strength and durability. Nearing completion is an investigation into effects of various factors on air void systems of mortars and concretes.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0044, FACTORS INFLUENCING THE RESISTANCE OF CONCRETE TO SULFATE ATTACK

J.T. DIKEOU, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The use of Type V cement or other special cements low in tricalcium aluminate will usually provide adequate protection against sulfate deterioration. However, other factors such as cement content, water- cement ratio, and admixtures in the form of accelerators, retarders, air-entraining agents and pozzolans have a pronounced influence on the rate and degree of sulfate attack. These factors are investigated through use of concrete specimens subjected to an accelerated wetting and drying cycle sulfate test, and a continuous soaking test. Both tests utilize a 2.1-percent solution of sodium sulfate. Other concentrations and types of sulfate solution are used in special investigations and research projects. Rate of deterioration is determined by periodic length change measurements. Work in this area includes (1) evaluation of special cements and admixtures submitted for testing, (2) correlation of results between the accelerated and soaking tests (3) analysis of test data obtained from longtime tests of concrete specimens stored in alkali ponds at the Columbia Basin Project, Washington; and (4) investigating the effect of fly ash pozzolan on sulfate resistance of concrete containing Types I and V cements (5) Effect of Absorption of concrete Drain Tile.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0045, THE DEVELOPMENT OF CONCRETE-POLYMER MATERIALS

J.T. DIKEOU, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

A research and development program is being sponsored by the Bureau of Reclamation, the Atomic Energy Commission, and the Office of Saline Water to study the formation of concrete-polymer materials. Brookhaven National Laboratory and the Bureau of Reclamation are cooperating in the investigative phase of this program. Experiments have been conducted to determine the feasibility of the impregnation and in-situ polymerization of monomers in preformed concrete and the inclusion of monomers as part of the formulation of a fresh concrete mix followed by polymerization. Two modes of initiating polymerization- -gamma radiation and thermal-catalytic--are being studied. Results to date show remarkable improvements in properties of concrete, including increased strength, durability, abrasion resistance, cavitation resistance, resistance to chemical attack and to hot distilled water, and reduced permeability, absorption and creep.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0046, EFFECT OF RETARDING ADMIXTURES ON PROPERTIES OF CONCRETE

J.T. DIKEOU, U.S. Dept. of Interior, Div. of Research, *Denver, Colorado* 80225

Freeze-thaw tests are being performed on concretes containing four different commercial water-reducing, set-controlling admixtures. These admixtures were combined with four distinctively different aggregates to determine the effect of the admixtures on the durability of concrete. The effect of several different commercial admixtures on rate of air loss and slump loss has been studied. A report correlating these variables will be forthcoming.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0047, DEVELOPMENT OF NX BOREHOLE INSTRUMENT FOR DEFORMATION MODULUS

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Exploratory drill holes (NX-3-inch hole) are used to secure cores, geophysical data, and geological data at proposed project sites. In situ small scale deformation testing would provide early statistical data on deformation modulus needed for preliminary design. Instrumentation to be developed would be inserted in the exploratory drill holes at various depths and deformation tests performed even below the water table. Various instruments are available for use in soils and low modulus material. Instruments are needed which can be used in medium and high modulus material. Initial work will consist of evaluating previously developed commercial equipment. Final phase will adapt or modify instrument to fulfull Bureau needs.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0048, INVESTIGATION IN THE DEVELOPMENT AND IMPROVEMENT OF SPECIAL CEMENTS

R.J. ELFERT, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Concretes having improved strength, durability, elasticity, and volume change characteristics are needed. Likely means of achieving these objectives are changing the characteristics of the cement during manufacture or altering the hydration products by additives or curing environment.

A study will be made of the effect of various additives and curing environments on the hydration products of portland cement. Physical, chemical, differential thermal analysis, and X-ray methods will be used to examine the nature and effect of the resulting binders.

This project will also include a limited investigation of the potential use of expansive cements in Bureau of Reclamation concrete.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0049, PERFORMANCE OF WATER-REDUCING SET-CONTROLLING ADMIXTURES IN CONCRETE, MORTAR AND CEMENT PASTE

R.J. ELFERT, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Some water-reducing set-controlling admixtures behave erratically with certain cements. Construction difficulties from slump loss occurs due to incompatibility of cement and admixtures.

Performance of cement from selected sources will be analyzed to isolate characteristics which might cause abnormal behavior and admixtures. Also cement clinker of different compositions will be ground with calcium sulfate to study the interrelationship of cement composition, form, and amount of calcium sulfate and the admixture with respect to the setting characteristics of the cement.

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8.0050, HARD SURFACE LININGS--LOWER COST CANAL LINING PROGRAM

L.M. ELLSPERMAN, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Hard surface linings being investigated are asphaltic concrete and portland cement concrete. For asphaltic concrete an attempt is being made to find an economical material for the maintenance of older asphaltic concrete linings in existence. Material is needed for filling cracks which develop in this type of lining to protect the lining from further deterioration. Several field test sections of asphaltic concrete linings requiring maintenance have been selected. Various products proposed by manufacturers for treating the lining surface and filling the cracks are being used in the test sections and the performance of the materials evaluated.

Seepage through portland cement concrete lining is considered to be almost entirely through cracks and joints in the lining, and an investigation of various materials for sealing the cracks and joints is underway. Field test sections have been established in which joint and crack sealing materials are being field tested to determine performance. An evaluation of these materials will assist in formulating specifications for more effective joint and crack sealers, better maintenance of existing linings, and in construction of new linings.

A laboraotry investigation is being started to determine the feasibility of reducing seepage through joints in concrete canal lining by the application of a gel with a controlled time of set through the joint. The purpose of this would be to fill the voids in soil beneath the joint and thereby reduce seepage.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0051, MEMBRANE LININGS-OPEN AND CLOSED CONDUIT RESEARCH PROGRAM

L.M. ELLSPERMAN, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Plastic film lining of polyethylene and polyvinyl chloride as buried membranes and butyl rubber as both a buried and an exposed membrane are being used in field experiments. Periodic field observations and a few field seepage tests are being conducted to determine performance and effectiveness in reducing canal seepage. Laboratory tests are conducted to evaluate these linings as improvements are made by manufacturers. Also, specifications for these linings are being developed.

To better evaluate hot-applied buried catalytically-blown asphalt membrane linings, a laboratory procedure was developed to determine the percentage of phosphorous in the asphalt lining material. Phosphorous pentoxide is a catalyst used in producing the best type of cationic asphalt for membrane linings and it is possible that the performance of the lining could be correlated with the amount of residual phosphorous in the asphalt.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0052, CIRCUIT BREAKER RESEARCH

B. EVANS, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Direct current (DC) transmission at high voltage (HV) and extra high voltage (EHV) promises substantial economic benefits over alternating current (AC) transmission for long distances and large blocks of power. DC transmission by cable circuits is also attractive, even for relatively short distances and moderate amounts of power.

Networks with interconnections of HVDC and EHV DC will be necessary to utilize the full potential and economy of DC transmission. This will require the development of a DC circuit breaker since none is available for switching HV and EHV power circuits. A DC circuit breaker may also find important application to future AC systems. The benefits of DC transmission and the need for DC circuit breakers are indicated in the February 1968 Transmission Study 190 Report.

The Electric Research Council (ERC) established a task force about a year ago, with the Bureau and BPA representation, to evaluate a proposal by Hughes Aircraft Company for development of a HV DC circuit breaker. The ERC task force has recommended that the proposed Hughes program be supported. In FY 1969 a program will be detailed and an agreement executed between ERC and Hughes. The Bureau will participate in the ERC effort as one of several contributors and will by itself or jointly with BPA, contract with Hughes to provide funds.

The Hughes development program for FY 1969 will include the further study and experimental verification of the sequential switching concept they have proposed. Circuit configuration, linear and nonlinear switching resistors, the crossed field tube and other types of interrupters will be evaluated.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0053, CHANNELIZATION STUDIES

R. FIFE, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Work is being done on the Middle Rio Grande Project, New Mexico, from Cochiti Diversion Dam to Elephant Butte Reservoir. The three original features of the program are: (1) the evaluation of river channel improvement by jacks /structural shape/; (2) the evaluation of channeling water through low-flow conveyance channels; and (3) the determination of the efficiency of settling basins for sediment control.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0054, HIGH-VOLTAGE D-C TRANSMISSION INVESTIGATIONS

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The unprecendented use in this country of high-voltage d-c power transmission for economy in large capacities, flexibility of control, and ability to operate between power systems not in synchronism requires investigation. There has been no three-terminal application made. A laboratory scale model suitable for control study and for combination with an A-C Network Analyzer has been designed and the prototype model pole has been assembled and evaluated. The prototype model may be expanded to a three-phase, four-pole (two each per terminal) representation employing silicon controlled rectifiers to represent the performance of the mercury rectifiers to actual installations. The d-c line model may be used as an educational and training tool, to assist in the development of parallel dc-ac power system digital computer programs, to investigate combination ac-dc system interconnections, to investigate variable frequency operation of motors and generators for improved efficiency and stability and ac-dc-ac system stabilizing schemes. A Bureau design engineer has been assigned to work with the project staff of the AC/DC System Operation Research Program (EEI Project RP56) for a period of 1 year. The major efforts in the program have been the design and construction of an intermediate power-level system model now in operation in a research laboratory in Philadelphia and the development of a digital program for study of parallel dc-ac systems using the model to verify program results.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0055, CAPACITOR SWITCHING DUTY EVALUATION

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Conventional power circuit breakers on capacitor switching service frequently experience difficulty in clearing due to high magnitude and rate of rise of recovery voltages. This condition frequently results in multiple reignitions and restrikes on clearing. Severe overvoltages during reignitions or restrikes may be damaging to connected equipment. Field tests of simulated capacitor switching have been conducted to determine the characteristics and magnitudes of capacitor switching transients in control circuit cables and to evaluate methods of limiting coupled voltage which could damage control equipment. Results are given in Research Report EP-19. Control circuit transients have been recorded for field tests of actual system capacitor bank switching and a report is in progress. Increased use of solid-state devices with less overvoltage capability than former vacuum tubes and relay devices require tighter limitation of induced voltage in control circuits.

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8.0056, HIGH-VOLTAGE A-C TRANSMISSION

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Extra-high-voltage a-c power transmission continues in contemporary development and application with EHV d-c transmission. EHV d-c transmission at present is essentially an express power link between geographically widely separated terminals. Serving as backup and providing enroute load and supply taps are EHV a-c transmission systems. Long a-c transmission lines require high percentage series capacitive compensation to provide for economic loading and stable operation. Analytical techniques are needed to predict EHV a-c line performance under abnormal loads and fault conditions. It is proposed to develop analog computer, digital computer and model procedures and programs to study EHV a-c transmission dynamic and transient performance, and related transformer, switch apparatus and protective system requirements. Infrared detection studies are being conducted in cooperation with the Air Force. Additional investigations include the measurement and evaluation of corona loss on EHV lines and measurement of earth current flow through transformers and transmission system as a result of high sunspot activity, and measurement of high-voltage switching surges. Corona loss and high-percentage compensated line studies are being conducted by a summertime research arrangement with the University of Colorado using graduate students in electrical engineering.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0057, SEISMICITY OF FAULTS - ENGINEERING GEOLOGIC EVALUATION

W.I. GARDNER, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Develop and evaluate a rapid method for determining the seismicity of faults occurring at the site of a proposed engineering structure such as a dam, reservoir, or tunnel. The engineering geological method would be a seismic detection system which would record the occurrence of micro-seismic events along a fault-little earthquakes too small to be felt or even recorded on ordinary seismographs.

The number of micro-events recorded over a short period of days or weeks would provide a factual basis, when compared against a rating curve for evaluating the degree of activity or probability of earthquakes. It would be particularly applicable to faults in damsite which could not, by other means, be confidently defined as 'live' or 'dead.'

The micro-seismic rating approach fills the gap between historical data on recorded epicenters and geologic data such as displaced river terraces or fault scarps. Major items of equipment exist and the principle stops for developing an operating procedure are evident.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0058, HYDROGEOLOGIC INVESTIGATION TECHNIQUES

W.I. GARDNER, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The rapid increase in water demand is overtaxing surface and ground-water supplies of many areas. The supplies are approaching exhaustion, becoming inadequate due to high storage and conveyance losses, or diminishing in quality and quantity due to pollution, climatic changes, and other factors. Engineering planning must consider increased use of leaky conveyance structures and reservoirs and more competent waterloss estimating is required.

Intensive research is essential to develop reliable hydrogeologic investigation methods--field methods and data analysis procedures--for estimating reservoir water-holding capabilities, effects of proposed projects on ground-water basins, and the possibilities of controlling losses or recovering the water for later use. Present methods of geologic and ground-water investigation yield erratic results.

All existing procedures of determining the subsurface geologic and ground-water regimen of an area, and locating and estimating water loss in proposed reservoirs will be reviewed and collated. Specific attention will be given to distinguishing between importand and unimportant parameters with respect to time-cost of securing the data and influence on reliability of final product, i.e., seepage estimates.

Investigation and analytical methods applicable to different typical geologic environments--volcanic layered sedimentary, fractured rock masses, glacial--will be outlined.

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8.0059, INSULATING MINERAL OILS AND SYNTHETIC LIQUIDS AND LUBRICATING OILS

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Research is needed to make possible the improving of existing test procedures and specifications for quality control of insulating oils, askarels, and other synthetic liquids used in Bureau electrical power equipment. It is essential that a standard reliable test method be developed to predict oxidation stability or resistance to sludge formation. Also, it is important that laboratory testing be conducted to acquire data for developing new or improved specifications to cover new synthetic insulating liquids, reconditioned or reclaimed insulating oils, and lubricating and governor oils.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0060, APPLICATIONS OF RESEARCH TO VARIATIONS IN SHEAR AND CONSOLIDATION TESTING

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The relationship of volume and the pore air pressure in partially saturated soils has been established to behave according to the physical laws of pressure, temperature, and solubility for gases. The most recent work has developed test procedures to measure the equivalent capillary effects of the pore water and the relation to volume change. These measurements are important because they significantly affect the test values of soil strength used for structures. The improved pore fluid measurements have given impetus to determining the relationship of effective stress to volume change in soils.

The purpose of this investigation is to fully apply the results of recent research by the Bureau and by others to shear and consolidation testing on a broad range of soil types.

This study requires the use of a range of tests, such as the isotropic consolidation, one-dimensional consolidation, triaxial shear, and a modified triaxial test which limits the lateral strain to zero. Data will be obtained to sustain current theory on the effective stress- volume change relationship. This will be done through application of the pore fluid measurement techniques to soils with a variety of plasticity characteristics. The studies would include regular triaxial tests as well as special tests. Final shear and consolidation tests procedures involving the latest developments in pore pressure measurements are to be completed. Additional work should be done to increase the uniformity of density, and moisture content conditions in soil specimens for better reproducibility of results.

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8.0061, EFFECTS OF EARTHQUAKES ON SOIL PERFORMANCE

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The soil foundation is an important consideration in the design of structures resistant to earthquake damage. The investigation of damage after major earthquakes has shown that some soils, particularly fine- grained, saturated sands and sensitive clays, may become unstable during shocks from earthquakes. Laboratory and field test procedures need to be improved to better indicate soil conditions that are susceptible to instability and to produce results that can be used for the design of the most economical structures.

Current literature on this subject has been reviewed.

Laboratory test equipment has been modified to conduct triaxial shear tests on soil specimens during the application of pulsating loads alternately in tension and compression. Tests with this equipment have been conducted on a few soils of particular interest in current Bureau projects.

Through a contract with the University of New Mexico, a graduate student is using Bureau laboratory test facilities to measure pore pressures on a variety of soils subjected to dynamic loads. If required to improve quality of measurements, he will attempt to modify existing laboratory equipment.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0062, EVALUATION OF CONCRETE AND RELATED MATERIALS FOR USE IN DESALINATION PLANTS

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This investigation, being performed for the Office of Saline Water, is divided into five parts, each under a principal investigator as numbered above, as follows: 1. Evaluation of concrete both natural and limestone coarse aggregate under a variety of temperature-pressure- brine concentration conditions. 2. Wall section model studies. 3. Selection and evaluation of accessory coatings, sealants, and polymeric products (Note: Some of the tests on these materials will be conducted concurrently and under the same exposures as the concrete in Item 1). 4. Concrete reinforcement materials (corrosion studies). 5. Concrete microstructural investigations.

Concrete and related materials are being exposed to hot synthetic seawater and hot distilled water ranging from 100 degrees F to 290 degrees F. Strength, elastic properties, microstructural changes, and corrosion potential of reinforcement steel are being determined.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

8.0063, EVALUATION OF CONCRETE PROPERTIES OF CORES FROM OLD STRUCTURES

J.R. GRAHAM, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Various properties of concrete such as compressive strength, modulus of elasticity, Poisson's ratio, specific gravity, etc., are determined from tests conducted on cores taken from new and old Bureau dams. Cores are usually extracted at predesignated intervals from the time the structure is new until it is perhaps 20-25 years old, or even 40-45 years old if need be. Occasionally, situations arise that require the extraction of cores from old structures having no previous core drilling program. Sampling and testing at intervals provide data early in the life of the concrete which can be used to help ascertain possible future economies. It also provides a method of monitoring chemical, physical, and microstructural changes in the concrete.

Long-time concrete evaluation investigations have, in the past, been programmed for Shasta and Friant Dams, now over 25 years of age, and Hungry Horse Dam, now over 13 years of age. Similar programs are now actively underway for Glen Canyon, Flaming Gorge, Yellowtail, and Morrow Point Dams. Cores have been tested and evaluated to establish the structural integrity and conformance with present design standards of: Wild Horse Dam, 30 years old; Horse Masa Dam, 40 years old; Warm Springs Dam, 48 years old; and American Falls Dam, 40 years old. From time to time, laboratory reports covering the aforementioned evaluations are published.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0064, DEVELOPMENT OF STANDARD DESIGNS FOR CANAL STRUCTURES

J.O. GRIMSLEY, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

An effort will be made to standardize the frequently used types of canal structures by determining the best designs for minimum head losses and maximum construction economy. The investigational procedure may include: 1. Request through appropriate channels for model studies where further data are necessary to establish a basis for design of standard structures. 2. Data collection from field offices as to size, type, or design limitations related to efficient and economical precasting or in-place construction. 3. Coordination of design for maximum usage of 'standards' consistent with required structure operation and good construction practice.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0065, RADIOISOTOPE WATER FLOW MEASUREMENT IN HIGH-HEAD TURBINES AND PUMPS

R.L. HANSEN, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Radioisotope methods and instrumentation systems developed by the Denver Office for open channel water flow measurements are adaptable in part to the problem of accurately determining the rate of water flow through high-head turbines and pumps--a measurement which cannot be accurately made by conventional methods. Research on measurement techniques is jointly financed in a cooperative program with the Bureau and the Atomic Energy Commission.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0066, RADIOISOTOPE GROUND WATER MEASUREMENTS IN SMALL DIAMETER DRILL HOLES

R.L. HANSEN, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Radioisotope technology is continually advancing in the field of ground water measurement in drill holes. In order to keep the costs of ground water investigations to a minimum, it is desirable to use the smallest size drill hole diameter possible. This leads to the need for improved instrumentation and techniques to work in the small size drill holes.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0067, MODEL STUDY OF UNDERGROUND OPENINGS

M.L. HAVERLAND, U.S. Dept. of Interior, Office of The Chief Engr. , *Denver, Colorado*

In the construction of Reclamation Dams and water tunnels, there are discrepancies concerning visco-elastic properties of rock. Little definite information is available by which effects of joints, faults, bedding planes, and other foundation irregularities can be accurately included in the design of underground openings. Fundamental data on the basic properties of rock are being analyzed to evaluate various methods of determining the structural behavior of a geologic formation surrounding a tunnel or at a foundation site for a dam. A structural model program will supplement field investigations to increase our knowledge in this field. The program will be progressive, starting with the construction and testing of a solid foundation and continuing through investigations of various openings and foundation irregularities.

A model foundation will be constructed containing predetermined irregularities. The test program will consist of various loading conditions for determining the transmission of forces in the foundation with no opening. A small pilot bore will be drilled, instrumented and tested. This will be followed by 'boring' a tunnel. Test will be conducted with the tunnel both unlined and lined.

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8.0068, COMPRESSIVE CREEP TESTS OF CONCRETE

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Creep characteristics of concrete (deformation due to long-time load) must be known to correctly evaluate the strain and stress behavior of structures from readings obtained with embedded instruments. Some test specimens are being retained 20 and 30 years under continuous load to verify extrapolation of creep based on 1- and 2-year creep measurements. Current and proposed research includes studies to determine the effects on creep of specimen and aggregate sizes, sealing methods, types of loading systems and strain measuring gages, moisture conditions of the concrete, load intensity, and the range of stress in which strain is linearly proportional to stress.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0069, STABILIZATION OF SLOPES

M.E. HICKEY, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

There is a need for economical stabilization of unstable or erosive-type soils often encountered in slope excavation or embankment construction on Bureau projects. Also needed are methods of sealing or waterproofing clay areas in slope or tunnel excavations to prevent slaking and slide problems. Testing is necessary to evaluate the stabilizing and sealing capabilities of various petrochemical materials such as plastic resins, asphalt cutbacks and emulsions, proprietary type products. This study is scheduled for completion in FY 70.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0070, FIELD PERFORMANCE OF ASPHALTIC CONCRETE

M.E. HICKEY, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

To guide future design work and field control for better asphaltic construction, a study is being made to evaluate asphaltic dam facings, linings, and pavement installations of varying service ages. When opportunity arises, inspections are made of these installations and samples are obtained for analyses in the laboratory. Samples from both the better and poorer installations are studied to determine short-comings of current specifications and construction methods. The current study is scheduled for completion in FY 70.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0071, STABILITY OF EARTH SLOPES

J.G. HOFFMAN, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

A means of accurately assessing the stability of earth slopes is a requisite to the design of earth dams, large canals, and other earth structures associated with the development of water resources. Numerous procedures for evaluating the stability of earth slopes are currently available, but all fall short of an adequate solution.

Research will be conducted with the goal of developing improved methods of stability analysis which will provide results of desired accuracy with a minimum expenditure of time and money. Particular attention will be devoted to the effects of earthquakes, surface cracking, seasonal and long-term variations in shear strength, pore pressures, rapid drawdown, and stresses imposed by structural loads. Activities will include:

1. Collection of relevant data from existing earth structures.
2. Review of pertinent technical literature.
3. Development of improved techniques of stability analysis which will, where possible, overcome the inaccuracies incurred in the mechanical procedures currently employed and provide for adequate treatment of all factors that significantly affect the stability of earth slopes.
4. Development of statistical procedures for evaluating the stability of long canals where soil parameters vary throughout the length of the channel.
5. Adaption of analysis procedures to the electronic computer.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0072, SOIL PRESSURES ON FLEXIBLE STEEL PIPE

A.K. HOWARD, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

More information is needed on the soil pressures which are developed on pipe in various embankment and trench conditions in order to arrive at the most economical design for the pipe. Therefore, large-scale laboratory tests are under way to more accurately determine the soil pressures and any pipe deflections. The tests are conducted on instrumented pipe sections buried in a large soil container with surcharge loads being applied by a large laboratory testing machine.

Prior to conducting tests on pipe it was necessary to select a soil pressure cell that could be installed in the pipe. The pressure cell selected for this purpose was a modification of the no-flow pressure cell used in triaxial shear tests.

The first series of tests were completed on 18-inch diameter rigid concrete pipe. Six different soil conditions around the pipe were investigated; these ranged from a uniform compressible soil to a condition in which the pipe was resting on a very firm soil foundation. From the test results it was possible to plot graphs showing the variations in pressure surrounding the pipe. The shape of the pressure curves was largely determined by the relative firmness of the soils beneath the pipe.

Recently four of a series of 18 proposed tests have been completed on flexible steel pipe. The test equipment and procedures are similar to those used for concrete pipe. The test results are showing the soil pressures on the pipe and deformation occurring under different soil and loading conditions.

8. ENGINEERING WORKS

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0073, DETECTION OF SUBSURFACE CAVITIES OR CONDUITS IN FOUNDATIONS OF PROPOSED RESERVOIRS AND ENGINEERING STRUCTURES

W.H. IRWIN, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Reservoirs in soluble rock terrain are being proposed with increasing frequency by water resource planning engineers. New and more reliable engineering geologic methods of locating subsurface cavities, conduits, and open-joint systems are essential.

Basic investigations are in progress to compare, define, and evaluate the capability of various investigation methods to locate subsurface openings. Geologic and geophysical techniques as well as the use of testing procedures and principles from other scientific disciplines are being studied and evaluated for possible testing at a selected field proving ground for engineering geologic investigation methods. The techniques being studied are: Gravimetric surveys, geothermal gradient, radioisotope and dye tracers, water dating (tritium), infra- red scanning and photography, geophysical and TV-drill hole logging, seismic fan shooting and potential-drop-ratio surveys, thermal capacity (heat sink) measurements. Results are being checked against subsurface data derived from reservoir operation and standard geologic studies and drilling.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0074, ENGINEERING GEOLOGIC BEHAVIOR OF FOUNDATIONS IN RESERVOIRS IN GYPSUM-LIMESTONE TERRAIN

W.H. IRWIN, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Engineering geologic criteria will be developed to guide judgment on rate of deterioration--due to factors such as solution, creep--of foundation rock for engineering structures.

Special laboratory tests of solution rates (over periods of 1 month to 1 year) will be compared with geologic observations (periods of geologic time--5,000 to 20,000 years), and with foundation service histories (periods of 20 to 100 years). The resulting criteria will be used in geologic investigations for planning and design purposes to evaluate probable rates of change (due to gradual solution) in strength, permeability, rate of ground water circulation, consolidation off proposed foundations over periods of project life (150-200 years). Comparative analytical calculation will be made to establish maximum- minimum rates and related laboratory and field observations.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0075, CONCRETE CURING COMPOUND INVESTIGATIONS

H. JOHNS, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Resin base curing compounds are being evaluated to establish their moisture retention properties and the value to the Bureau of their broader use as finish coatings and as bases for other coatings, tile, or other treatments. When confirmed, satisfactory performance should enable early form removal, better concrete curing, elimination of water curing and/or sandblast cleaning, and possibly other consequences which will importantly facilitate both the work and scheduling in the construction of power and pumping plants. Jointly with the Concrete and Structural Branch, the study is being extended to include use of the compound on up- and downstream surfaces and internal joint surfaces of dams.

Moisture retention, bond to concrete, and outdoor weathering have been tested. Concrete finish and repair materials to be used in conjunction with these compounds have been evaluated. Tentative procedures for application of the resin compound to interior walls of power and pumping plants were established. A progress report of the above tests, including 46 compounds, was prepared (ChE-63).

The next phase of the program will be initiated to develop more data regarding the suitability of resin base compounds as a base for paint and tile. As part of a joint program with the Concrete and Structural Branch, the cleanability, weathering resistance, and color stability of resin base compounds will be tested.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0076, INVESTIGATION OF GROOVE AND CRACK SEALING MATERIALS

H. JOHNS, U.S. Dept. of Interior, Office of The Chief Engr. , *Denver, Colorado*

Effective sealing of grooved joints in concrete canal linings is one of the more difficult jobs to accomplish, particularly when high heads are involved. Leakage results in loss of considerable water, and can cause damage to the canal by washout of the subgrade or from expansion due to wetting expansive subgrades. Effective sealing of dams, powerplants, pumping plants, and other structures is also necessary, but similarly not easy to accomplish. These problems are recognized by the sealant industry and many new materials and systems are produced each year. These new materials are being evaluated and the overall problems are being studied. Considerable effort was expended in laboratory evaluations of new, machine-grade coal-tar polysulfide sealants, and a field test was made including this material in a variety of applications. The program to evaluate the effectiveness of placing rapid-set polysulfide sealer in fresh concrete has been completed. A laboratory report on the results of these tests is being prepared. Further studies were conducted on cast-in-place, plastic, joint forming and sealing strips. Several new designs were established and experimental quantities produced. Limited tests on a polyethylene strip designed to form a groove for the placement of polysulfide rubber sealant in the contraction joints of concrete-lined canals were conducted. The tests demonstrated the degree of concrete consolidation required to permit removal of part of the strip, and the sealing capabilities of the remaining part. Tests were continued on 66 joint- sealing materials and caulking compounds, and completed on four materials. Testing the new joint sealers and sealant systems and new caulking compounds will be continued. Further laboratory testing of plastic joint forming and sealing strips is planned and a field test will be started soon. Contacts with industry will continue.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0077, TURBINE AND PUMP TESTING

G.H. JOHNSON, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Accurate determination of the quantities - power, head, and discharge are necessary to accurately determine the performance of turbines and pumps.

Through research work in connection with this project an attempt is being made to develop new methods, equipment, and techniques for measuring these quantities more accurately.

Report No. HM-3 covers accomplishments to date in the area of head measurements and determination of specific weight of water at the test site.

Work in the area of flow measurement by the Salt Velocity method has progressed to the point where criteria for the design of an adequate mixing section (i.e., injection station to first electrode) has been developed but not proven. The new criteria requires the use of a turbulator downstream of the injection station in most installations to provide sufficient mixing energy.

Future work will consist of verification of these new criteria in every way possible. Flow measurement by the pressure-time principle (Gibson Method) will also be investigated from the standpoint of using modern components for obtaining the required diagrams.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0078, NEW ROOFING SYSTEMS

B.V. JONES, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Many new roofing systems, especially in elastomeric products are being introduced by major material manufacturers.

There is a need for more durable roofing construction on Bureau projects. Therefore, it is important that new and better roofing materials be evaluated to provide data for upgrading Bureau specifications for roof construction. Both laboratory and outdoor exposure tests are conducted to evaluate the various new roofing systems. This study is scheduled for completion in FY 72.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0079, SCREENING TESTS ON NEW ASPHALTIC, PLASTIC, AND RUBBER PRODUCTS

B.V. JONES, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Industry is continually developing new or improved products for meeting requirements of the present-day construction. Many of these materials may be of value in Bureau construction and maintenance programs. Thus, it is important that the various materials submitted annually to the laboratory be given preliminary evaluation. Also, new test methods for appraisal of materials and for specifications are evaluated. Those products and new techniques that show promise are then more fully investigated in a subsequently scheduled research program. The current study is scheduled for completion in FY 70.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0080, PORE-PRESSURE MEASURING REFINEMENTS IN SOILS FOR SHEAR AND CONSOLIDATION

C.W. JONES, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Within the past few years, a new method of measuring capillary (negative pore) pressures has been developed. Such pressures are important because they influence the strength developed in soils when external loads are applied. Measurements obtained by this method are now used in triaxial shear tests, and the analysis of results better simulate actual field conditions. Present research is being devoted to refinements in test procedure to further improve the test results.

Pore-pressure measurements made near the top, middle, and bottom of cylindrical test specimens of cohesive soils have shown that the pressure distribution was not as uniform as desired. An attempt is being made to modify the current method of compacting the soil specimen to produce a more uniform density which affects pore pressures. Also the contacts between the specimen ends and the measuring system are being improved.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0081, EVALUATION OF ROCK RIPRAP AND DEVELOPMENT OF SUBSTITUTES

C.W. JONES, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Laboratory methods are developed to better determine the suitability of rock for use as riprap by providing basic information on rock properties that affect quality and durability. A program has been outlined and rock specimens prepared for a comprehensive correlation of petrographic characteristics and the effects of freezing and thawing, wetting and drying, and heating and cooling. A study of rock fractures and their effect on the stability and resistance to weathering of rock used for riprap was started.

In some areas where earth embankments are constructed, suitable rock is not available for riprap to protect the slopes against erosion from water-wave action. Soil-cement is proving to be one of the most effective and economical substitutes. The performance of field installations of soil-cement is closely observed, and this will be continued. Petrographic examination and related physical tests of soil-cement specimens representative of five different field installations have been completed. In a cooperative laboratory testing program, chemical tests were conducted in the development of a rapid, field, control test for the determination of the cement content of fresh soil-cement.

On several field installations where soil-cement has been used as a riprap substitute, a lack of bond between layers at their edges has been detected. This is now being investigated for possible improvement in future soil-cement construction.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0082, RAPID SOILS EXCAVATION

C.W. JONES, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The development of methods to improve excavation in terms of speed and economy is needed both for surface and subsurface applications. Advancements are being made in equipment development for rapid and continuous excavation systems. Also, other agencies are exploring possibilities of explosive excavation either by chemical or nuclear charges. We are participating in furthering advancements where possibilities exist for future benefits to the Bureau.

Activity is now largely devoted to literature review and contacts with others to keep abreast of new developments in rapid excavation that might be applicable in Bureau work. The Corps of Engineers project REDSOD on the development of an explosive excavating machine has been closely followed. Meetings with representatives of the Atomic Energy Commission have been held to explore the possibility of using nuclear explosives in future Bureau work. Representatives witnessed an experiment by the Corps of Engineers in which a ditch was excavated in Bearpaw shale near Ft. Peck, Montana, using chemical explosives. Financial support is being given to the NAS-NAE Committee on Rapid Excavation and there is a Bureau representative on the committee.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0083, FILTER CRITERIA FOR DRAINS AND WATER WELLS

C.W. JONES, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The purpose of this program is to establish criteria for the grading of granular filter materials used for packing around perforated casing in water-producing wells. This material needs to have a suitable gradation to prevent excessive infiltration of soil fines from the surrounding aquifer into or through the filter and yet allow a free flow of water to be pumped from the well. Such infiltration is sometimes caused by the violent hydraulic action occurring during well development which is needed to open water passages to the well and remove drilling fluid deposited during well-drilling operations.

Laboratory tests will be made with typical aquifers and with various gradings for filters subjected to the action of water similar to that occurring during well development. observations, the range of filter gradings resulting in the required performance can be established. The effect of drilling fluid normally used in well excavation on the performance of the well will also be studied.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0084, DEVELOPMENT OF SOIL TESTING PROCEDURES AND ANALYSIS OF RESULTS

C.W. JONES, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

There has been a continual effort to improve testing equipment and procedures for laboratory soil testing and field sampling and in situ testing. This includes the evaluation of commercially produced equipment and the development of equipment for special tests where commercial equipment is not available. Equipment for the following tests are of particular concern at this time: high-pressure, triaxial shear for gravelly soils; high-range, direct shear for soil-cement and soft rock; plain-strain shear; soil compaction by laboratory mechanical compactors; and field vane shear. Also double-tube augers and piston samplers for undisturbed soil samples are being investigated.

New testing procedures are developed, often in cooperation with other organizations, such as the American Society for Testing and Materials.

Petrographic methods for examining soils are developed and used in some research programs, particularly those involving clay-type soils.

Computer methods are being applied to save time and labor for the computation of test data and in the analysis of complex soil problems such as slope stability.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0085, EVALUATION OF CANAL SEALANTS -OPEN AND CLOSED CONDUCT RESEARCH PROGRAM

C.W. JONES, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

This project involves a search for materials, particularly chemicals, that can be economically applied as canal sealants to accomplish seepage reduction. Of particular interest is a waterborne- type sealant that can be introduced into canal water in a ponded or flowing condition so that the water will distribute the sealant to areas of seepage and seal the soil to an effective depth.

An attempt has been made to interest industry in developing canal sealants. After companies have completed at least initial development of prospective sealants, the Bureau conducts tests to evaluate them. These tests are first made in small scale laboratory permeameters. Later, for those sealants that appear to be promising, larger laboratory tests under flowing water conditions in laboratory flumes are conducted. For a few sealants, the investigation has been carried forward in field tests on Bureau canals requiring seepage control.

Tests made to date on canal sealants have shown considerable promise, and are useful under certain conditions where a partial and temporary seepage reduction would be economical. Efforts are continuing to find sealants that will have greater ability to penetrate canal soils and provide a more lasting water barrier.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0086, BINDERS OF CONCRETE RESISTANT TO SALINE WATER AT ELEVATED TEMPERATURES

G.L. KALOUSEK, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The overall objective is to determine what combinations of cementitious materials will form the most resistant binders for concrete in concentrated sea water at elevated temperatures. Portland cements, fly ash, slag and gypsum in different proportions have been prepared as pastes and cured at different temperatures. A calcium aluminate cement is included in similar tests. The samples were first screened by x-ray diffraction and differential thermal analysis for desirable and undersirable phases. The more promising mixes were cast as pastes, cured at representative temperatures and tested for strength. Twenty- four selected mixes were cast as small cylinders and bars and immersed in concentrated sea water at 250 F. The specimens are examined periodically for phases, length change and dynamic modulus of elasticity. The most recent examinations (after 111 days of exposure) indicate satisfactory resistance by all mixes.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

8.0087, PROTECTIVE LININGS FOR WATER PASSAGE SURFACES OF FERROUS METALWORK

J.L. KIEWIT, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Protective linings for water passage surfaces of ferrous metalwork are being studied in several distinct programs. Linings with good erosion resistance are needed when sand- or silt-laden waters are conveyed in a piping system. Specific materials for these applications are being studied in a laboratory test which simulates sand and silt erosion in field exposure. Other selected lining materials, which performed successfully in screening tests, and which are not expected to be affected by certain service conditions that would damage coal- tar enamel or cement-mortar linings, are also being field tested. Forty-two materials in 36 systems are being tested in siphon piping on the Southside Canal, Collbran Project, Colorado, with companion specimens being tested in the laboratory. Field tests on epoxy coal- tar and modified phenolic linings are being conducted in turbines at Spring Creek Powerplant, California, and at Flaming Gorge Powerplant, Utah. Erosion resistance of a neoprene paint is being field tested on pump-turbine runners at Chandler Pumping-Generating Plant, Yakima Project.

Erosion tests were completed on 16 specimens. All of these were shop- applied by the manufacturers. Four field test linings placed in Coulee outlets were inspected for resistance to high-velocity flows.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0088, DESIGN IMPROVEMENTS--GATES AND VALVES

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Investigations and research are continuing on various design and operating features of gates and valves for the purpose of simplifying designs, reducing manufacturing costs, improving reliability and minimizing maintenance requirements. The following principal features and equipment are currently being studied: 1. Rubber Gate Seals- Various types of rubber seals are currently being tested to establish design criteria and pressure limitations for such seals. 2. Gate Wheels--Investiationss have been completed and designs are being prepared with corrosion-resistant wheel rims. 3. Gate Roller Trains- -Evaluation of data and preparation of a report covering tests of friction and operation of roller trains is in process. 4. Butterfly Valves--A review of available design and operating data has been made to establish areas which merit further tests and study to establish more definite and reliable design information. 5. Stainless Steel Fluidway Linings--Galvanic corrosion problems which have arisen in the use of stainless steel clad plates have been carefully studied, so that serious damage to gate fluidways which are lined with such plate will be minimized. 6. Gate Testing--A broad program of operating tests is in process to insure that the guard gates and valves for hydraulic turbines will be close under emergency conditions.

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8.0089, ARCH DAM ANALYSES BASED ON THE MATHEMATICAL THEORY OF ELASTICITY

A.T. LEWIS, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Mathematical stress analyses for arch dams include several fundamental assumptions which have been necessary to reduce the complexity of the computations. With the use of electronic computers it is now possible to have a direct application of the mathematical theory of elasticity. This will eliminate the necessity of some of the important simplifying assumptions and improve the accuracy of stress analysis in both the dam and foundation.

The basic mathematical concepts have been developed and necessary relationships prepared to provide a general solution for three dimensional stresses in any arch dam and its foundation. Future research will consist of preparation of programs for the solution of large numbers of equations resulting from this approach, testing these programs, and checking the results of solutions

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8.0090, STUDY OF POLYCENTERED, PARABOLIC, AND OTHER SHAPES FOR ARCH DAMS

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Because of the simplicity in laying out and constructing arch dams with circular faces, this shape has been adopted for practically all arch dams built in the United States. Actually the most efficient shape is one in which the line of thrust follows the centerline of the arch.

Research will be continued to determine the most efficient shape for horizontal arch section. A three-centered arch dam has been designed, analysed and compared with circular faced arches. Parabolic, elliptical, and possibly other shapes will be studied as time permits. Both theoretical and applied analyses will be required to determine the most desirable shape. It is expected that more efficient use of material, better stress distribution, and a more direct approach to the abutment rock can be obtained by the use of other than circular shapes for arch dams. Structural models are being constructed and tested to check theoretical analyses.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0091, ABUTMENT PADS FOR ARCH DAMS

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Concrete pads between arch dams and their abutments may be used to reduce the intensity of pressure and distribute it more uniformly on the foundation rock. They also provide a means of reducing the effects of foundation irregularities and obtaining symmetry for the arch shell.

Investigations will include determination of the most efficient sizes and shapes of abutment pads; effects of pads on the stresses in both the dam and foundation; and advantages, if any of a perimetrical joint between pad and the dam. This research will require several mathemetical analyses, probably of the trial-load type, and possibly some photoelastic or other structural model studies.

The initial structure for study is a symmetrical thin arch dam in a non-symmetrical site. Concrete pads have been designed and the analysis is presently underway.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0092, EFFECTS OF CRACKING IN ARCH DAMS

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Tensile stresses are often the limiting criteria in the design of thin arch dams. A method for including the effects of cracking in cantilever elements was developed many years ago, but is now considered inadequate. A method is to be developed to evaluate the effects of cracking in arch dams and incorporate it into our computerized trial load method of analyzing arch dams. Such a procedure is very important in determining the safety of old dams as well as layouts of new dams.

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8.0093, REINFORCEMENT OF OPENINGS IN MASSIVE CONCRETE STRUCTURES

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In general, the required reinforcement around openings in massive concrete dams has been determined from tensions developed with photoelastic models or analytically by theory of elasticity. In many instances the strain capability of the concrete is not sufficient to stress the steel to more than a few thousand psi. In cases where the dam stresses are all compressive, any cracks due to tensile stresses adjacent to openings propagate only a short distance whether or not reinforced.

Where appurtenant structures are attached to and restrained by the dam, the interrelation of temperature stresses, cracking, and reinforcement requires clarification.

This study will include analytic analyses only.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0094, MASSIVE-HEAD BUTTRESS DAMS

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Buttress type dams are well adapted to wide valleys with variable foundation conditions. Hollow buttress dams compared to gravity dams reduce uplift, minimize temperature problems, and require much less material. This investigation will include design layouts, stress studies and economic investigations to evaluate the feasibility of massive head buttress dams in the United States. Data available from technical publications and magazines will be collected and evaluated.

SUPPORTED BY U.S. Dept of Interior - Bu. Reclamation

8.0095, DESIGN OF DOUBLE-CURVATURE MULTIPLE-ARCH DAMS FOR USE IN WIDE VALLEYS

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One of the principal economic deterrents to multiple arch dams is the necessity of reinforcing areas of high tensile stress in the arch shell. Double-curvature designs will be developed to eliminate or reduce tensile stresses. Multiple-arch dams offer an effective means of combining spillways and powerplants with the dam to provide an economical hydroelectric unit. It is believed that this type of structure will permit savings over other conventional types of dams in some wide valleys. This research is to include design layouts, stress analyses, and economic investigations to evaluate the feasibility of double-curvature multiple-arch dams in wide valleys.

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8.0096, EARTHQUAKE THEORY AS APPLIED TO DAMS AND APPURTENANT STRUCTURES

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Based upon the premise that earthquakes are capable of producing resonance in thin arch dams, a method has been developed for computing dynamic loadings. The earthquake response spectra concept was used. The first two arch modes were considered and frequencies computed for them. Damping rates were assumed.

To substantiate computations and provide needed information on the dynamic properties of arch dams, field tests have been completed on Monticello Dam in California, using exciters, owned by the California Department of Architecture. Natural frequencies damping, and the deflected shape of the crest and three vertical elements were measured for the first five modes. Data reduction and evaluation are now in progress.

To improve and refine the proposed earthquake loadings, electric analogy methods will be used to determine the effective mass of water that is accelerated by arch dams vibrating in the first and second modes. Analytical studies of the dynamics of arch dams are being pursued.

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8.0097, DRILL PERFORMANCE MONITOR

M. LOGAN, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

In oil well drilling, continuous measurements of various aspects of drilling operations are customary. Small-scale equivalents of such measured instruments have not been developed for foundation exploration drilling. Continuous records of controlled foundation drilling may provide means of defining or assessing the 'natural design' of foundation rock. For example, accurate recording of the variations in drill fluid loss might indicate drilling through open joints, and the amount of loss would be an indication of the extent of the fractures.

Various portions of the drill performance monitor will be designed and fabricated and tested in the laboratory. Individual units passing laboratory tests will be field tested in actual foundation drilling operations. Study and design of a drill bit sensing device for relaying pressures, temperature, and other facets of drill performance to the operator at ground level will be continued.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0098, ENGINEERING GEOLOGIC PROPERTIES OF ROCK

M. LOGAN, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Current and anticipated design and planning problems require provision of more comprehensive and exacting engineering geologic data on actual subsurface rock conditions in proposed foundations.

The development and integration of new field investigation methods such as the drill performance monitor and TV drill hole camera; the evaluation of the capability of geophysical drill hole logging devices in foundation exploration - an entirely new field of application; and the comparison of results of the various methods, such as infrared scanning and camouflage aerial photography, are essential to the formulation of multipurpose engineering geologic exploration programs and the effective use of the results in engineering studies. These data will yield criteria for judging, for example, need of tunnel supports, foundation and reservoir seepage rates, stability of natural earth and rock masses, recognition of faulting and structural patterns in lithologically similar rock strata with extensive savings in excavation costs, and the use of rock bolts, reinforcing steel, and concrete.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0099, INTAKES, ENTRANCES, AND TRANSITIONS

H.M. MARTIN, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Hydraulic laboratory investigations are being performed to determine optimum configurations for intakes, entrances, and transitions for penstocks and outlet pipes. Entrances are normally streamlined and made as large as practicable to minimize entrance losses, to maintain positive pressures throughout, and to prevent formation of vortices which may reduce the capacity and entrain objectionable quantities of air. Economic considerations dictate that these entrances should be as small as possible in keeping with good hydraulic performance. Tests are planned to determine the actual losses at entrances of different sizes and configuration. These tests will extend to include studies of pressures and of vortex formation to determine minimum submergence required to maintain adequate wall pressures and to prevent vortices, and to determine the pressure variations and velocity distribution in penstocks as affected by bends and a symmetrical approaching flow.

Surging in draft tube transitions has resulted in poor operational characteristics for many powerplants, and in some cases has restricted power output. The basic properties of swirling flow in a cylinder will be investigated initially. The research will be expanded to explore the effects of draft tube length and inlet swirl on amplitude and frequency of surging. Various surge suppressor configurations will be tested in the facility to determine remedial corrections for existing facilities.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0100, BEHAVIOR OF STRUCTURAL ELEMENTS OR MODELS UNDER TEMPERATURE AND DYNAMIC LOADS

R.M. MCCAFFERTY, U.S. Dept. of Interior, Office of The Chief Engr., *Denver, Colorado*

The effects of vibrations and earthquakes on structures are a field in which little testing has been conducted. Much research must be completed before economical design of earthquake resistant structures can be accomplished.

Through the use of a hydraulic vibration test system, specimens will be subjected to vibratory forces. The system's force rating will be 25 tons vector force with a frequency range from DC to 400 cps.

Many different materials will be tested to determine their dynamic properties. Structures, structural components, or models, depending upon the size of the prototype, will be tested to determine their characteristics due to sinusoidal and earthquake type forces.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0101, EVALUATION AND DEVELOPMENT OF SPECIFICATIONS AND TEST METHODS FOR CEMENT AND POZZOLAN

R.L. MCKISSON, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

To assure that high quality and economic construction is obtained on Bureau projects, continual evaluation and development are made of specifications and test methods.

Practical maximum-minimum specification limits on the physical properties and compound composition of portland cement will be determined. Such limits are desirable because the maximum or minimum limitations in current specifications cannot be relied upon to provide the desired uniformity in concrete and mortar.

This program will consist of statistical evaluation of data on cement uniformity obtained by the Bureau of Reclamation and similar information reported by other groups. Of primary interest is the variability of compressive strength as related to the physical and chemical properties of the cement and the degree of uniformity that can reasonably be expected in cement production.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0102, GENERAL ROCK MECHANICS INVESTIGATIONS

D.L. MISTEREK, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The physical properties and the structural action of a rock mass which includes various joint systems and other discontinuities are not well known. Studies are needed to more clearly define which of the rock properties are required to predict the structural action of a rock mass, how the properties can be determined most easily, and how the data should be included in designs. Special attention will be directed toward stability of rock slopes, stability and support of openings in rock, and deformability of dam foundations.

Published literature will be reviewed. Results of Bureau of Reclamation tests will be reviewed and compared with existing theory.

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8.0103, ANALYSIS OF LENGTH CHANGE OF CONCRETE

L.J. MITCHELL, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Design of concrete structures with proper crack control requires consideration of numerous factors influencing drying shrinkage. Extensive data are available, indicating that aggregate composition can be responsible for excessive drying shrinkage and occasionally may be responsible for structural failures. Some project data indicate extremely high shrinkage where graywacke constitutes a significant proportion of the aggregate. Drying shrinkage considerations are increasingly more important as thin arch dams and prestressed or precast concrete units are used for smaller structures.

Recent developments have increased our knowledge on effect of specimen size and maximum aggregate on shrinkage of concrete. These data, along with other information concerning effect of aggregate composition are being tabulated and evaluated to produce a method in which preliminary estimates of potential drying shrinkage of concrete may be possible.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0104, STUDY OF TUNNEL LININGS AND REINFORCEMENT

J.W. MORRIS, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The requirement for lining water conveyance tunnels is often a problem for planners and designers of water development projects. Studies will be made to determine the limits of practicability of unlined tunnels and to establish the feasibility of tunnels that are partially lined. Efforts will be directed toward establishing criteria for use of unlined and partially lined tunnels.

For many years there has been a need to establish better guidelines for the use of reinforcement in linings of pressure tunnels. A study is underway which will attempt to outline the conditions under which reinforcement should be provided. The results of lining behavior measurements will be applied in this program where they are applicable.

Programs utilizing automatic data processing equipment are being developed for combining the various loading-restraint conditions that may exist at a given location. These programs will facilitate the determination of stresses at different locations of the tunnel section for various assumed lining thicknesses.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0105, CHANGES IN PHYSICAL CHARACTERISTICS OF ASPHALT MATERIAL

W.R. MORRISON, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The service life of asphaltic concrete used in dam facings, linings, and pavements and of asphaltic roofing and various waterproofing applications depends to a large degree on the resistance of the asphalt cement to hardening or aging. Asphalt cements from different sources, being of a different base stock and produced by different refineries vary considerably in aging characteristics. Measurements of the penetration, ductility and softening point properties before and after exposure to 140 degrees F for 14 days and 325 degrees F for 5 hours will indicate a degree of susceptibility of an asphalt to aging in service. To make possible the selection of the best asphalts possible for durable construction, it is important to evaluate the physical properties of asphalt cement samples under accelerated aging conditions.

Correlation between accelerated laboratory aging and field aging for several asphalt cements is described in Water Resources Report No. 12 entitled 'Buried Asphalt Membrane Canal Lining' and which was published in FY 68. Test results for the laboratory accelerated aging studies is scheduled for publication in FY 69.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0106, ASPHALT BINDING OF COBBLES FOR RIPRAP

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In some construction areas, there is a lack of rock suitable for riprap for erosion control of earth embankments which necessitates costly importation of riprap or application of other methods of slope protection. Often in these areas, cobbles up to 12 inches in diameter are available and could be placed for riprap protection provided some method could be devised for anchoring the cobbles in place. One possibility that warrants investigation is binding the placed cobbles together with a grouting application of asphalt or an asphaltic sand- mastic. Hydraulic laboratory testing will be conducted to evaluate different asphalts and asphalt mixtures for binding cobbles sufficiently for use a riprap.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0107, EFFECT OF PROPERTIES OF FRESH CONCRETE ON FORM PRESSURES

E.L. ORE, U.S. Dept. of Interior, Div. of Research, *Denver, Colorado* 80225

Many concrete forms have been over- or underdesigned because information on lateral pressures is sparse or incomplete. Of interest in this study is the effect of variables such as cement hydration, slump, rate of placement, admixtures, and temperature. Also, an attempt is being made to establish the influence of each ingredient, such as sand and coarse aggregate, upon the lateral pressure of concrete. A model form having inside dimensions of 1- by 3- by 10- feet high is being used in the study. Gloetzel cells have been adapted to measure pressures exerted on the form.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0108, REVIBRATION OF CONCRETE AND MASONRY

R.R. OWEN, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

In recent years, some research has been conducted to determine the value of revibration in improving the physical properties of concrete and masonry, but due to the inconsistency of the findings, the need for additional studies is evident. An investigation of available data on this subject is being conducted in an effort to arrive at some definite conclusions. Laboratory experiments may then be required to verify the accuracy of these conclusions. If revibration is found to be of definite value in improving the physical properties of concrete, its use should be incorporated into Bureau designs and specifications.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0109, DEVELOPMENT OF THREE-DIMENSIONAL PHOTOELASTIC TECHNIQUES

H.B. PHILLIPS, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The development of epoxy resins which are suitable for photoelastic stress analysis has expanded the field of possible studies to include three-dimensional models of complex engineering structures that cannot be studied by two-dimensional models. However, except for planes of symmetry, the interpretation of the stress patterns is a much more complex procedure. Initial investigations under this research project will be directed toward the basic problems associated with three dimensional photoelasticity. These investigations will include: 1. Studies of mix proportioning to obtain consistent and desired properties of the cast epoxy. 2. Development of proper casting techniques to obtain stress-free, clear, and otherwise suitable models. 3. Procedures for loading and freezing of stresses within the model. 4. Development of methods and procedures for evaluation of stresses by either slicing or coring procedures.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0110, EFFECT OF AGGREGATE PROPERTIES AND CEMENT CONTENT ON THE TENSILE STRENGTH OF CONCRETE

J.S. PIERCE, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

A method of test for determining the tensile strength of concrete is being developed using 18-inch prisms and cylinders as a maximum size test specimen. A series of tests is being conducted to determine the effects of varying cement content, maximum-size aggregate, and the use of a water-reducing, set-controlling admixture. Initial tests will include maximum aggregate sizes of 1-1/2 and 6 inches, and cement contents varying from 3 to 8 sacks per cubic yard. Future considerations for study may include other maximum aggregate sizes (3/16, 3/8, 3/4, and 3 inches), several types of aggregate with varying mineralogic characteristics, surface roughness and grading (specific surface).

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0111, EFFECT OF THE MAGNITUDE OF COMPRESSIVE STRENGTH OF CONCRETE AT VARIOUS AGES ON THE STANDARD DEVIATION AND COEFFICIENT OF VARIATION

J.S. PIERCE, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

This study includes concretes with and without pozzolan, at various water -cement ratios from which specimens will be cast for compressive strength tests at ages up to 1 year. A statistical analysis will be made upon the results of these tests to determine the effect of the magnitude of compressive strength upon the standard deviation and the coefficient of variation.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0112, DEVELOPMENT AND EVALUATION OF TEST PROCEDURES FOR DETERMINING REACTIVE EXPANSION, AIR AND WATER PERMEABILITY, AND BONDING EFFICIENCY

L.C. PORTER, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Improved methods of determining reactive expansion are needed. Current research related to reactive expansion is directed towards determining the nature of reactive expansion in old concretes, particularly the duration and conditions necessary to promote the reaction in concrete which is known to contain potentially reactive materials. Expansions developed to date suggest that reactive potential is present in concretes even after many years in service.

With methods presently used for measurement of air and water permeability, various irregularities are encountered. Therefore, development of a sensitive means of measurement of vacuum-treated, oven-dried, or routinely-cured specimens has been undertaken. For air permeability, measurement of inflow will be made either by displacement of water at atmospheric pressure, or by change in absolute pressure due to air flow into an evacuated container.

The repair of cracks, spalled, and eroded areas is a continuing problem in the maintenance of concrete structures. Epoxy resin type adhesives are the most prominent of the many bonding agents available for repair work. Investigations are conducted to determine the application of the various bonding agents to the necessary repair conditions, as well as special techniques for application and curing requirements.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0113, CONCRETE TEST VESSEL

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The overall objective is to supplement data obtained in the laboratories of the USBR on the feasibility of concrete as the principal construction material in large desalination plants; to study openings in the concrete shell and methods of sealing such openings; to determine structural behaviour of the vessel and its component parts when subjected to rapid heating and cooling attending the startup and shutdown of the main test module to which the vessel is attached. Specifically, (1) the effects of flow velocity, (2) corrosion of the concrete and reinforcing steel due to exposure to hot sea water and/or distilled water, (3) behavior of coating and sealing materials and microstructural changes will be determined. These tests, except for (2) are visually evaluated. The structure is highly instrumented to provide data on its structural behavior.

The test vessel located at the OSW San Diego test facility, has been constructed and fully instrumented to obtain the data necessary to achieve the objectives outlined above. The data acquisition system is scheduled to be installed by the middle of August 1968. After this installation the vessel will be ready to go on stream.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

8.0114, ENERGY DISSIPATORS

T.J. RHONE, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The objective of these studies is to develop many types of energy dissipators so that future investigative work on individual structures will be a minimum. The studies include tests with sudden enlargements in pipelines, vertical stilling wells, vortex basins, chute blocks, slide gate stilling basins, surges in stilling basins, and energy dissipators for low-head conduits and road culverts.

Models are used to obtain basic data used in the development of the various structures. From these data a correlation between the model and the prototype is found for such variables as the Froude number, discharge, gate opening, operating head, and energy dissipated. Pressure transducers and electronic recording equipment are used to assist in measuring impact forces and pressure fluctuations.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0115, REGION 2 - WEED CONTROL

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The Bureau of Reclamation's concrete mix design procedure has been derived from laboratory investigations and past experience. Currently, mix designs are based on information obtained prior to the prevalent use of water-reducing, set-controlling admixtures in concrete. One result of the use of such admixtures in concrete is a reduced water requirement, and hence, higher compressive strengths for a given water- cement ratio when compared with concretes without the water-reducing, set-controlling agent.

This study will investigate two types of water-reducing, set controlling admixtures; namely, a lignosulfonate and a hydroxylated carboxylic acid. Both agents will be used, at different dosages, in concretes with water-cement ratios varying, by 0.05 increments, from 0.35 to 0.70. It is also anticipated to measure the effects of the aggregate by using two different types, each with maximum sizes of 3/8, 3/4, 1-1/2, 3, and 6 inches.

Upon completion of the testing, mix design tables in the Bureau's Concrete Manual will be replaced utilizing the new data. Also, new constants for Abram's equation, S equals A over B to the X power, will be determined for different ages through use of electronic data processing.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0116, ULTRASONIC TESTING OF ROCK AND CONCRETE

H.C. RIFFLE, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Ultrasonic testing techniques have the potential of providing a positive and rapid means to check materials for quality control in the laboratory and the field. The test is nondestructive, can be performed on either samples or rock and concrete in-ssitu, and in many cases provides a more rapid test than other methods. Characteristics of rock and concrete that should be obtainable by ultrasonic testing include moisture content, physical soundness deterioration, location of internal cracks, faults, and uniformity of material.

Investigations are being made of the feasibility of testing rock in-situ for cracks and faults by means of reflected waves or by surface waves. Direct transmission tests are being conducted with concrete samples to evalute ultrasonic techniques when applied to heterogeneous material. Particular attention is being given to the determination of proper pulse frequency ranges with regard to energy level attenuation during transmission through a very heterogeneous medium. Suitable ultrasonic transducers are being developed to produce useful signal propagation in rock and concrete. Development works is done where required to produce specialized equipment needed. Evaluation will be made of ultrasonic test data to correlate it with that obtained by other standard tests.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0117, SLAB ANALYSIS

W.H. ROTH, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The only methods now available for designers to accurately determine the stress distribution in flat slabs are rigorous and complicated. In the interest of economy, the designer uses approximate methods, such as coefficients or modified frame analyses, rather than the more time-consuming, expensive methods.

We propose to make studies which will lead to an electronic data processing program for flat slabs. This program will produce moments and shears in slabs of varying as well as uniform thicknesses, with various edge conditions and loadings and openings in the slab.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0118, BASIC ROCK PHYSICS

S. RUBENSTEIN, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

By the observation, petrographic classification, description, and laboratory testing of a wide variety of rocks it is believed the physical properties and the engineering performance characteristics for various rock-type groups can be more firmly established on a petrographic basis. Values from the physical observations and variations from these values can be studied and related to the petrographic characteristics of individual samples for each group. With the knowledge of which rock properties are characteristic, it may be possible to quantitatively assess the effects of weathering, fracturing, and other alterations of a rock as related to the petrographic features.

Two new petrographic methods of evaluating rock for foundation and riprap were investigated. One method related the area of the micro-fractures to the total volume of rock. The other determines a ratio of the weathered or altered minerals to quartz in the total rock. It has already been shown that both of these procedures have significant bearing on the quality of rock for engineering purposes. With further investigation, it is believed the results of these procedures will give another parameter to rock testing which can be related and coordinated with the elastic and strength properties.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0119, PETROGRAPHIC INVESTIGATIONS

S. RUBENSTEIN, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Petrographic techniques which investigates the microstructure, composition, and physical and chemical properties of materials are used in the solution of many engineering material problems; the development of uses for new manufacturers substances and in gaining a better understanding of the engineering behavior of materials necessary for more efficient and advanced design and O&M of Bureau projects. Petrography is especially important in the study of rocks and soils and can be a powerful approach in the investigation of any crystalline material where microstructure is of significance. Materials research and studies of new laboratory techniques which show promise and require extensive further work in physical and chemical testing methods include impact hammer, sonic velocity measurements, investigation of concrete deterioration from various causes.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0120, POWER TRANSMISSION STRUCTURES, NEW TYPES

R.S. SALIMAN, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Transmission structures comprise a large percentage of the cost of transmission facilities. To achieve economy of construction, improvement in efficiency, and lowest possible operation and maintenance charges, a continuing search for new types and refinements of existing types of structures for transmission lines and substations are needed.

Data will be collected on a variety of materials which might be used for transmission line structures.

New structural forms and modifications of structural forms now in use will be studied to gain improvement in appearance.

Data and illustrations from technical publications, magazines, meetings, and conferences will be collected and evaluated as they become available.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0121, REACTOR SWITCHING DUTY EVALUATION

F.R. SCHLEIF, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

For circuit breakers in reactor switching duty specifications requirements on a performance basis discourage manufacturers. Technical requirements which could be factory tested would be preferable but such data have not been available. Practical performance of oil circuit breakers on reactor switching duty has been characterized by excessive carbon sludge formation and the need for frequent maintence. This project is to obtain basic data to better adapt circuit breakers to this application. Field investigations that have been conducted include the examination of circuit breaker performance when switching reactor circuits with and without modification by surge suppressors. Effectiveness of oil filtration equipment is being investigated. Model tests, using a circuit breaker simulator, and field tests are being conducted to determine effective locations and configurations of surge suppressors, develop protective relay schemes and determine internal reactor transients when switching with a circuit breaker in the reactor neutral. These phases of the research are being conducted under a summertime research contract with the University of Colorado using a graduate student in electrical engineering.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0122, RELAY, CONTROL, AND METERING CIRCUIT INVESTIGATIONS

F.R. SCHLEIF, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

More reliable relaying, control and metering systems and devices are needed to accommodate specific design limitations and to correct special operating problems. Investigations are conducted to improve design, reduce maintenance, and increase reliability of relay, control and metering devices, circuits and systems. Typical projects researched are ground relaying systems, influence of stray capacitance on large battery installations and surge suppression in d-c control circuits. Experimental determination of comparative accuracy for two-element and three-element metering on grounded wye systems with phase unbalance existing from untransposed transmission lines is given in Report No. EP-24. High-speed power flow prototype relay systems are being investigated for protection of power system interties to achieve controlled sectionalization when needed during severe and unusual disturbances. The objective is rapid sectionalization so each of the separated systems will retain stability with sufficient generation to independently serve the local area loads. Prototypes of a power swing relay and auxiliary have been designed, assembled, calibrated and placed in service on the East-West ties. Power flow, rate of change of power flow, power flow bias, blocking for nearby system switching, pretrip alarm and high-speed tripping at a favorable time are some of the salient features incorporated in the prototype relay. High sensitivity in a narrow band near a critical power system oscillation with tripping near a point of oscillation quiescence is provided in the prototype auxiliary. System performance data are being evaluated and other applications are under study.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0123, UNDERGROUND TRANSMISSION AND EQUIPMENT DIELECTRICS--SOLID, LIQUID, AND INERT GAS

F.R. SCHLEIF, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Influence of dielectric absorption or polarity reversal upon dielectric strength of underground cables and equipment insulation will be evaluated. Possible utilization of polarity reversal in cable as a testing technique is proposed. Many new systems of insulation are being offered with widely different characteristics, and a practical means of evaluating insulations to meet the users' applications is needed, taking into consideration initial and aging characteristics of dielectric properties, and mechanical properties and ease of handling. A corollary part of the solid insulation problem is that the evaluating insulations after various stages of service to permit scheduling of repair or replacements as needed, but yet utilize the maximum service life indicated to be available. Evaluation systems employing power factor and power factor tip-up measurements proved to be influenced by nonlinear corona control paint applied to the ends of machine stator coils. Furthermore, in electric machines these measurement techniques require isolation of each coil before measurement. Evaluations of coil conditions by ionization measurements have shown some capabilities of avoiding these difficulties. The winding of a machine is being evaluated by each of the techniques for comparison and for refinement of an evaluation technique for field use. Investigation also includes application of inplace repair techniques for generator stator coils. Inert gas atmosphere for oil insulated equipment is being evaluated. A portable high-voltage d-c power supply specially designed for insulation testing is being developed.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0124, GOVERNOR REGULATION FOR SPEED AND SYSTEM CONTROL

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The increasing interconnection of systems makes the former approximate experimental system of governor adjustment more difficult, yet the needs are for still more accurately coordinated adjustment. The procedure for calculation of adjustments evolved by computer studies has been applied. This investigation includes correlation of calculated settings with actual response, development of a field test and adjustment procedure to achieve the desired settings, and means of reconciling the diverging requirements of governor adjustment for speed control and response of a governor to tieline control signals. A scheme of simulating isolated operation of a generator under normal system load has been developed for adjusting governors. Optimum system performance is achieved by machines so adjusted. Refer to IEEE Paper No. 31 PP 67-22. Electrical control schemes have been developed for application on hydromachine mechanical governors. Two different prototypes of supplementary fringe control have been used at Grand Coulee Powerplant to improve system stability. Fringe control study results are given in Report EP-13. A prototype electronic governor auxiliary for a mechanical governor is being operational tested at Grand Coulee Powerplant. Hydro-machine actual response time is decreased and tieline and frequency regulation improved by the electronic auxiliary. Prototype supplementary excitation control systems have been assembled and placed in service at Glen Canyon and Yellowtail Powerplants. Analog computer studies and application results of supplementary excitation control are given in Reports EP-16, EP-18 and EP-25. Further studies are being conducted to optimize the excitation control and its coordination with governing systems.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0125, ELECTRICAL MACHINERY TEMPERATURE CONTROL

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This investigation assumes importance because of the trend to more extensive load peaking with hydro and to centralization of power control to necessarily conserve manpower. A prominent deleterious effect on electrical machinery is produced by thermal cycling. Use of automatic temperature control is an evident means of relief. Applications to steam turbine units have been fairly common, but few applications have been made on hydro units. Beyond the need to minimize deleterious effects on the machine itself, there is also a need to eliminate manual control operations to facilitate centralization of control. An automatic temperature control installation has been designed to compare the performance of several different type sensing systems. The sensing systems employed for comparison include stator resistance temperature detector, a bulb-type sensing element inserted under the stator slot wedge, and a bulb-type sensing element attached to the end section of the coil. Preliminary results showed good performance of control apparatus driven by the resistance temperature detector. Subsequent phases of the study are to continue examination of capabilities of the more rugged and less expensive bulb-type detector with associated controllers to achieve the desired control function of limiting the temperature cycling range. Control of temperature to a constant value is not the object of the control.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0126, COORDINATION OF PLANT FREQUENCY, D-C-TRANSMISSION AND SYSTEM CONTROL

F.R. SCHLEIF, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The new technique of a-c/d-c conversions offers promise of flexiblity which may not only relieve the confinements of speed at generators and of pumps under varying head and gate conditions, the conversion technique may also yield valuable flexibility for control for system stabilization along with its advantages in d-c transmission, both overhead and underground. This project is concerned with evaluation of the potential of the techniques of a-c/d-c conversions, particularly by solid-state devices, for relieving these prominent problems singly or in combination. If the study phase results are sufficiently promising, the work would continue with acquisition and evaluation of prototype apparatus.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0127, OPEN CHANNEL HYDRAULICS

J.C. SCHUSTER, U.S. Dept. of Interior, Hydraulics Branch, *Denver, Colorado* 80225

Minimum head losses in canals and canal structures are essential for an economical and efficient transportation of irrigation water. Canal structures include drops, turnouts, wastways, overchutes, culverts, transitions, bifurcations, side channel weirs, and other structures. Verification of model investigations with field tests are required on a number of individual designs. These include research on culverts, transitions, drops, and bifurcations.

Research is continuing on different sizes of uniform riprap and of graded riprap to relate the rate of flow of water to a stable size of riprap.

Studies of canal surges was terminated with the publication of the Hydraulics Branch Report Hyd-575,‘ Attenuation of Surge Waves by a Side Weir in a Trapezoidal Channel.‘

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0128, WATER MEASUREMENT

J.C. SCHUSTER, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Commitment of more and more of our water resources compels us to improve water measuring methods, to increase measuring accuracy, and to supply information to people measuring the water. Distribution of water from older systems of canals and pipelines needed only an understanding of relatively simple measuring devices. Newer distribution systems demand a much greater knowledge of many complex measuring devices and water controls. The expected increased automation of water control and its measurement will raise the level of knowledge needed to account for water into and out of the system. Studies in progress and planned are to increase our knowledge of both old and new devices.

The studies include evaluation of acoustic dye, momentum, and thermal methods of discharge measurement, and the capabilities of new controls and indicators.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0129, STUDIES OF EQUATIONS FOR SEEPAGE LOSS FROM CANALS

M.W. SCRIVNER, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Numerous equations have been developed for computing seepage losses from canals. These equations were based on certain idealized assumptions such as uniform soil permeability and that seepage is not affected by ground water or subsoil stratifications. Such ideal conditions are rarely encountered in practice. Seepage loss equations are required which will accurately predict seepage by application of measured values of permeability and other measurable properties of the soil in which the canal is to be built.

Published literature on seepage losses will be reviewed to assist in selecting or developing equations which would permit a more accurate prediction of canal losses and needs for canal lining. Seepage rates obtained from ponding tests on Bureau of Reclamation canals will be compared to the published equations. Permeability and other laboratory measured properties of soil samples from the canals will be examined for possible correlation with seepage rates measured by ponding tests in the field.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0130, STUDIES OF CANAL HYDRAULICS

M.W. SCRIVNER, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Economic design of canal systems depends on accurate determination of the head losses that will occur in each component part of the systems. Wide variations between the losses allowed for in design and measured in prototypes indicate a need for information as to the cause of these variations.

A program for measuring head losses in Bureau of Reclamation canals began in 1957 will be continued. Tests will be made in cooperation with other programs on Bureau of Reclamation canals. Tests will include measurements in earth and lined sections of various sizes and on typical canal structures.

Data collected under this and other programs will be analyzed for useful information. Data from technical publication and magazines will be collected and evaluated as they become available.

Data collected will be used to aid in determining the relative influence of size, shape, slope, alinement, surface roughness, aquatic growths and deposits on friction coefficients for open channel flow. Data from structure measurements will be analyzed to determine the effects of piers, transition bends, etc. on overall structure losses.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0131, COATING TECHNOLOGY

C.E. SELANDER, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Each year there are many new developments related to protective coatings and sealers which are not covered by other specific research items. Many of these are of potential value to the Bureau and are being investigated. These investigations may include new techniques of surface preparation or application and the evaluation of coating materials for use in humid or wet and low temperature situations, as well as performance surveys and service estimates. Studies of the relationships of certain properties of coatings to actual field performance under various exposure conditions are expected to provide information to better understand differences in performance in various geographic areas. The results from these studies are used in upgrading and improving specifications. General survellance of the protective coating field continued. A computer program is in use for analysis of coating performance data from paint screening tests.

Maintenance painting, an evergrowing problem as Bureau structures age, usually proceeds under adverse physical conditions and a strigent time limitation. In recent years, developments in the properties of coating materials may permit or at least improve their applicability in humid or wet, low-temperature situations. Variations on surface preparation and application techniques with such materials are being investigated to enable selecting those most suitable to specific O&M problems. New projects and procedures which show promise and warrent a major effort will be investigated further in separate programs.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0132, PLASTIC PIPE AND TUBING

C.E. SELANDER, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

One of the most active and expanding of the industries is that related to plastic pipe, and the industry appears to be redirecting its efforts to water service. Plastic pipe produced under suitable standards can withstand exposure to many severe environments. Recent developments, particularly in reinforced plastic mortar (RPM) pipe, now make available most any size of pipe desired. Samples up to 96 inches in diameter have been furnished to the laboratory. Plastic pipe, properly selected, can replace metal pipe which requires unusual protection or it is not suitable because of environmental conditions. Developments in RPM pipe make this type of piping competitive with concrete or asbestos-cement pipe in various sizes up to 54 inches diameter on a regular basis. The only major unanswered questions concerning this pipe are related to its durability under service conditions. Laboratory and field evaluations are being conducted with excellent cooperation by industry and in association with the Open and Closed Conduit Systems (OSSC) program to answer these questions.

Developments in plastic drain pipe which may result in substantial savings in large-scale drainage systems are being studied. Sections of the field test pipe from Westlands Irrigation District, California will be tested in the laboratory after delivery from the project and thereafter at 6-month intervals as planned. The Concrete and Structural Branch is cooperating closely in this study. Monitoring of the field installation will continue.

Samples of other plastic pipes were received for preliminary examination and numerous meetings were held with industrial representatives.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0133, PLASTICS TECHNOLOGY AND ENGINEERING APPLICATIONS

C.E. SELANDER, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Specific engineering applications of a variety of plastic materials are being investigated. Oftentimes, certain specific properties govern the uses of plastic materials under particular service conditions. Materials and their properties are being studied. New materials and uses not specifically covered by other research programs are investigated to establish if there is potential value to the Bureau. Preliminary studies in this program are useful in determining whether separate research programs for detailed and comprehensive investigations are justified. Technical developments and engineering advances are monitored by review of technical publications and frequent contacts with industry, Government, and technical groups.

Environmental testing of certain plastics was continued with periodic evaluation. Minor miscellaneous tests were conducted as needs dictated, but no new major studies were undertaken because of higher priority work. Report No. ChE-73 on a study of impact and tensile strengths of two polyethylenes and Report No. ChE-74 on moisture absorption of one type of nylon are planned.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0134, CORRELATION OF JOINT DENSITY AND ROCK LOADS--INSTALLATION OF TUNNEL SET LOAD CELLS IN DIVIDE TUNNEL, COLORADO

E.J. SLEBIR, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Correlation of joint density and rock loads remains an important unknown in the design of underground openings. Instrumentation of tunnel sets will be performed using load cells. Correlation of underground and surface joints with loads on tunnel sets in a specific rock type will be studied. Particular evaluation will be made of Terzaghi's formula for estimating rock loads based on joint density in a special rock type.

Status--All data have been furnished to Graduate Student L. A. Brown. Data will be incorporated in PhD thesis. Target date for thesis--1968.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0135, VIBRATORY COMPACTION OF COHESIVE SOILS

D.A. TIEDEMANN, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

A research investigation is being conducted to determine the effects of vibratory compaction on the properties of cohesive soils. Although vibratory equipment has successfully compacted cohesionless soils, its effect on cohesive soils, particularly in dams, has not been established. Equipment company representatives and contractors have claimed that vibratory rollers are more economical than conventional-type rollers on cohesive soils and that they can effectively compact this type of material. This research is designed to gather data which will serve as a basis for our engineers to allow or disallow the use of vibratory equipment in the compaction of cohesive soils, particularly for water barriers.

Equipment has been acquired to study the dynamic properties of soils subjected to vibratory action, both under field and laboratory conditions. Vibration records have been obtained from a test embankment of lean clay compacted by a vibratory roller. These records are being analyzed preparatory to establishing a laboratory test program. This program will consist of a series of vibratory tests on samples of different cohesive soils to determine the mechanics of the compaction process and the properties of the soil compacted in this manner.

8. ENGINEERING WORKS

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0136, DESIGN CRITERIA FOR OPEN CHANNELS

P.J. TILP, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

To secure maximum project benefits, it is essential that water distribution and drainage systems be designed with adequate capacity. Experience shows that under capacity in open channel portions of canals has resulted in costly modification work after original construction. Criteria used in the design of open channels should result in a system that is economical to construct, operate, and maintain and should account for all factors which will have a significant effect on their capacity.

Criteria for the design of open channels will be revised as required to account for factors which have been shown to have significant effect on capacity. Activities will include:

1. Review data from canal hydraulic tests and other information on hydraulic performance of Bureau of Reclamation canals.
2. Assemble and evaluate data from other agencies on hydraulic tests and performance of open channels.
3. Analyze data and formulate criteria which will be reliable for use in design of future canal systems.
4. Revise existing design aids and devise new aids to assist in applying the adapted design criteria.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0137, EARTH AND ROCKFILL DAM DESIGN PRACTICES

F.C. WALKER, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

A continuing program to improve Earth Dam Design practices is being pursued through evaluation of construction performance, structure performance measurements, operation and maintenance experience and review of literature. Collected data is evaluated from time to time and compared to previously established design practices. Modifications are then introduced in the design practices, data collection procedures, measuring apparatus, or methods of analysis and evaluation to reflect the effect of accumulated experience.

Current operations include: Improved piezometer design to register negative pressures and reduce failure in installations. Statistical appraisal of construction variation in compaction of materials and establishment of conditions for testing. Development of standards for earthquake hazard evaluation. Improvements in stability analysis.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0138, AUTOMATION OF CANAL SYSTEMS

L.F. WEIDE, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

The trend in management and operation of canal systems is toward more automatic controls. Many existing automated installations have been developed by local entities and many have been modified to solve local operational problems. The factors responsible for conditions which make modification of simple controls necessary are not defined. Design engineers and canal operating personnel require definition of these factors to provide satisfactory automatic control of canal systems.

A review of literature on existing automated installations was begun in 1966 and will be continued. Information obtained from this review will be used to determine (1) the operational capabilities of each type of installation, (2) the suitability of the electrical and mechanical components of each installation, and (3) the factors which require special consideration in the modification of simple controls. Automation of individual structures as well as complete systems will be included.

Related studies will include equipment and methods of monitoring and controlling rates of flow and water surface elevations, as well as capabilities for remote control and supervision.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0139, HYDRAULIC AND STRUCTURAL DESIGN - SPILLWAYS AND OUTLET WORKS

R.W. WHINNERAH, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Further investigations of prototype performance of existing selective level outlet works with the objective of improving future designs. Development of programs to speed conversion of various design and estimating computations from manual to ADP procedures will continue. Data collection on high head gates and valves will soon be completed. Study of cavitation and abrasion of concrete flow surfaces will continue. Initiation of research in the following areas is proposed: 1. Application of the finite element theory to counterfort design. 2. Effects of ultimate strength design on hydraulic structures. 3. Simplification of structural outlines to reduce form costs. 4. Efficacy of repairs of concrete flow surfaces. 5. Methods of splicing 14S and 18S reinforcing bars. 6. Establishment of uniform standards in determining hydraulic head losses.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0140, ADMINISTRATION, GENERAL, AND OTHER EXPENSES--SOIL AND MOISTURE CONSERVATION PROGRAM

R.J. WILLSON, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

Coordination of the activities within and controlled by the Office of the Chief Engineer, which includes providing design assistance of a minor nature not justifying transfer of funds from regions for accomplishment, providing technicians for field consultation on matters not provided for otherwise in the program, and meeting general administrative and other minor expenses.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0141, PRECAST CONCRETE FORMS

W.H. WOLF, U.S. Dept. of Interior, Bureau of Reclamation, *Denver, Colorado* 80225

As part of continuing efforts to improve quality and reduce costs, investigations are being made of the utilization of precast reinforced concrete units as construction forms and permanent protective facing for reinforced concrete structures, particularly hydroelectric powerplants. The initial phase involves study and correlation of available data and information on the subject, after which preliminary designs and economic studies will be prepared to determine the structural elements, the types and sizes of structures, and the various construction site factors for which the use of precast concrete forms will prove most advantageous and economical. These determinations will involve study of equipment and methods used in the manufacture and installation of the units. Modifications of designs and details of structures to better adapt them to precast concrete forms will be investigated. Finally standardized designs and specifications for the various types of precast form units found to be economically feasible will be prepared along with recommendations as to the conditions most favorable to their use.

Special research into some phases of the development will be undertaken as the need becomes apparent.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0142, UNSTEADY FREE SURFACE FLOW IN LONG STORM DRAIN

A.H. BARNES, Colorado State University, School of Engineering, *Fort Collins, Colorado* 80521

Three numerical methods have been developed for digital computer solution of the teo partial differential equations explaining gradually varied unsteady flow. These are the diffusing method, the Lax-Wendroff method, and the method of characteristics. The Lax-Wendroff is the preferred for its superior stability. Unsteady flow observations were made for base discharges, peak flows, boundary conditions, initial conditions, and lateral flow conditions. Energy losses through junction boxes were determined for steady flow conditions. These were in agreement for observations taken on a 3-ft diameter pipe and a 6 1/4 in. pipe. Computer wave forms were compared with observations made in England. Good agreement was attained.

Reports issued: A development of a numerical solution to a system of partial differential equations, W. B. Frye, thesis, June 1966. Free surface flow energy losses in a 90-degree junction box, W. L. Lorah, thesis, June 1966. Hydraulic roughness of free-surface flow in a smooth steel pipe, F. M. Yevdjevich and A. H. Barnes, Aug 1966. Solution of the unsteady free surface flow in a storm drain by the method of characteristics, S. Pinkayan, Sep 1966. Velocity distribution factors in a circular cross-section, A. H. Barnes, Oct 1966. Comparison of mathematical versus experimental flood wave attenuation in part full pipes, J. S. Mitchell, Nov 1966.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Colorado State Government

8.0143, WATERSHED IMPROVEMENT--SOIL AND MOISTURE CONSERVATION PROGRAM

R.E. DILS, Colorado State University, Graduate School, *Fort Collins, Colorado* 80521

The objectives of this research are to test snowmelt acceleration materials and techniques on a larger scale treatment basis; continue field testing of a continuous method of gaging streamflow; evaluate the water yield benefit expected from operational conversion of lodgepole pine forest to herbaceous vegetation, and evaluate the different herbaceous species with respect to their adaptability to such conversions, their relative demands on water, and their utility for protection and recreational use of the land.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0144, SEALING OF CANALS AND RESERVOIRS WITH COLORADO CLAYS

R.D. DIRMEYER, Colorado State University, Agricultural Experiment Sta., *Fort Collins, Colorado* 80521

A. To inventory clay deposits close to major irrigated areas in Colorado. B. To develop methods of utilizing locally available clays and sealing leaky canals and reservoirs in Colorado.

Description of Work: Samples of deposits of clay are evaluated in the laboratory to determine particle size, permeability, washability, mixability, swell and other chemical and mineralogical characteristics.

Field trials are conducted in existing canals and reservoirs with clays that appear favorable from laboratory tests.

SUPPORTED BY Colorado State Government

8.0145, ENGINEERING INVESTIGATION PERTAINING TO FLOOD PROTECTION OF BRIDGES AND CULVERTS

D.B. SIMONS, Colorado State University, School of Engineering, *Fort Collins, Colorado* 80521

This research is to develop design criteria required to establish methods and the physical requirements of materials necessary to control erosion downstream of highway culverts, contracted bridge sections, and other hydraulic structures. Scope: Laboratory facilities will be utilized to initially study the flow phenomenon, the forces acting on bank stabilization materials, and design criteria for selecting and placing material for scour prevention.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Wyoming State Government

8.0146, HYDRAULICS LABORATORY

D.B. SIMONS, Colorado State University, Agricultural Experiment Sta., *Fort Collins, Colorado* 80521

A. A study of sediment transport in alluvial channels. B. A study of the mechanics of turbulence and its effects on flow in open channels. C. A basic study of fall velocity--the fall velocity of porous particles.

Objectives of Project: A. Improve the theory of sediment transport in open channels. B. Develop techniques of measuring the turbulence of water in open channels. C. Improve the concept of fall velocity of particles.

Sediment data are being collected in both the laboratory and the field. A new recirculating flume is being built in the new hydraulics laboratory for further study. A special fall velocity tube and associated photographic equipment will be used for fall velocity studies.

SUPPORTED BY Colorado State Government

8.0147, REVERSE FILTER EROSION PROTECTION

C.J. POSEY, Univ. of Connecticut, School of Engineering, *Storrs, Connecticut* 06268

Paving with concrete, asphalt, or ether impermeable materials, as commonly done to protect the bed and banks or drainage ditches and canals from erosion, is not only expensive, but hastens the flow away with minimum opportunity for replenishment of groundwater. It has been shown recently that more dependable protection can be obtained with a pervious lining having the properties of a reverse filter. Economical designs and placement methods need to be developed and tested in a wide range of soils. Work is starting at the Hydraulics Research Laboratory of the University of Connecticut, with support from the Connecticut State Highway Department, and should be completed by 1969.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Connecticut

8.0148, COASTAL WORKS EVALUATION FOR CHECKING, IMPROVING AND DEVELOPING DESIGN RELATIONSHIPS AND CONSTRUCTION TECHNIQUE

J.V. HALL, U.S. Army, Coastal Engin. Res. Center, *Washington, District of Columbia* 20016

Data are obtained and studied on the behavior of shore improvement projects during and after their construction. The data are obtained in cooperation with appropriate field offices insofar as practicable. Protective works studied include beach fills which serve to rehabilitate and/or nourish shore segments, as well as gravity or cantilever type shore structures of both monolithic and rubble construction.

Projects currently being followed also involve sand bypassing at improved inlets, permeable and impermeable groins, jetties and breakwaters, and reconstruction of protective sand dunes. Utilizing the collected data, applicable design relationships, both functional and structural, are evaluated. Study objectives are improvement of existing design relationships and construction techniques, or development of new ones.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0149, PROTOTYPE ANALYSIS-STRUCTURAL BEHAVIOR

J.A. RHODES, U.S. Army, Office of The Chief of Engrs., *Washington, District of Columbia*

Mass Concrete Temperature Summaries (ES 627.1) - Temperature histories of mass concrete and related parameters affecting heat generation and temperature changes, measured during and subsequent to construction at large concrete gravity dams, are collected, summarized, and presented in a series of reports. To date 12 summaries have been published.

Uplift Studies - Flood Walls (ES 627.6) - Piezometer and well point devices, installed at three Ohio River flood wall sites, are observed at high stage periods to determine hydrostatic pressures and flow nets in the underlying pervious strata.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0150, WAVE ACTION ON STRUCTURES

T. SAVILLE, U.S. Army, Coastal Engin. Res. Center, *Washington, District of Columbia* 20016

The action of all types of waves on various types of structures will be studied in the laboratory using experimental models, in the field making prototype measurements, and by analytic theoretical approach. In particular such things as wave run-up, wave overtopping, wave forces, and structure stability are planned for investigation.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0151, STRUCTURAL DESIGN OF SHORE STRUCTURES

T. SAVILLE, U.S. Army, Coastal Engin. Res. Center, *Washington, District of Columbia* 20016

This project involves continuing review of literature on the design of shore structures, field tests on wave action on structures, and model tests on wave action on models of various coastal structures.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0152, EFFECTIVENESS OF WEB REINFORCEMENT IN REINFORCED CONCRETE BEAMS SUBJECT TO AXIAL FORCES

UNKNOWN, U.S. Army, Office of The Chief of Engrs. , *Washington, District of Columbia*

The purposes of the research are to obtain a fundamental understanding of the action of web reinforcement to resist shear in reinforced concrete beams when axial forces are present and to develop expressions for shear strength of such beams. No data are presently available on this subject.

Investigation will be made of the behavior of a series of reinforced concrete beams with web reinforcement when subject to various combinations of shear and axial force. The variables will be axial stress, amount of web reinforcement, concrete strength, amount of longitudinal reinforcement and the ratio of moment to shear.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0153, UTILIZATION OF RADIOACTIVE TRACERS IN BEACH STUDIES

G.M. WATTS, U.S. Army, Coastal Engin. Res. Center, *Washington, District of Columbia* 20016

The feasibility of utilizing radioactive and fluorescent tracers in beach studies is being followed and investigated. Preliminary tests familiarizing staff personnel with such techniques are carried out. Study is made to utilize and alter laboratory techniques for field application.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0154, DEVELOPMENT OF OFFSHORE SOURCES OF SAND SUITABLE FOR BEACH RESTORATION AND NOURISHMENT

G.M. WATTS, U.S. Army, Coastal Engin. Res. Center, *Washington, District of Columbia* 20016

This study is to locate and quantitatively assess those offshore deposits which contain sediments suitable for beach restoration and/or nourishment. The present geographical limits of the study are from New Hampshire to the Florida Keys along the Atlantic Coast in water depths of 15 to 100 feet below low water datum. The method of exploration is twofold: (1) Geophysical (acoustic) surveys or the bottom and shallow subsurface strata in selected areas; and (2) The extraction of short (10-15 feet) cores of the unconsolidated sediments. These data are analyzed to develop two and three dimensional maps delineating areas of usable sediments which may be exploited economically. Concurrent studies are in progress to develop and refine methods of offshore dredging and delivery of the material from the dredge to the shore.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0155, DEVELOPMENT OF CRITERIA FOR ARTIFICIAL BEACHES

G.M. WATTS, U.S. Army, Coastal Engin. Res. Center, *Washington, District of Columbia* 20016

The study is to develop beach fill design criteria, and to establish a systematic procedure for the investigation of the characteristics of littoral material. Program involves 2 steps: (1) Develop design criteria for beach fill through application of statistical principles to special test data; (2) Reexamination studies of completed artificial fill projects to obtain data for comparative evaluation of developed design criteria. Data which have been derived under the functional study of fill projects are utilized in step 2 procedures of developing the criteria for artificial beaches. Studies through contracts with educational institutions are being carried out regarding the use of statistical principles by repetitive collection of field data at one location. High speed computers are utilized in the analysis of the field data.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0156, RUBBLE-MOUND PROTOTYPE STUDIES

G.M. WATTS, U.S. Army, Coastal Engin. Res. Center, *Washington, District of Columbia* 20016

Prototype rubble-mound structures, including structures with pre- cast armor units, are subjected to programmed surveillance for damage or movement of armor units by wave action in order to correlate such data as are obtained with that previously obtained from hydraulic model and theoretical studies. Armor units at selected positions in the structure are permanently tagged, positioned by survey measurement, and subsequently checked semi-annually, or after each major storm, to determine the degree of movement of the units. Wave gaging instrumentation is installed to provide continuous sampling of incident wave action, and survey measurements of adjacent beach and bottom are also taken periodically. Data are currently being measured at three locations on the Pacific Coast which include a rubble-stone jetty; a jetty with pre-cast quadripod armor units, and a shore-connected breakwater constructed with a rubble-stone stem and monolithic concrete head.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0157, CORROSION MITIGATION

G.M. WATTS, U.S. Army, Coastal Engin. Res. Center, *Washington, District of Columbia* 20016

The investigation is to involve the collection and presentation of data showing the corrosion rate in sea water of various shapes of steel piling and of the stressing steel in pre-stressed and post stressed concrete piling. The corrosion rates are to be determined from piling installed at locations having various climatic, tidal and contamination conditions. The objective is to furnish information to aid in determining the life expectancy of steel used in piling installations.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0158, HYDRAULIC PERFORMANCE OF BRIDGES

UNKNOWN, U.S. Dept. of Interior, Geological Survey, *Washington, District of Columbia* 20242

Information is being obtained on the overall efficiency of bridges, on the hydraulic efficiency of earthen spur dikes, and on the hydraulic efficiency of excavated areas under bridges. This will lead to a more effective design of waterway openings under bridges.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Mississippi State Government

8.0159, DEVELOPMENT OF HYDRAULIC DESIGN PROCEDURES FOR STRUCTURAL PLATE PIPE AND PIPE-ARCH CULVERTS USING RESISTANCE FACTORS FROM RECENT RESEARCH

H.G. BOSSY, U.S. Dept. of Transportation, Bureau of Public Roads, *Washington, District of Columbia*

Design aid for selection of a structural plate pipe-arch culvert (new section of 31-in. corner radius) adequate for a given design flood peak is being developed and made available to highway engineers. This will be supplemented by data on resistance factors for all sizes and types of corrugated metal culverts.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.

8.0160, COASTAL ENGINEERING STUDIES RELATED TO FLORIDAS SHORELINE AND BEACH EROSION PROBLEMS

R.G. DEAN, Univ. of Florida, School of Engineering, *Gainesville, Florida* 32601

The proposed program represents a long-range investigation to define the causes of and solutions to Florida's shoreline and beach erosion problems. The emphasis during the first year of the project will focus attention along the lower southeast coast from Jupiter Island south to Government Cut. In subsequent years, attention will be directed to other segments of the State's coastline. The primary objectives of the study are described in the following paragraphs.

Inlets. shoreline problems will be investigated. Special consideration will be given to the hydrographic features and sand bypassing processes at the various inlets.

Nearshore Sand Resources. define near-shore sand resources suitable for beach nourishment purposes.

Susceptibility of General Coastline to Wave Attack. refraction techniques will be employed to identify areas that are particularly vulnerable to storms originating from various directions. Erosion-deposition occurrences for particular storms will be correlated with these results.

Coastal Construction. types of coastal structures and practices will be assembled and interpreted in order to document the most effective solutions to Florida's coastal problems.

SUPPORTED BY Florida State Government

8.0161, SAND TRACING AT SPECIFIC INLETS AND AREAS ON THE LOWER EAST COAST OF FLORIDA

J.A. PURPURA, Univ. of Florida, School of Engineering, *Gainesville, Florida* 32601

The purpose of this tracing program is to determine the pattern of natural as well as artificial sand bypassing that is occuring at three inlets and to study the longshore and transversal littoral drift of the shoreline between two of the inlets. It is hoped this data will be useful in determining the most practical way(s) of stabilizing and/or protecting beach area adjacent to inlets.

Natural, native sand in large quantities is coated with a fluorescent pigment. The coated sand is placed at different locations throughout the study area. After placement, a comprehensive sampling program is carried out. Results are then analyzed and correlated with measured physical parameters.

SUPPORTED BY Florida State Government

8.0162, SILVEX PERSISTENCE IN WATER AND HYDROSOIL

H.P. NICHOLSON, U.S. Dept. of Interior, Southeast Water Lab., *Athens, Georgia*

Methodology has been developed for the differential analysis of the propylene glycol butyl ether esters of silvex and silvex acid in water and the underlying hydrosoil. The persistence of the esters and acid of silvex in water and hydrosoil have been determined in the laboratory. Soil types involved were: Cecil sandy clay loam of the Piedmont Plateau of Georgia, Lakeland loamy sand from the Coastal Plain of Georgia, and Brighton muck from Florida. These studies are being extended, under field conditions to Louisiana soils of the Olivier Calhoun-Loring Association. The Louisiana tests involve applications to three natural ponds.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0163, TWO-PHASE FLOW IN A VERTICAL BEND

M.R. CARSTENS, Georgia Inst. of Technology, Water Resources Center, *Atlanta, Georgia* 30332

The proposed research is designed to contribute to a general understanding of two-phase (air-water) flow in enclosed conduits involving a vertical shaft, an elbow, and a horizontal discharge leg. Special attention will be paid the transition from a bubbly mixture in the vertical leg to stratified (open-channel) or plug flow in the horizontal leg.

Generalized conclusions regarding important design and performance parameters will be based on an experimental investigation in which the following variables will be considered: (a) air concentration, (b) radius of curvature of the bend, (c) length of the horizontal conduit, and (d) Froude Number of the flow in the horizontal conduit.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Georgia Institute of Technology

8.0164, UNSTEADY FLOW OF DILUTE AQUEOUS HIGH POLYMER SOLUTIONS IN PIPES

P.G. MAYER, Georgia Inst. of Technology, Water Resources Center, *Atlanta, Georgia* 30332

The proposed research plan involves mathematical and experimental studies of unsteady pipe flows of dilute aqueous solutions of high polymers. The main purpose of the studies is to formulate mathematically and to verify experimentally the progress of slugs of water having changed physical properties due to polymer additives. The mathematical study involves solutions to hydraulic transients due to changed fluid properties. Numerical methods and electronic digital computers are to be employed.

The experimental study involves measurements of pressure transients in controlled laboratory experiments. Different concentrations of polymeric substances are to be injected and the progress of the slug and its effect on the system are to be observed.

The mathematical study and the laboratory investigation would be correlated to suggest practical applications of polymer injections to improve water distribution systems.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Georgia Institute of Technology

8.0165, CIVIL ENGINEERING STRUCTURES IN THE OCEANS

P.G. MAYER, Georgia Inst. of Technology, School of Engineering, *Atlanta, Georgia* 30332

Engineering structures in the ocean involve forces and constraints which demand attention to the interrelationships between the soil dynamics of the ocean floor, the hydrodynamics of wave action and of the viscous damping, and the structural response characteristics. These interrelationships must be understood as random phenomena and must be treated by probablistic methods.

The present study involves the formulation of a structural model based on continuous mass distribution, an analysis of the wave force spectrum using the theory of random processes as applied to structure and the ocean, and an analysis of foundation conditions. The synthesis of the above will be attempted by numerical methods. (Ph.D. thesis.)

SUPPORTED BY Georgia Institute of Technology

8.0166, TURBULENT FLOW SPECTRAL ANALYSIS

P.G. MAYER, Georgia Inst. of Technology, School of Engineering, *Atlanta, Georgia* 30332

Boundary layer turbulence creates random pressure fluctuations. This pressure fluctuation creates noise and structural vibrations. Many engineering structures are subjected to random force applications and their response characteristics are closely related to noise problems. In fluid mechanics, pressure fluctuations are responsible for large drag forces and structural fatigue.

Design of hydraulic structures should include an analysis of the turbulent flow spectra.

SUPPORTED BY Georgia Institute of Technology

8.0167, HYDRAULIC INVESTIGATION OF TAINTER GATES AS FLOW MEASURING DEVICES

P.G. MAYER, Georgia Inst. of Technology, School of Engineering, *Atlanta, Georgia* 30332

An analytical and experimental study is proposed in which Tainter gates will be used as flow measuring devices.

The analytical study will entail a study of similitude relations and a hydrodynamic treatment of flow under and over partially open gates.

Scale models of existing installations will be built and systematic tests will be conducted in the hydraulic laboratory.

SUPPORTED BY Georgia State Government
U.S. Dept. of Agriculture

8.0168, AQUATIC PLANT CONTROL

A.B. MONTGOMERY, U.S. Dept. of Interior, Bureau of Sport Fish. & Wlfe., *Atlanta, Georgia* 30323

The ever-increasing demands on water resources of this country are being severely curtailed by the rapid encroachment of obnoxious aquatic plants. This has resulted in the necessity for control of interfering aquatic weed infestations. Such is most effectively accomplished through the use of chemicals. However, the chemicals must be harmless to aquatic organisms and safe for uses associated with human water supply.

The objectives of the investigation are to determine the effects of herbicides, used in the control of obnoxious aquatic plants, to fish and related organisms and their environment. Pre-, during and post-treatment data will be collected from field study areas which are treated under operational procedures. Standard fisheries collecting equipment and methods will be used. The studies will include acute and chronic toxicities of the chemicals, as well as residues which are accumulated in the various tissues and organs of the organisms, bottom muds and the water. Laboratory studies will be conducted as are deemed necessary and beneficial. In addition, the good or bad effects of alteration of the habitat through plant removal will be evaluated. This is a continuing study and will consider different plants, environments, and chemicals.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0169, INVESTIGATION EVALUATION AND DESIGN OF OPEN AND CLOSED CONDUIT SYSTEMS AS IT RELATES CONVEYANCE AND DISTRIBUTION SYSTEMS

UNKNOWN, U.S. Dept. of Interior, Bureau of Reclamation, *Boise, Idaho*

Review, evaluate and consolidate presently available studies and information, study operating costs of controlling and delivering water including justification of water control features such as meters, automation and remote control facilities, study maintenance costs, including amount and kind of personnel and equipment required to operate the system, from the information obtained develop models of closed conduit irrigation systems. This program replaces the Lower-cost Canal Lining Program.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0170, OBSERVATION AND EVALUATION OF INSTRUMENTATION IN THE FOUNDATION AND EMBANKMENT OF MORAINE STATE PARK DAM

C.H. MCCONNELL, Individual Grants, *Illinois*

To install piezometers in the foundation and embankment of dam to monitor the stability of lacustrine clay deposits in foundation during construction; to monitor stability of abutments after filling of reservoir and check effectiveness of Wakefield Sheet Piling and upstream blankets; and to monitor uplift pressures in bedrock and check effectiveness of grouting. Settlement plates will be installed and observed for foundation settlement during construction of dam embankment.

SUPPORTED BY Pennsylvania State Government

8.0171, GREAT LAKES, PORTS AND SHIPPING SYSTEM

A.R. MACMILLAN, Southern Illinois University, Transportation Institute, *Carbondale, Illinois* 62903

Purpose of Work: The purpose of this research is to: (1) to assemble under one cover technical and non-technical information regarding all phases of activities in Great Lakes ports; (2) to show the influence of the St. Lawrence Seaway in forming and reforming the ports and their waterborne directed functions; (3) to give complete details on a great many economic matters affecting a large number of Great Lakes ports, including investigation of territorial regions and zones tributary to such ports; and (4) the opportunities available for the American Merchant Marine.

Scope of Work: The basic purpose of this work is to compile a large amount of new diversified port and shipping data into a single volume. The Contractor is making a complete analysis of the present port system including the fundamental trends in land and water transportation. There is a growing need for a solid representation of the position of the Great Lakes ports and their data relevant to the economy of this vast coastline particularly to the promotion of the United States Merchant Marine.

SUPPORTED BY U.S. Dept. of Commerce - Maritime Admin.

8.0172, CORROSION MITIGATION -CATHODIC PROTECTION OF WATER-IMMERSED STEEL STRUCTURES

F.W. SHANKS, U.S. Army, Engineer District, *Rock Island, Illinois* 61201

Objectives. To investigate the technical and economic feasibility of cathodically protecting water-immersed steel structures of the Corps of Engineers and to develop practical cathodic protection designs for such structures.

Current and Proposed Investigations. The technical and economic practicability of cathodically protecting water-immersed steel components of Corps of Engineers waterways projects has been under study for several years. Numerous cathodic installations both of the galvanic anode type and impressed-current type have been designed and evaluated on practical structures. Factors which complicate the satisfactory application of cathodic protection are: (1) The components (usually gates of some type) move during operation. (2) The surface configuration is frequently complex. (3) Anode assemblies are generally subject to physical damage by turbulent water, ice, debris and waterborne vehicles. (4) Surfaces to be protected may be immersed only in part and only part of the time. (5) Competitive methods of protection, primarily coatings, are being continually improved and do not require the continuing surveillance inherent in cathodic protection installations. Currently a survey of cathodic protection experience on waterways projects is being conducted on a Corps-wide basis. The direction of future work will depend largely on the survey findings.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0173, PAINT TESTS

F.W. SHANKS, U.S. Army, Engineer District, *Rock Island, Illinois* 61201

Objectives. To conduct an investigative program designed to provide the greatest overall economy in protective coatings for Corps of Engineers structures, with primary emphasis on the metal components of hydraulic structures which are subject to water immersion.

Current and Proposed Investigations. This investigation has been in progress for many years and has led to the coating systems now used throughout the Corps on hydraulic structures and appurtenant works. In general, the investigation is designed to keep abreast of progress in the rapidly changing paint industry by formulating basic new film- formers and other new ingredient materials, or new combinations of accepted materials, into finished coatings which are evaluated on test panels and eventually on practical structures. Current and proposed work is designed to: (1) Improve the characteristics and further evaluate the performance capabilities of the standard coal tar-epoxy paint system used in the Corps. (2) Develop a zinc-rich primer best suited for use under standard vinyl type paint systems employed on water-immersible surfaces. (3) Continue the improvement of the Corps' vinyl systems for water-immersed steel. (4) Update previous studies of epoxy and urethane coatings. (5) Update previous studies relative to the ability of paint coatings (on steel) to resist damage by cathodic current. (6) Carry on cooperative test work with other independent agencies.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0174, ENGINEERING GEOLOGY

W.C. SMITH, State Geol. Survey, *Urbana, Illinois*

Continuing research and service on geologic conditions as they relate to engineering problems. Cooperation is extended to other State Departments with particular reference to highway construction, dam sites, reservoirs, foundation conditions, etc. Field conferences, examination of borings, and preparation of reports are undertaken for other State Departments or at the request of consulting engineers engaged on various projects.

SUPPORTED BY Illinois State Government

8.0175, COOLING TOWER TREATMENT

R.W. LANE, State Water Survey, *Urbana, Illinois*

Investigation is being made of cooling tower corrosion and scale prevention, and methods of water treatment and control. This program is being carried out in the several hundred cooling towers at State Institutions of Illinois.

SUPPORTED BY Illinois State Government

8.0176, EVALUATION OF CORROSION RATE TESTERS

R.W. LANE, State Water Survey, *Urbana, Illinois*

Investigation is being made of various corrosion measurement methods (as the I.S.W.S. corrosion test method, Berk tester, N.D.H.A. tester, and coupon tester), as applied to corrosion in cold and hot water distribution and in cooling tower and steam condensate systems.

(In cooperation with J.F.J. Thomas, Head, Industrial Waters Section, Canada, Dept. of Mines & Technical Surveys, Ottawa, Canada.)

SUPPORTED BY Illinois State Government

8.0177, STUDIES OF CORROSION SPECIMENS

R.W. LANE, State Water Survey, *Urbana, Illinois*

Pipe test pieces of galvanized steel, galvanized wrought iron, aluminum, and Alclad were distributed and installed for two years at twenty locations throughout the United States and Canada. After exposure to waters at measured velocities, the test pieces were cut into specimens and studied. Analysis is being conducted to strive for more meaningful relationships to predict corrosion rates from the water quality data.

Specimens were distributed in 1962 and collected in 1964. This study has been completed and the results have been reviewed by the committee, now called 'Technical Unit Committee T7E of National Association of Corrosion Engineers.' It is expected that the report will be published in a forthcoming issue of Materials Protection.

SUPPORTED BY Illinois State Government
National Assoc. of Corrosion Engineers

8.0178, CORROSION TESTING

R.W. LANE, State Water Survey, *Urbana, Illinois*

Corrosion tests (ISWS method, ASTM D2688) are being conducted in cold and hot water distribution systems in 50 Illinois State Institutions. The results are expected to aid in specifying materials which will be corrosion resistant to a particular water quality.

SUPPORTED BY Illinois State Government

8.0179, NITRATE IN SURFACE WATERS IN ILLINOIS

T.E. LARSON, State Water Survey, *Urbana, Illinois*

Periodic analyses are being made for NO3 on samples from streams in Illinois. These have clearly shown that this ingredient is increasing in concentration over the past 20 years. Intensive sampling of farm drain tiles is being conducted at several small watersheds to correlate with the fertilizer application over the past 5 or more years, and with the soil types, NO3 in streams, and factors influencing its presence in tile drainage.

SUPPORTED BY Illinois State Government
University of Illinois

8.0180, BOUNDARY EFFECTS ON JET FLOW PATTERNS RELATED TO WATER QUALITY AND POLLUTION PROBLEMS

W.H. MAXWELL, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

This experimental program will be divided into two phases: (1) Collection and analysis of further experimental data on velocity distributions downstream from a water jet introduced horizontally beneath the free surface of a deep reservoir. (See Project A-010-111). The diameter of the jet, submergence of the jet and velocity of efflux from the jet will be varied systematically to determine their influence on the flow pattern. (2) Velocity traverses will be taken of the flow field downstream from a water jet introduced horizontally beneath the free surface of a shallow reservoir. The diameter and submergence of the jet, velocity of efflux and the vertical location and slope of the lower fixed boundary will be varied systematically.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Illinois

8.0181, TURBULENT BOUNDARY LAYERS IN PRESSURE GRADIENTS

J.M. ROBERTSON, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

Near separations and in flows along surface of appreciable curvature (in flow direction) the pressure distribution across a turbulent boundary layer is not uniform, as predicted by elementary boundary layer theory. Integral equation analysis of layer development is able to cope with a pressure difference across the layer if it is known. Present phase of general turbulent boundary-layer studies is concerned with an evaluation of transverse pressure occurrences.

SUPPORTED BY University of Illinois

8.0182, FLOW IN ECCENTRIC ANNULAR PIPES

J.M. ROBERTSON, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

Motivated by an interest in the effect of an inserted pipe on the flow capacity of sewers, this study is concerned with the effects on flow capacity and friction factor of the eccentricity and diameter ratio. Experiments have been conducted on two diameter ratios at several eccentricities in the turbulent pipe-flow-regime. In the second phase of work the occurrences over a wider range of variables are being evaluated with the aid of the computer.

Appreciable deviations have been found from the common hydraulic assumption of no effect on friction factor.

SUPPORTED BY Amer. Society of Civil Engineers
U.S. Dept. of Interior - F. Water Pol. Ctl

8.0183, MICROSCOPIC INVESTIGATION OF TRACTIVE FORCE DISTRIBUTION IN OPEN CHANNEL

H.G. WENZEL, Univ. of Illinois, School of Engineering, *Urbana, Illinois*

Tractive forces for the case of three dimensional subvertical turbulent flow in open channels are determined using a microscope to observe the motion of small particles suspended in the flow. The small depth of field of the optical system permits velocity determinations to be made at various planes in the sublayer region. High speed photography is employed to record the particle motion. Velocity profiles near the boundary are used to compute the tractive force. A small glass walled channel is being employed with the depth of flow approximately one-half inch. Smooth and rough boundaries will be studied.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Illinois

8.0184, STUDY OF LIQUEFACTION OF SATURATED SANDS

S. PRAKASH, School of Res. & Trn. Equake., *Roorkee, India*

Loose sands may get liquefied if subjected to earthquake shocks. The variables affecting liquefaction are relative density of sand, vibration characteristics i.e. amplitude, frequency and acceleration of motion, time of vibrations and type of sand.

Studies of all these variables was undertaken for Obra Dam sand. Obra Dam is proposed to be 100 ft. high earth dam on 80 ft. deep deposit of loose to medium sand. The maximum earthquake acceleration to which the samples were subjected on a steady state vibration table was 10% g. It was found that the Obra sand was too coarse to liquefy. However, the maximum settlement under no super load was about 10%-15% of the height of sample. Settlement of this order may cause damange to slopes of the earth dam.

Blasting tests were performed at the proposed site, in order to verify the applicability of laboratory data to field problem. 60% gelatin was fired at a depth of 6m below the river bed. The quantity of charge varied from 1 kg to 3 kg. Pore pressure, settlement and surface acceleration (both in the vertical and horizontal direction) were measured.

It was found that results of laboratory could be extended to field conditions and Obra sand did not liquefy under simulated earthquake conditions.

Settlements of foundation were predicted under anticipated ground shocks in future and remedial measures suggested.

SUPPORTED BY Scientific & Industrial Research Council

8.0185, LIQUEFACTION STUDIES OF TENUGHAT DAM SAND

S. PRAKASH, Univ. of Roorkee, *Roorkee - Uttar Pradesh, India*

Tenughat Dam is proposed to be 165 ft. high earth dam on 50 ft. deep deposit of loose to medium sand. Loose sand may get liquefied and experience large settlements if subjected to earthquake shocks. The variable factors, the effect of which was studied on this sand, were (i) frequency (ii) acceleration (iii) number of cycles and (iv) effective surcharge under fully drained condition.

Saturated sand samples of 26 cm height were tested on a steady state horizontal vibration table. Pore pressures at 6 cm, 15.5 cm and 25 cm depth were measured. The settlement of the deposit was also recorded. It was found that Tenughat sand did not liquefy at anticipated ground motion and the maximum settlement under no super load was about 4 to 5% of the height of sample. When the surcharge was increased to 0.23 kg/cm2 the settlement & rise in pore pressure was reduced considerably.

Blasting tests were performed at proposed site to verify the aapplicability of laboratory data to field problem. 80% special gelatin was fired at a depth of usually 6 m below the river bed. Pore pressure, settlement, surface acceleration were measured. It was found that results of laboratory could be extended to field conditions. Settlements of foundations were predicted under anticipated ground shocks in future.

SUPPORTED BY Scientific & Industrial Research Council

8.0186, LIQUEFACTION STUDIES OF UKAI DAM SAND

S. PRAKASH, Univ. of Roorkee, *Roorkee - Uttar Pradesh, India*

Ukai Dam is proposed to be 265 ft high earth dam. In the river portion there remains a standing pool of water 12' to 15' deep. An under water sand fill will be constructed and will have 22 ft of maximum depth. Problem of excessive settlement and liquefaction under earthquakes of this loosely filled sand is being studied.

Saturated sand samples are planned to be tested on steady state horizontal vibrations table. Pore pressures of three different heights will be measured.

SUPPORTED BY Scientific & Industrial Research Council

8.0187, TURBULENCE IN LIQUIDS

J.W. DELLEUR, Purdue University, School of Engineering, *Lafayette - West Lafayette, Indiana* 47907

Heat transfer characteristics, system response and other operational factors were investigated, for the Hubbard Hot-Wire Anemometer and for the Thermo-Systems Cylindrical Hot-Film Anemometer using bare metal wire and quartz coated cylindrical film on glass wire, respectively. Experiments were done in deionized water and in ethylene glycol. Turbulence measurements were made in a submerged water jet. Measurements include mean velocity, fluctuating velocity, and one dimensional energy spectrum.

SUPPORTED BY Purdue University

8.0188, FLUID MECHANICS INSTRUCTIONAL EQUIPMENT

J.W. DELLEUR, Purdue University, School of Engineering, *Lafayette - West Lafayette, Indiana* 47907

This project calls for improvement in Undergraduate instruction in Fluid Mechanics. A number of new apparatus have been developed, designed, and built. Also a number of commercial equipment has been acquired. New methods of teaching undergraduate fluid Mechanics Laboratory have been evaluated.

SUPPORTED BY Purdue University

8.0189, FLOW REGIMES IN POROUS MEDIA

R.A. GREENKORN, Purdue University, School of Engineering, *Lafayette - West Lafayette, Indiana* 47907

The immediate objective of this proposal is to study the pressure response of fluid-filled porous media to determine predominant flow regimes as a function of the frequency of input pressure oscillations. The effects of property variation (heterogeneity) of the media, property variation of the fluids, and variation of pressure level will also be included. The initial mathematical model selected for the experiments is the linear wave equation for a viscous, fluid-filled porous medium. Four possible flow regimes, including the Darcy regime (creeping flow), have been deduced from this model for various combinations of the frequency of the input pressure, of fluid properties, and of media properties. The existence of these regimes and the parameters delineating these regimes will be determined by measuring the pressure response to input pressure oscillations in rigid and elastic capillaries, in homogeneous porous media and in heterogeneous porous media, all containing several different fluids. Measurements of the pressure response of fluid-filled porous media will be made at several pressure levels such that the compressibilities of the fluids and of the media may change. The wave equation model and the results of the experiments in rigid media, will be compared to determine the dynamic range of the regimes. Results of the experiments at higher pressure levels will be compared with models for elastic porous media. This project started in 1968 and completion is anticipated in 1972.

SUPPORTED BY U.S. National Science Foundation

8.0190, FLOW IN HETEROGENEOUS POROUS MEDIA

R.A. GREENKORN, Purdue University, School of Engineering, *Lafayette - West Lafayette, Indiana* 47907

A study of the phenomonological, statistical and mechanistic behavior of multiphase flow in heterogeneous porous media by measurement on Hele-Shaw and other physical models and by theoretical calculations based on mathematical and statistical models.

SUPPORTED BY Amer. Chemical Society

8.0191, FLUCTUATION OF RESERVOIR LEVELS AND THE RELATED CAUSE OF LANDSLIDES (THE OHIO RIVER VALLEY)

M.E. HARR, Purdue University, School of Engineering, *Lafayette - West Lafayette, Indiana* 47907

The specific objective of the project is to develop solution procedures whereby an assessment can be made of the potential instability of earth (soil or rock) slopes abutting bodies of water whose surfaces fluctuate with time. Such slopes may be natural or man-made. The earthen material may exhibit varying degrees of homogeneity and anisotropy with respect to permeability and strength.

Current procedures assume that seepage conditions are steady state; however, this state of affairs seldom is realized and is almost never critical. A computer solution will be developed to provide the location of the phreatic surface within the slope at any time. Of particular importance is the phenomenon of 'rapid drawdown', wherein a lowering of the water surface greatly leads the change within the earthen body. This condition is believed to be responsible for the recent failures in the Markland Dam Area on the Ohio River. These failures are to provide input for developing and checking the analytical procedures produced in the study.

The assessment capability will be developed at two scales: (a) general or regional and (b) detailed, or for a specific site.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Purdue University

8.0192, THE CHARACTERIZATION OF OVERLAND FLOW ON VERY ROUGH SURFACES

L.F. HUGGINS, Purdue University, School of Agriculture, *Lafayette - West Lafayette, Indiana* 47907

The objective of the proposed research is to determine the hydraulic relationships which govern the mechanics of shallow fluid flow over very rough surfaces. Such conditions characterize the majority of overland flow on natural surfaces where the flow geometry is composed of a myriad of small interconnected rivulets and channels rather than a continuous film or sheet of fluid.

The primary emphasis of the proposed research will be a comprehensive laboratory study of shallow flow over a variety of surface roughness conditions. This investigation will utilize equipment capable of applying controlled surface flow and artificial rainfall to a 12 foot square, variable sloping flow table. Results of the experimental investigation will be used to develop flow analysis techniques to describe the composite flow pattern on the basis of a statistical characterization of the flow surface rather than a complete mathematical description of the boundaries of each individual flow channel.

SUPPORTED BY Purdue University

8.0193, DEVELOPMENT AND CALIBRATION OF A PITOT SPHERE

G.H. TOEBES, Purdue University, School of Engineering, *Lafayette - West Lafayette, Indiana* 47907

A need exists for directionally sensitive mean flow measuring devices and a 5-hole pitot sphere is being developed. Used in conjunction with pressure transducers it will, when ultimately hooked up to the planned campus-wide hybrid computor, provide the possibility to map three-dimensionsl vector fields.

SUPPORTED BY Purdue University

8.0194, DESIGN OF INSTRUCTIONAL EQUIPMENT FOR LABORATORY DEMONSTRATIONS IN FLUID MECHANICS

G.H. TOEBES, Purdue University, School of Engineering, *Lafayette - West Lafayette, Indiana* 47907

The preliminary design for the equipment of a Towing Tank 150 feet long by 11 feet wide has been completed.

Final design of a research wind tunnel is being completed. Actual use of the equipment is scheduled in the fall of 1969.

SUPPORTED BY Purdue University

8.0195, PERFORMANCE CHARACTERISTICS OF LARGE SCALE HYDROMECHANICS LABORATORY EQUIPMENT

G.H. TOEBES, Purdue University, School of Engineering, *Lafayette - West Lafayette, Indiana* 47907

Under design are a 35' x1.5' x 3' and a 90' x 6' x3' tilting glass-lined flumes. The largest flume will accommodate sediment recirculation. A number of design problems are being studied which will be verified upon completion of the equipment. The main problems are: uniformity of inflow from headbox; residual turbulence in inflow; the boundary layer development in free surface flow and the length of flow establishemnt. The smaller flume is completed and measurements are being started using pressure transducers and hot-wire equipment.

SUPPORTED BY Purdue University
U.S. National Science Foundation

8.0196, FREE SURFACE FLOW AND WAVE PROPAGATION THROUGH CHANNEL-FLOOD PLAIN GEOMETRIES

G.H. TOEBES, Purdue University, School of Engineering, *Lafayette - West Lafayette, Indiana* 47907

This research consists in part of a laboratory investigation of the flow field through a prismatic channel flood plain geometry. Velocity distributions and energy losses have been evaluated for five geometries and at least nine flow conditions for each. An automated data collection system and data reduction computor programs for velocity distribution and free surface elevations have been developed.

SUPPORTED BY Purdue University
U.S. Dept. of Agriculture

8.0197, DESIGN REQUIREMENTS FOR MUNICIPAL DIATOMITE FILTERS

P.E. MORGAN, Iowa State University, School of Engineering, *Ames, Iowa* 50010

This study was undertaken to determine the characteristics of municipal applications in which diatomite filters may be used successfully, to study the effect of various variables on filtration economy and effectiveness, and to outline a procedure for designing a plant to operate with maximum economy. A theory of diatomite filtration has been proposed and verified for use in designing plants for the filtration of raw and chemically treated water. In the current work, a computer program is being developed that will be used for determining the characteristics of a filter to operate at least cost. A truck mounted diatomie water treatment plant is being operated in the field to gather design data for typical municipal water applications: iron removal, surface water filtration, coagulated water filtration, and filtration of limesoda ash softened water. These data will be fed into a computer to determine the economics of filtering such waters with diatomite filters.

Laboratory studies are being made to determine the hydraulic characteristics of filter cakes used in the removal of kaolin, montmorillonite, and other clays from water. The evaluation of coagulant and polyelectrolyte coatings for filter aids will be extended to determine the effects of pH and other factors on their removal of biological organisms and turbidity and on their hydraulic characteristics.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

8.0198, EFFECTS OF RIVER CURVATURE ON RESISTANCE TO FLOW

E.M. OLOUGHLIN, Univ. of Iowa, School of Engineering, *Iowa City, Iowa* 52240

Bed-form characteristics developed in a flow over cohesionless beds in straight and curved laboratory channels will be analyzed with the purpose of identifying readily measured and reproducible measures of stream-bed roughness. The roughness measures so derived will be incorporated into resistance relationships, and the effects of channel curvature upon the resistance equations will be examined.

Data will be obtained in the laboratory with the use of an ultrasonic depth recorder whose output is digitized by an IBM 1800 Data Acquisition and Control System.

Similar field data are being collected on the Missouri River under a cooperative research agreement with the Omaha District of the U. S. Corps of Engineers.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Iowa

8.0199, STUDIES ON THE GEOSCIENCE VALUE OF RADAR IMAGERY

D.S. SIMONETT, Univ. of Kansas, Graduate School, *Lawrence, Kansas* 66045

Eight students were supported on this project for the equivalent of about 6 man months each. Reports produced with

partial support from the project are: Kirk, J. N. and R. L. Walters (1966) Preliminary Report on Radar Lineaments in the Boston Mountains of Arkansas: The Compass of Sigma Gamma Epsilon, Vol. 43, No. 2, pp. 85-933. MacDonald, H. C., P. A. Brennan and L. F. Dellwig (in press) Geologic Evaluation by Radar of NASA Sedimentary Test Site: Institute of Electrical and Electronics Engineers (IEEE) Transactions on Geoscience Electronics, vol. GE-5, no. 3, pp. 72-78. McCoy, R. M. (1967) An Evaluation of Radar Imagery as a Tool for Drainage Basin Analysis. CRES Report 61-31, 102 pp. Morain, S. A. (1967) Field Studies on Vegetation at Horsefly Mountain, Oregon and its Relation to Radar Imagery: CRES Report 61-22, 19 pp. Morain, S. A. and D. S. Simonett (1967) K-band Radar in Vegetation Mapping: Photogrammetric Engineering, Vol. 33, No. 7, pp. 730-740. Moore, R. K. and D. S. Simonett (1967) Potential Research and Earth Resource Studies With Orbiting Radars: Results of Recent Studies. American Institute of Aeronautics and Astronautics, Proceedings, Fourth Annual Meeting, pp. 1-22. Walters, R. L. (1968) A Radar Bibliography for Geoscientists: CRES Report 61-30, pp. 1-27.

SUPPORTED BY U.S. Natl. Aero. & Space Adm.

8.0200, UNSTEADY FLOW PARAMETERS IN HYDRAULIC DESIGN

***Y. YU*, Univ. of Kansas, School of Engineering, *Lawrence, Kansas* 66045**

The purpose of this research project is to investigate experimentally and theoretically the characteristics of unsteady, incompressible flow involving the interaction between a conduit and a reservoir or other non-uniformities of boundary configuration.

The test system consists of a reservoir from which water flows through a conduit. Flow is varied by controlling a quick-acting valve. We propose to measure transient pressures with pressure transducers and transient velocities in the outlet conduit and reservoir with a hot-film anemometer or from high-speed movies.

Existing theoretical solutions will be compared with the experimental results and extended to other cases.

**SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Kansas**

8.0201, STUDY OF ENGINEERING PRACTICES OF IRRIGATION IN KANSAS

***G.R. TENEYCK*, Kansas State University, Agricultural Experiment Sta., *Manhattan, Kansas* 66504**

Objectives: The objectives of the project are to study (1) the factors limiting crop production on bench leveled land, (2) the factors that control the design of irrigation systems on sloping land, (3) the distribution of water on irrigated farms, (4) methods of irrigating orchards, and (5) the effects of tillage tools and time of tillage operations on crop production.

A contour bench has been leveled. Various fertility and cropping treatments are being carried out to determine the best method of bringing the area into irrigated crop production. Feasibility of bench leveling will be determined by comparing bench leveling with contour irrigation and sprinkler irrigation. Open ditches with portable and permanent structures and gated pipe to deliver water to level and sloping fields are being evaluated. An orchard has been established with trees growing in terrace channels. Irrigation water is applied in these channels. Additional trees will be planted on bench leveled land to determine a good method for irrigating trees along with the spraying operations that must be carried out. Roto tillers, moldboard plow and lister will be compared to determine their effects on crop yields and soil structure.

SUPPORTED BY Kansas State Government

8.0202, OPTIMAL DESIGN OF WASTE TREATMENT SYSTEMS

***L. TSENGFAN*, Kansas State University, School of Engineering, *Manhattan, Kansas* 66504**

The primary purpose of this investigation is to develop optimal designs and methods that lead to optimal designs for a veriety of waste treatment systems. The research will begin with an analysis, optimization, and process design study of the conventional activated sludge process and the complete mixing activated sludge process. Optimal designs of these two systems will be developed and the designs will be experimentally verified by operating pilot-scale models of the optimal systems.

Efforts will also be made to optimize other biological oxidation processes, entire waste treatment systems and advanced waste treatment systems (those involving adsorption, electrodialysis, etc. which are designed to provide reusable water).

A secon objective of this research will be to illustrate how modern optimization techniques such as dynamic programming and the generalized version of the maximum principle can be used to develop optimal designs and optimal operating conditions for waste treatment processes.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl

8.0203, SIPHON TYPE TRICKLE TUBE FOR FARM PONDS AND RESERVOIRS

***H.J. BRAUD*, Louisiana State University, Agricultural Experiment Sta., *Baton Rouge, Louisiana* 70803**

The design and field testing of siphon type trickle tubes for water level control in a pond or reservoir.

Design, fabricate and test in the laboratory several types of siphon pipes. Install an experimental siphon tube on a dam of a reservoir suitable from the hydraulic standpoint for evaluating the water level control achieved.

Alter and improve tube design as indicated by performance of field installation.

1. To design and test a siphon type trickle tube for maintaining a regulated water level in a reservoir. 2. To observe the performance of several siphon tube installations to determine life expectancy and problems encountered in actual field installations over a several year period.

SUPPORTED BY Louisiana State Government

8.0204, ENVIRONMENT CONTROL FOR ORCHARDS AND FIELDS

***H.J. BRAUD*, Louisiana State University, Agricultural Experiment Sta., *Baton Rouge, Louisiana* 70803**

Objectives: 1. To develop and evaluate practical methods for protecting citrus trees against damage due to windborne freezes. 2. To develop and evaluate practical methods for reducing hot weather stress on fruit and vegetable crops.

A citrus orchard is instrumented to study the effectiveness of water spray for preventing cold damage to trees. Several application methods will be evaluated. The use of irrigation spray for reducing hot weather stress on strawberries will be studied.

SUPPORTED BY Louisiana State Government

8.0205, DIVERTING MISSISSIPPI RIVER WATER TO TEXAS - A PRELIMINARY EVALUATION OF PLANS

***R.G. KAZMANN*, Louisiana State University, School of Engineering, *Baton Rouge, Louisiana* 70803**

A preliminary evaluation of published plans to divert water from the Mississippi River to Texas will be made. The alternate routes will be studied in view of the hydrologic characteristics of the river. An attempt will be made to evaluate the effects both positive (possible reduction of flood stage) and negative (degradation of water quality and reduction of discharge & stage at low flows) on the existing uses of water. The possible effects on the geomorphology of the lower Mississippi River will be determined on the basis of an operational analysis which will superimpose the proposed diversions on a portion of the historical record of flow.

**SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Louisiana State University**

8.0206, A STUDY OF STORM WATER INLET CAPACITIES

***UNKNOWN*, Louisiana State University, School of Engineering, *Baton Rouge, Louisiana* 70803**

The purpose of this project is to study the existing Louisiana Department of Highways standard storm-water inlets. The quantity of storm water that can be intercepted by the various types of inlets will be determined for various roadway grader and crown slopes. Full size wooden models will be tested in the laboratory and then field tests will be performed to verify the laboratory findings.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Louisiana State Government

8.0207, VERIFICATION OF HYDRAULIC COMPUTATION METHODS FOR BRIDGE SITES

UNKNOWN, U.S. Dept. of Interior, Geological Survey, *Baton Rouge, Louisiana*

To verify computation methods used for bridge sites, particularly with regard to stage discharge relationship, backwater determination, and division of flow among multiple bridges.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Louisiana State Government

8.0208, AQUATIC PLANT CONTROL - EQUIPMENT FOR MECHANICAL AND CHEMICAL DESTRUCTION

W.E. WUDERLICH, U.S. Army, Engineer District, *New Orleans, Louisiana* 70160

Short description of machinery that has been used in the past for aquatic vegetation destruction in Louisiana.

Development of special devices used in application of chemicals on aquatic vegetation. Description and sketches of these devices.

Examination of the equipment available on the commercial market for use in this kind of work and listing of those that appeared to be satisfactory for various types of jobs.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0209, FREE DROP WATER CONTAINER

R.L. WOODBURY, U.S. Army, Limited War Laboratory, *Aberdeen Proving Ground, Maryland* 21005

Tech Objective: To develop a water container which will survive a free fall drop from low flying aircraft. This container will provide a convenient means of water resupply to units operating in remote areas.

Tech Approach: The free drop water container is an eight inch tube, fifty-two inches long and holds 3 gallons. The tube is made of eight thicknesses of five mil modified polyurethane material, one inside the other. The external bag is international orange in color. The container is filled with three gallons of water and each tube is tied by means of a simple overhand slipknot. The filled bag is inserted in a corrugated carton 4-1/2' x 5-1/2' x 38'. The filled container ready for free drop weighs approximately 27 pounds. Empty tubes weigh 1 lb 10 oz and the corrugated carton weighs 1 lb 15 oz.

Progress: Development through successful South East Asia evaluation has been completed. The U. S. Army Materiel Command (U.S. Army Natick Laboratories) is currently processing operational requirements for the item.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0210, METHODS FOR CONTROLLING ALLIGATORWEED AND OTHER WEEDS IN CANALS, WATERWAYS, AND ADJACENT WATERS IN THE SOUTHEASTERN U. S.

F.L. TIMMONS, U.S. Dept. of Agriculture, *Beltsville, Maryland*

Research is conducted under laboratory, greenhouse, and field conditions to develop chemical and biological methods for the control of alligatorweed and other aquatic weeds such as waterhyacinth, waterlettuce, naiad, and others which clog navigation channels, irrigation and drainage ditches, and other waters in the Southeastern States and which interfere with boating, fishing, hunting, and other recreational activities. The research is conducted by the U. S. Department of Agriculture in cooperation with the Departments of the Army; Interior; and Health, Education and Welfare; the Florida U. S. Department of Agriculture in cooperation with the Departments Agricultural Experiment Station; Central and Southern Florida Flood Control District; Florida Fish and Game Commission, and other interested agencies including chemical companies. New and promising herbicides are evaluated for their effectiveness in controlling difficult-to-kill aquatic weeds in relation to environmental influences and including studies on factors affecting the absorption, translocation, and effectiveness of the chemicals and their disappearance pattern in water. The above studies and research on the Marisa snail and other biological control agents for aquatic weeds are conducted in Florida and adjoining states.

Work is also conducted in South America to find insects with sufficient specificity in their feeding habits to suppress alligatorweed and waterhyacinth without causing any damage to beneficial ornamental plants, crop plants, or other valuable plants.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0211, USE OF ATTERBERG LIMITS IN APPLIED SOIL MECHANICS

A. CASAGRANDE, Harvard University, Graduate School, *Cambridge, Massachusetts* 02138

The objective of this project is to develop a comprehensive set of guides which can be used to prevent errors and ensure reliability of Atterberg limits test results and applicability of these tests for defining other soil characteristics.

During previous fiscal years, the instruments and procedures for determining Atterberg limits were investigated, and laboratory tests were performed to measure physical properties of soils for correlations with Atterberg limits. Additional correlations were made between Atterberg limits and other engineering properties of cohesive soils. During FY 68 and FY 69, residual shear strengths of overconsolidated clays and clay shales are being determined to complete correlations.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0212, EMBANKMENT AND FOUNDATION MOVEMENTS ON THE INSTRUMENTED SECTIONS OF THE EAST ATCHAFALAYA BASIN PROTECTION LEVEE, ST. MARTIN PARISH, LOUISIANA

T.W. LAMBE, Mass. Inst. of Technology, School of Engineering, *Cambridge, Massachusetts* 02139 (DACW29-68-C-0016)

Soils research including analyzing and predicting embankment and foundation movement on the Instrumented Sections of the East Atchafalaya Basin Protection Levee which requires efforts in the areas of computer programming, analysis of field performance data and soil test data, soil testing, study of new data, field inspections, coordination with Government soils and levee design engineers, and preparation of reports summarizing work performed and results. The purpose of this research is to review, refine and confirm results of testing performed by personnel of the U. S. Army Corps of Engineers, New Orleans District, on the Instrumented Sections of the E.A.B.P.L. Extremely poor foundation conditions characterized by very soft subsurface soils which cause extreme settlement and shear failures have made it difficult to raise the guide levees of the Lower Atchafalaya Floodway which are deficient in grade and section. The instrumented sections were constructed to obtain data on settlement, stability and pore water pressures, prior to, during and after construction of stability berms and levee enlargement to determine the best methods of construction and the minimum factor of safety to use in design all in order to improve and accelerate levee construction in the Atchafalaya Basin.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0213, A GENERALIZED COMPUTER LANGUAGE FOR HYDROLOGIC AND HYDRAULIC ANALYSIS

F.E. PERKINS, Mass. Inst. of Technology, School of Engineering, *Cambridge, Massachusetts* 02139

Specifically it is proposed to develop a set of computational routines which are of general interest to hydrologists and hydraulic engineers, and to integrate these through a common data base and command structured language. It is proposed that this work be placed into a broad engineering context by making it a compatible part of the Integrated Civil Engineering System (ICES) which is presently under development by the Civil Engineering Department at M.I.T.

This would permit then the development of an extremely flexible data structure for integration of the routines and a convenient problem oriented language for the user. In addition it would place the hydraulic/hydrologic language in a system which is expected to find wide use by practicing engineers.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

8.0214, SNOW DISTRIBUTION MAPPING FROM SATELLITE PHOTOGRAPHY

A.F. FLANDERS, Allied Research Assoc. Inc. , *Concord, Massachusetts* 01742

Satellite snow-mapping techniques for plain's areas, developed under Contract No. Cwb-11209 with Allied Research Associates, subsequently have been tested under Contract No. E-162-67(N) with ARA. It has been deemed desirable by the Office of Hydrology of the Weather Bureau and the Environmental Sciences Group of the NESC to extend satellite snow-mapping to mountainous areas. The purpose of the proposed contract is to adapt the techniques previously developed for non-mountainous areas or, as is more likely to be necessary, develop new techniques for snow-mapping in the type of terrain characteristic of the western third of the United States.

TIROS and ESSA satellite pictures from the winter and spring months of 1964-1968 will be used to generate a representative sample of cloud-free days over the western third of the United States. After snow covered areas have been identified by techniques developed in previous studies, maps of snow cover distribution will be prepared, and the satellite snow mapping will then be compared with that done with conventional ground data.

SUPPORTED BY U.S. Dept. of Commerce - E.S.S.A.

8.0215, EXPLORATORY DEVELOPMENT OF WATER PROPULSION FOR COMBAT VEHICLES

Z.J. JANOSI, U.S. Army, Tank & Automotive Command, *Warren, Michigan*

The current study will investigate the following: a. Systems Analysis: A systems analysis will be initiated which ultimately will encompass all aspects of the military vehicle river crossing problem. The first phase of this study will be to establish the significance of various degrees of water performance, including swimming, fording, entry, and exit capabilities. Extensive river survey work will be conducted to identify the river characteristics and these data will be used as inputs to the systems analysis study. b. Mathematical Models: A mathematical model of the mechanics of river crossing will be established. This model will include the river environment, the pertinent vehicle characteristics and the mathematical relationship between them. c. Propulsion Systems: Various propulsion and control systems will be studied and experimentally evaluated to determine their performance and applicability for providing a significant improvement in swimming speed and maneuvering capabilities of future military vehicles.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0216, HYDRAULIC DESIGN OF STRUCTURES FOR WATER USE AND CONTROL IN THE CORN BELT

K. YALAMANCHILI, U.S. Dept. of Agriculture, *Minneapolis, Minnesota*

Object: To develop new and improved structures for water use, disposal, conveyance, and control; and to determine the hydraulic criteria for their safe, efficient, and economical design.

Plan of Work: This research seeks to establish principles and develop dimensionless designs for various water control structures which can be adapted to various site situations and size requirements on individual farms and ranches and in up stream watersheds. Studies are carried on principally by means of model studies at the St. Anthony Falls Hydraulic Laboratory, Minneapolis, Minnesota, and in close coordination with related research at the Outdoor Hydraulic Laboratory, Stillwater, Oklahoma.

SUPPORTED BY U.S. Dept. of Agriculture

8.0217, MODEL STUDY OF CONTROL STRUCTURES FOR FOOTHILL FEEDER TUNNELS

A.G. ANDERSON, Univ. of Minnesota, School of Engineering, *Minneapolis, Minnesota* 55455

These model studies are being carried out to examine the operating characteristics of several proposed control structures to be used to regulate the flow through the Foothill Feeder tunnel. This tunnel, 18.5 ft. in diameter, will receive water from the California water project and distribute it to the metropolitan area of Southern California. The control structures are needed to provide the proper hydraulic gradelines throughout the system and to provide for discharge rejection and distribution of the flow to various branches. The study is being carried out by the use of transparent models at a scale of 38.3:1. The principal objective is the development of the operating characteristics and to examine the efficacy of the proposed designs. The fluctuating pressure on the gates and piers are measured by pressure transducers and estimates are made of any potential cavitation. The project was started in January 1966 and its termination is expected by December 1968.

SUPPORTED BY Harza Engineering Company
California State Government

8.0218, MODEL STUDY OF SEWER DROPSHAFT

A.G. ANDERSON, Univ. of Minnesota, School of Engineering, *Minneapolis, Minnesota* 55455

This project is an investigation of the hydraulics of flow in vertical conduits or drop shafts having a length of the order of 200 ft. Thjs discharge is variable and air is entrained at the inlet and separated from the flow at the downstream exit. The flow of air-water mixtures at atmospheric pressures with entrainment in the direction of flow is the subject of interest. The project involves the experimental design of drop shafts for use in the proposed sewer system to accommodate surface runoff. The study was started in February 1967 and terminated in july 1968.

SUPPORTED BY Harza Engineering Company
Chicago City Government - Illinois

8.0219, LAKE ERIE DIKE

E. SILBERMAN, Univ. of Minnesota, School of Engineering, *Minneapolis, Minnesota* 55455

The Bethlehem Steel Corporation at its Lackawanna, New York plant proposes to contain the slag and other waste products previously dumped freely into Lake Erie by enclosing the waste area within a dike. It is the purpose of the investigation to determine the optimum outline and structure of the dike to (1) limit interference with navigation into Buffalo Harbor by wave reflection and refraction and (2) prevent contamination or silting of the several adjacent water intakes, especially the Erie County Water Authority and the City of Buffalo intakes. Other objectives may include a study of a larger enclosure to contain public wastes and a means for providing a ship docking facility. The study will be made by means of a physical model of the east end of Lake Erie at a distorted scale of 1:600 horizontal and 1:60 vertical. The research will take about one year from July 1968.

SUPPORTED BY Bethlehem Steel Corporation

8.0220, ENGINEERING PHASES OF SOIL AND WATER MANAGEMENT

C.L. LARSON, Univ. of Minnesota, Agricultural Experiment Sta. , *Saint Paul, Minnesota*

Cooperation with ARS-USDA is proposed on the following objectives: (1) To study characteristics of rainfall, infiltration, percolation, and runoff as related to soil and water management. (2) To determine what methods of drainage are best suited to soils of West Central and Northwestern Minnesota. (3) To develop amounts of and methods of irrigation needs in Western Minnesota. (4) To develop methods of controlling soil erosion.

SUPPORTED BY Minnesota State Government

8.0221, DURABILITY OF CONCRETE DRAIN TILE AND IRRIGATION PIPE
P.W. MANSON, Univ. of Minnesota, Agricultural Experiment Sta., *Saint Paul, Minnesota*

Description: 1. To develop a crushing strength test requirement where no absorption test is required, that will accurately measure whether or not a concrete drain tile meets the 'Extra Quality' specification. 2. To improve the type of the bearing head now used in making the crushing strength test of pipe.

SUPPORTED BY Minnesota State Government

8.0222, THE FLOW OF WATER IN FLUMES AND CANALS
J.C. MCWHORTER, Mississippi St. University, Agricultural Experiment Sta., *State College, Mississippi* 39762

The most commonly used basic equations for describing the flow of water in open channels suffer from some deficiency such as lack of dimensional homogeneity, improper assumptions of intensity of shear or some other reason. This project proposed to develop more reliable relations for describing the turbulent flow of water in certain man- made canals and flumes.

The study will be accomplished in three steps: (1) a dimensional analysis using the physical quantities necessary to describe the turbulent flow of water in prismatic open channels, (2) a collection of the reported data from the flow of water in man-made structures of various materials and cross-sectional shapes, and (3) an evaluation and relation of parameters through which the flow in channels of various materials and cross-sectional shapes may be described.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Mississippi State University

8.0223, CORROSION OF UNDERGROUND STEEL PILING
E.H. ARDAHL, U.S. Army, Lower Miss. Valley Div., *Vicksburg, Mississippi*

Objectives: 1. To investigate corrosion of underground steel piling by field inspection. 2. To develop criteria for the application of corrosion mitigation means to underground piling installations.

Procedures: The corrosion of underground steel piling in different soil environments is being studied by excavation of test holes at piling installations and by extraction of piles, where possible. Soil samples are obtained for classification and for electrical resistivity and pH determinations. Steel rod and pipe corrosion specimens have been placed at four select sites to compare the corrosion in distrubed and undistrubed soils with that of piling. Polarization curves are run periodically on the corroding specimens using a bridge-type circuit.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0224, GEOLOGIC AND ENGINEERING SIGNIFICANCE OF FRACTURED ROCK
D.C. BANKS, U.S. Army, Waterways Experiment Sta., *Vicksburg, Mississippi*

The study is to provide practical guidance for the investigation and analysis of rock masses, and define the direction and scope of future studies in rock mechanics.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0225, GROUTING RESEARCH - DAM FOUNDATIONS
R.A. BENDINELLI, U.S. Army, Waterways Experiment Sta., *Vicksburg, Mississippi*

The objective of this project is to conduct experiments on compositions of neat grouts, sanded grouts, and chemical grouts in order to develop effective and economical compositions for various conditions of grouting dam foundations so as to fill openings of a wide range of dimensions with materials having satisfactory properties of strength, ability to penetrate, volume constancy, and durability.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0226, DEVELOPMENT OF HYDRAULIC DESIGN CRITERIA
R.G. COX, U.S. Army, Waterways Experiment Sta., *Vicksburg, Mississippi*

The objective of the program is the analysis of hydraulic data, theories and procedures; the development of design criteria therefrom; and the dissemination of this information in the form of Hydraulic Design Criteria to insure adequate capacity, economy of design and construction and safe and satisfactory operation of the large hydraulic structures being designed, built and operated by the Corps of Engineers. Data sources include hydraulic model and prototype studies of all Federal Government agencies, domestic and foreign university work and professional periodicals and literature.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0227, MODEL STUDIES OF MASS CONCRETE STRUCTURES
H.G. GEYMAYER, U.S. Army, Waterways Experiment Sta., *Vicksburg, Mississippi*

The objective of this project is to select and/or develop instrumentation and techniques for the investigation of three dimensional stress fields in mass concrete structures by the use of small-scale microconcrete models. The initial phase consists of a thorough review and evaluation of small embedded strain (and stress) measuring devices, now being used in the United States and foreign laboratories in order to select or develop suitable model instrumentation. The second phase comprises materials studies and preliminary tests on basic concrete models to develop adequate model materials and techniques and to select optimum scales for subsequent studies on different scale models of existing and well investigated prototype structures.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0228, HYDRAULIC PROTOTYPE TESTS
E.D. HART, U.S. Army, Waterways Experiment Sta., *Vicksburg, Mississippi*

The general objective of prototype tests is to obtain experimental results from field tests on problems which cannot be solved by laboratory tests. The objective of this project is the coordination of the hydraulic prototype testing program of the Corps of Engineers to insure complete coverage of needed testing, to prevent unnecessary duplication of testing facilities and tests, to recommend instrument installations at projects where physical and hydraulic conditions will be suitable for obtaining data and to investigate hydraulic performance. Under the ES 805 program, Waterways Experiment Station personnel and equipment are made available to Districts conducting hydraulic prototype tests. Assistance also is given in planning test facilities, analyzing data and preparing reports.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0229, INVESTIGATION OF WATERSTOPS FOR CONSTRUCTION JOINTS
B.J. HOUSTON, U.S. Army, Waterways Experiment Sta., *Vicksburg, Mississippi*

The objective of this project is to determine the properties and performance of nonmetallic waterstops for use in joints in concrete structures and to prepare revised acceptance specifications and methods for testing. To correlate variations in properties with laboratory performance and performance in simulated service under a variety of exposure conditions, in order to realize the benefits of reduced costs and improved performance in the event that such will result from the substitution of appropriate nonmetallic materials for the metallic materials previously required.

The project is mainly concerned with the development and reporting of data resulting from the field exposure tests in severe environments. It is naturally concerned with new plastics that could be better than polyvinyl chloride plastic. Water retentivity properties of various shapes of waterstops have been investigated.

It will continue indefinitely also in connection with improvement and revision of specifications and methods of testing rubber and plastic waterstops.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0230, STABILITY OF RUBBLE-MOUND BREAKWATERS

R.Y. HUDSON, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to develop formulas and design criteria from which the action of waves on rubble-mound breakwaters can be determined with sufficient accuracy to provide economical and safe designs of full-scale structures.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0231, HARBOR DESIGN STUDIES

R.Y. HUDSON, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to determine criteria for designing harbors and harbor structures to obtain optimum wave protection for medium and large-size vessels. This will be accomplished by running tests to determine the optimum arrangement of breakewaters and navigation entrances to harbors to obtain the maximum wave reduction in the harbor, and to determine the effect of wave-front curvature on the amount of distribution of wave energy that enters a harbor through navigation openings of various dimensions and orientation with respect to the direction of wave approach. Additional tests will be run to determine effects of the so-called Mach stem phenomena on the optimum orientation of breakwater and vertical-wall piers; the relationship between the rate of wave attenuation in channels through shallow reef areas, and channel lenght, width, depth, and side slope; the effect of extending fill seaward along entrances of channels, through shallow reef areas, on wave pattern at the entrance of the channel and wave propagation through the channel; the relationship between harbor basin geometry and habor response to wave energy reaching the basin via the entrance channel.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0232, WAVE FORCES ON BREAKWATERS

A.M. KAMEL, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to develop a theory and obtain experimental data on wave pressures from which the magnitude, duration, and location of wave pressures and impact forces on full-scale breakwaters of the vertical wall and composition types can be predicted.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0233, INVESTIGATION OF PLANE STRAIN

B.N. MACIVER, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to develop the apparatus and techniques for determining the strength and stress-deformation characteristics of soils in terms of principal stresses under conditions of plane strain.

A high-capacity plane strain apparatus was constructed in FY 1968 following literature search and analyses conducted in FY 1967. Comparative plane strain and triaxial compression tests will be performed on several cohesionless soils to evaluate the significance of plane strain conditions. Subsequent testing will investigate the influence of specimen proportions, apparatus features, and variations in testing techniques on results. A larger plane strain apparatus may be constructed later to permit investigations of the effect of particle size of the test materials.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0234, INVESTIGATION OF TESTING METHODS AND APPARATUS

B. MATHER, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to carry out all authorized investigation of new methods of concrete testing, new apparatus for testing, and modifications of existing test methods and apparatus in order to determine whether such methods or modifications should be standardized for use in the Corps of Engineers.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0235, HANDBOOK FOR CONCRETE AND CEMENT

B. MATHER, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to maintain by means of quarterly supplements the Handbook for Concrete and Cement containing the latest and best compilation of specifications and methods of testing freshly mixed and hardened concrete, concrete aggregates, cementitious materials, concrete curing materials, mixing and curing water, and other materials for use in connection with concrete construction of Corps of Engineers. This project provides the Corps of Engineers with the only complete, up to date, reference work on specifications applicable to cement, pozzolans, aggregates, admixtures, curing materials, waterstops, joint sealers, concrete water, etc. Through quarterly supplementation, it is kept up to date.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0236, CEMENT - AGGREGATE REACTION

K. MATHER, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to investigate the factors affecting the development of excessive expansion of portland-cement concrete resulting from the chemical reaction between aggregates and cements, in order to improve the methods of detecting cement-aggregate combinations capable of reacting to cause such excessive expansion and to improve the procedures for avoiding undesirable results of the use of such combinations by modification of the composition of the concrete.

This project has made studies on effects of alkali content of cement, cement composition, effects of alkali-silica reactions, internally and externally applied restraint effects, and carbonate rock reactions. It has also sought means to measure the effectiveness of pozzolan to inhibit alkali-silica reactions.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0237, CONCRETE AGGREGATE RESEARCH

K. MATHER, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to conduct investigational work relating to the properties, performance, specification, and testing of aggregates for portland-cement concrete, so as to improve the prescribed procedures for selecting, approving, processing, and using such materials. It also maintains, by means of annual supplements, the compilation of test data developed by all Corps of Engineers laboratories on samples from sources of concrete aggregate in the continental United States. These activities have as their ultimate purpose the reduction of costs and improvement of quality of concrete used in Corps of Engineers construction.

This project has made studies of clay in aggregates, effects of aggregate on time-dependent volume change of concrete, and quality tests of aggregates. It has also studied the effects on structures of chert gravel aggregate, cherty limestone, graywacke, quartzite, etc.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0238, SOIL SAMPLING MANUAL

A.L. MATHEWS, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

Following a survey of the techniques and equipment currently in use by the Corps of Engineers and drilling contractors to determine the types of available equipment satisfactory for obtaining undisturbed and disturbed soil samples and performing in situ soil tests, a draft of a manual was prepared containing specific instructions as to techniques and drilling and sampling equipment to be used for foundation exploration on all Corps of Engineers' projects. The use of these techniques and drilling and sampling equipment will result in recovery of less disturbed soil samples, obtaining samples that might not otherwise be recovered, and reduction in exploration costs. As a result, the results of laboratory tests performed on the soil samples would be more reliable and would result in safer and more economical design. Future work will consist of revision of the manual based on review by others and subsequent publications.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0239, DEVELOPMENT OF INSTRUMENTS FOR PROTOTYPE TESTING

E.E. MCCOY, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to develop and to evaluate the performance of instruments designed to permit measurements of structural behavior of concrete structures through laboratory investigations and through experimental installations in prototype structures. This project develops procedures by which prototype behavior data can be reliably developed over long periods of time in order to provide a basis for improved structural design to effect improvements in serviceability and reduced costs of concrete structures.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0240, INVESTIGATION OF CREEP IN CONCRETE

E.E. MCCOY, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to develop standardized procedures for determining the time-dependent volume changes of concrete (especially creep and shrinkage), to develop data on the factors affecting the rate and magnitude of such changes of concrete as affected by the characteristics of materials, magnitude, time of application, duration of load and relative humidity, so as to permit more accurate interpretation of structural behavior data and more appropriate selection and use of materials to provide desirable performance.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0241, CONTINUATION OF FIELD EXPOSURE STATIONS

E.E. MCCOY, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to maintain field exposure stations at Treat Island, Cobscook Bay, Maine, and at Salt Run, St. Augustine, Florida, to continue the development of data on the resistance of concrete and concrete materials to the effects of natural weathering so as to permit the development of improved criteria for the selection of materials and concrete mixtures that will give satisfactory service regardless of the exposure to which they may be subjected.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0242, GENERAL SPILLWAY TESTS

T.E. MURPHY, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to provide general data for improvement of the design of spillway weirs and stilling basins. Discharge coefficients and pressure on spillway weirs of various heights for a full range of flow conditions to include heads in excess of that for which the weir is designed are of concern. This project will study pier and abutments contraction coefficients and discharge characteristics of crest gates. Stilling basin tests will be conducted for establishment of general rules for design of roller type energy dissipators and hydraulic jump-type stilling basins. The overall effort can be divided into under designed crest pressures and coefficients, tainter gate coefficients, pier and abutement contraction coefficients, and stilling basin design.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0243, CAVIATION

T.E. MURPHY, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to assist in development of designs for elements of hydraulic structures which will be free from cavitation damage. In accomplishing the purpose, efforts will be made to develop improved methods for prediction of prototype cavitation from model data. Also resistance of various materials to damage by cavitation will be studied. Close contact will be maintained with other installations conducting cavitation studies in order to take advantage of any new developments in technique. The overall project anc be divided into resistance of material, scale effects, and shapes for specific elements of structures.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0244, LOCK FILLING AND EMPTYING SYSTEM

T.E. MURPHY, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to provide new or improved design information and procedures to assist in the design of navigation lock filling and emptying systems. Present designs are accomplished largely by empirical methods based on results of hydraulic model studies of specific structures. Comprehensive tests will be conducted on different types of filling systems to obtain data over a wide range of conditions. Analysis of tests and other available data will result in improved generalized design information. The overall effort can be divided into side-wall port systems, multiport systems, interlaced lateral and split-lateral systems, and longitudinal floor culvert systems.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0245, RIPRAP-PROTECTION FOR HYDRAULIC STRUCTURES

T.E. MURPHY, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to develop criteria for the design of riprap protection at hydraulic structures. At present no positive design rules exist for riprap protection immediately upstream from low crests, along training walls, below stilling basins, or on overflow dikes. The overall effort can be divided into specific model tests, and basic mechanics of drag and lift.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0246, RIPRAP, REQUIREMENTS IN CHANNELS

T.E. MURPHY, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to develop improved criteria for the design of riprap protection for channels. Present methods have resulted in over design and thus excessive costs in some cases and under design and failures in others. Analytical studies will be made using presently available data. Flume tests will be made to provide data on shear forces, velocity distribution, and the basic mechanics of lift and drag. Large scale model tests of typical channels are planned for development of the final criteria.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0247, INVESTIGATION OF CONCRETING MATERIAL (OTHER THAN AGGREGATE AND CEMENTITIOUS MATERIALS)

L. PEPPER, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to carry out all authorized investigations of materials other than aggregates, cementitious materials, pozzolans and chemical admixtures, nonmetallic waterstops and gate seals, that may be proposed for use as concrete materials or in connection with concrete construction so as to evaluate any benefits that may accrue from their use and to indicate the desirability of developing specifications and methods of tests.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0248, EPOXY RESINS FOR CIVIL WORKS PROJECTS

L. PEPPER, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to develop information on the application that can be made of epoxy resin systems in connection with concrete construction and maintenance, and to select the most advantageous systems for the accomplishment of specific results, such as the repair of concrete surfaces that have been eroded by cavitation and the repair of cracks in existing concrete structures in order to permit the preparation of appropriate specifications and methods of testing for the acceptance of such systems for specific applications.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0249, RESEARCH ON PROPERTIES OF CEMENTITIOUS MATERIAL

L. PEPPER, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to conduct investigational work relating to cementitious materials including both portland cements and other cements so as to relate their properties to the performance of concrete containing them and to develop improved specifications and methods of testing in order that cementitious material may be selected and used to give the maximum assurance of satisfactory performance.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0250, RESEARCH IN MASS CONCRETE

J.M. POLATTY, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to develop information on pozzolans and chemical admixtures (including air-entraining) for use in portland-cement concrete, so as to permit the preparation of improved acceptance specifications and engineering manuals. The more effective utilization of such materials will permit the production of concrete with improved technical properties at a lower cost.

This project includes studies of pozzolans, lean mixtures with large amounts of pozzolan, temperature rise, water-reducing admixtures, lime-pozzolan reactions, air-entraining agents, calcium-chloride base solutions, low-activity pozzolans, sulfate resistance, frost resistance, effect of temperature on air-entraining admixture demand and effect of chemical admixtures on workability.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0251, PERFORMANCE OF CONSTRUCTION PLANT AND EQUIPMENT

J.M. POLATTY, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to conduct investigations and to develop data on the performance of items of plant and equipment that are used or may be proposed for use in Corps of Engineers concrete construction and to develop appropriate method for testing to evaluate the performance of such items of plant and equipment in the field in order to permit appropriate modifications of criteria for approving proposed construction plant and equipment so as to realize the benefits of new developments, the use of which may result in the production of concrete of improved quality and uniformity at reduced cost.

Investigations will be made of new plant and equipment as such becomes available and comes to our attention. Project plans will be formulated for approval as appropriate. Among the types of plant and equipment that may be investigated are: concrete mixers, including truck mixers; apparatus for indicating moisture content of aggregates; equipment for splicing reinforcing bars; belt conveyors.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0252, TENSILE CRACK EXPOSURE TESTS

E.C. ROSHORE, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to obtain information on the influence of variation in class of reinforcing steel, type of deformation on steel, depth of concrete coverage over steel, quality of concrete cover, and magnitude of tensile stress in steel on the performance of reinforced concrete beams subjected to severe natural weathering in order to permit appropriate revision of specifications governing the design of reinforced concrete members and the specifications for steel reinforcement when severe weathering is a characteristic of the exposure.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0253, DURABILITY AND BEHAVIOR OF PRESTRESSED CONCRETE BEAMS

E.C. ROSHORE, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to develop information on the factors affecting the performance of prestressed concrete members subjected to severe natural weathering as this performance is affected by the nature of the prestressing system employed and the state of stress of the member during exposure and the quality and properties of the concrete. It will also develop information on accessories such as end anchorages and construction procedures and materials such as the composition of grout mixtures and the methods of accomplishing grouting of prestressing tendons used in posttensioned prestressed members in order to permit the employment of prestressed concrete designs so as to realize advantages that may be inherent in such design.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0254, COMPILATION OF EARTH DAM CRITERIA FOR DESIGN USE

W.E. STROHM, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is the publication of design criteria for recently completed earth dams, giving sufficient information for use of designers in the field. The data on physical aspects, construction experience, and behavior of these earth dams are assembled and published.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0255, SPECIAL STUDIES FOR CIVIL WORKS SOILS PROBLEMS

W.E. STROHM, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

Includes collection, correlation, and analysis of field compaction control data and procedures for earth and rockfill dams, and other special studies such as evaluation of data on performance of slope protection subject to wave action to develop improved design criteria.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0256, PROTOTYPE ANALYSES - LOCK BEHAVIOR INVESTIGATION

C.C. TRAHAN, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

Field instrumentation of existing lock facilities to obtain prototype measurements of soil stresses on locks, internal stresses in concrete structure and lateral movement of the lock structure. Reports on instrumentation programs for two recently completed structures are being prepared.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0257, FORMING, FINISHING, AND CURING CONCRETE

R.V. TYE, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to develop data on the factors affecting the quality of concrete surfaces as these are the result of materials and practices employed in forming, finishing, and curing so as to develop procedures and specifications that will prevent to the greatest possible extent the occurrence of defective surfaces.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0258, INVESTIGATIONS OF PLACEABILITY OF CONCRETE

W.O. TYNES, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to conduct investigations and to develop data relating to the factors affecting the workability and consolidation of freshly mixed concrete and to evaluate the procedures currently employed in consolidating concrete so as to develop improved methods of measuring the consistency, workability, and placeability of concrete and improved criteria for the approval of equipment to be employed in effecting consolidation.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0259, IMPROVEMENTS IN CONCRETE CONSTRUCTION PRACTICES

W.O. TYNES, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to evaluate concrete construction practices and to compare the results obtained by variations in practices either within the limits of current requirements or outside of such limits as the case might be in order to appraise the desirability of revising current specifications so as to improve the quality and uniformity of concrete construction and reduce its cost. This project includes studies on effects of random fluctuations in coarse aggregate, effects of early freezing, effects of shape of grading curves for coarse aggregates, and preplaced-aggregate concrete.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0260, IMPROVEMENTS IN MASS CONCRETE MIXTURE PROPORTIONING

W.O. TYNES, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

The objective of this project is to investigate procedures for selecting proportions for concrete mixtures containing large aggregate particles in order to determine whether concrete of improved quality and uniformity or concrete of lower cost or both can be produced by the adoption of mixture proportioning procedures differing from these currently employed. This project will include studies on air content of mass concrete, maximum size aggregate mass concrete, and water cement ratio of exterior mass concrete.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0261, INVESTIGATION OF SHOTCRETE

W.O. TYNES, U.S. Army, Waterways Experiment Sta. , *Vicksburg, Mississippi*

Shotcreting is not a new art; however, poor practice on many applications has resulted in difference of opinion on the merits of shotcrete as a construction material. Laboratory evaluation of shotcrete has been hampered by the difficulty of securing representative samples of inplace shotcrete. The objective of this investigation is to evaluate shotcrete as a construction material for application to Corps Projects. Tests will be conducted to determine the correct sampling techniques, pertinent physical properties, and problem areas.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0262, STRENGTH OF JOINTED ROCKS

K.S. LANE, U.S. Army, Missouri River Engr. Div. , *Omaha, Nebraska*

This investigation is primarily concerned with developing methods to determine the rational design strengths of rock foundations - particularly intermediate quality rocks such as the softer limestones, shales, weakly cemented breccias and weaker layers within hard rock where strength is sufficiently low that it is often a key factor in design of superimposed structures of concrete and earth.

Emphasis is placed on shear strength of open joints, naturally cemented joints, seams, cleavage planes and weaker bedding planes with limited reference testing of intact cores. Studies include effect of cyclic loading, pore pressure, and joint surface roughness, supplemented by petrofabric studies of microcracks. As one product of this research, reports are being prepared covering the various testing techniques developed which it is hoped will serve to establish guides for rock testing procedures in other Corps laboratories. Furthermore, this effort will result in the preparation of reports which will discuss the factors which affect rock shear strength and the extent to which they should be considered in design.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0263, CONTROL OF SEEPAGE FROM CNNALS AND STORAGE PONDS IN NEVADA

P.R. NIXON, U.S. Dept. of Agriculture, *Reno, Nevada*

Objective: To develop treatments for control of seepage from small irrigation water storage reservoirs, stock ponds, and irrigation canals using locally available materials such as clay deposits and playa lake sediments or other materials as economically feasible within the area.

Plan of Work: Continue laboratory and field evaluation of available clay deposits and playa lake sediments to determine the factors and conditions resulting in durable and effective seals in canals and reservoirs. Emphasis to be on developing a procedure for predicting sealing capability of materials and on devising systems of applying or installing the seal. Work will involve both laboratory and field plot tests.

SUPPORTED BY U.S. Dept. of Agriculture

8.0264, MECHANICS OF ICE

G.E. FRANKENSTEIN, U.S. Army, Terrestrial Sciences Center, *Hanover, New Hampshire* 03755

Studies will be continued on ice jams on inland rivers, and ice conditions on the St. Lawrence Seaway. Studies will also be continued on removal of ice jams by use of explosives and other means.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0265, APPLIED PHYSICS AND MECHANICS

G. FRANKSTEIN, U.S. Army, Terrestrial Sciences Center, *Hanover, New Hampshire* 03755

Technical Objective: Study bearing capacity of sea and lake ice and means of increasing or decreasing this capacity. Develop theories of elastic and plastic deformation and stress distribution in snow and floating ice sheets. Study movement, ablation, deformation and subsurface temperature of glacial snow and ice.

Approach: Conduct strength and load tests on fresh and salt water ice including compression, tensile, flexural and heavy loads. Develop methods of increasing ice thickness by flooding techniques. Elimination of ice by bubbling techniques will be tested. Conduct field tests relative to leveling ice for airfields. Develop theory for bearing capacity of ice sheets and snow layers. Obtain measurements of annual ice cap movement at the Tuto ramp in Greenland. Observe pressure and deformation rates of buried structures in snow at Camp Century and in the ice tunnel at Tuto. Analyze data and prepare reports.

Progress: Strength and load tests on fresh and salt water ice have been made and analysis and reports prepared on ice thickness required for support of military vehicles. Studies of leveling rough sea ice for airfields have resulted in the development of an ice chipper which has been successfully used at Barrow, Alaska, and the Antarctic. Theoretical work has resulted in analysis of the river crossing problem, time dependent deflection of an ice sheet, and a design criterion for snow runways. Charts have been prepared using these theoretical results, which give required ice thickness to cross ice bridges of different widths and lengths. Three pressure cells have been installed at dye 3 and a data collection program established.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0266, TECHNICAL SUPPORT, INVESTIGATIONS OF ARCTIC CONSTRUCTION

***C.W. FULWIDER*, U.S. Army, Terrestrial Sciences Center, *Hanover, New Hampshire* 03755**

1. As part of a current study of dams in arctic and subarctic regions used to impound water, the following are in progress: a. Ground temperature observations made during 1953-1959 on a cross-section of an earth-fill dam at Thule, Greenland, were analyzed to determine the thermal regime in the structure under the influence of the impounded water. A report will be issued on the results in FY 69. b. of the design, construction and performance of an earth-fill dam at Livengood, Alaska, has been completed and a report will be issued in FY 1969. c. Liaison was maintained with the Division of Building Research, National Research Council on Power Generating Dams constructed in Canada.

2. Revised editions of the following Technical Manuals on Arctic and subarctic construction were prepared: TM 5-852-1 (EM 1110-345 660) 'General Provisions' TM 5-852-2 (EM 1110-345-661) 'Site Selection and Development TM 5-852-5 (EM 1110-345-664) 'Utilities' TM 5-852-7 (EM 1110-345-666) 'Surface Drainage'.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0267, STUDY OF MECHANISMS IN SOIL RELATED TO FROST HEAVE AND ITS CONTROL

***J.M. SAYWARD*, U.S. Army, Terrestrial Sciences Center, *Hanover, New Hampshire* 03755**

Technical Objective: Study fundamentals and use of foam bubbles for filling voids in soil to reduce water migration and hence frost heave.

Approach: Initially seek understanding of interfacial relationships involved in soil frost action, to assess the likelihood that fixed, i.e. film-enclosed, bubbles might limit movement of water to the freezing interface. Make practical test to determine if permanent foams can be mixed or produced in soils, and, if so, will they reduce water migration and heave without harmful effect on soil packing or strength.

PROGRESS: 21 April - 1 July 1966 - Technological literature and contacts with some ten authorities in foamed plastics suggest that the use of plastic film stabilized bubbles added to soil may not be promising. In the presence of appreciable proportions of mineral fillers, ordinary closed cell foams are collapsed. Temporary foams may find application as a means of more amount of soil. Two informal progress reports have been prepared, dated 9 May and 6 June 1966. It is expected that this project will be reinstated to one active status in FY 1970.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0268, HYDRODYNAMIC CHARACTERISTICS OF FLOW CONCENTRATION GROINS

***E.L. BOURODIMOS*, Rutgers The State University, School of Engineering, *New Brunswick, New Jersey* 08903**

The proposed work will evaluate hydrodynamic characteristics of a type of flood concentration groins devised to assist in artificial river aeration. The need for a sturcture to concentrate flow for mechanical type aerators in streams has been shown by other work in process.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Rutgers The State University

8.0269, STRUCTURE AND MECHANICAL BEHAVIOR OF POLYMERIC MEMBRANES

***J.A. SAUER*, Rutgers The State University, School of Engineering, *New Brunswick, New Jersey* 08903**

A study is to be carried out of the structure and mechanical behavior of polymeric membranes. Specific attention will be given to cellulose acetate films. The morphology and structure of such films will be studied by means of x-ray and electron microscopy. Samples to be investigated include dense films, porous films, asymmetric Loeb- type membranes, ultrathin films, and films prepared from single crystals. The mechanical behavior of the polymer films and membranes will be investigated by varied means, including sonic modulus measurements, and torsion pendulum measurements over a broad temperature range. Relaxation and melting transitions will be further investigated by means of calorimetric measurements. Attempts will be made to relate observed transitions, and the accompanying molecular motion, to the structure and morphology of the film as well as to preparation conditions and prior history. It is intended also to study the phenomenon of compaction as well as to initiate a stress analysis study of the reverse-osmosis membrane system.

SUPPORTED BY U.S. Dept. of Interior - Off. Saline Water

8.0270, EXPERIMENTAL STUDY OF MOTION OF CAVITATION BUBBLES

***V.J. LUNARDINI*, State University of New York, School of Engineering, *Buffalo, New York* 14214**

An analytical study of the inception of cavitation in venturi systems has been completed. This study has uncovered a number of questions which seem to be best resolved through an experimental program. A study will be made of the motion and growth of cavitation bubbles in an internal flow device. High speed photography will be used to obtain data on nucleation, the growth history of a bubble, and the position of a bubble within the venturi. Water will be used as the test fluid. It is hoped that the experimental program will clarify the basic mechanisms sufficiently to allow a more complete theoretical study to be undertaken.

SUPPORTED BY State University of New York

8.0271, EVALUATION OF POLYVINYL CHLORIDE (PVC) AND VINYL CLAD ALUMINUM PIPE USED FOR CARRYING IRRIGATION WATER WHEN BURIED WITHIN THE FROST ZONE

***H.M. OLSON*, North Dakota State University, Agricultural Experiment Sta. , *Carrington, North Dakota* 58241**

Polyvinyl chloride (PVC) pipe, 8-, 10-, and 12-inch diameter, and vinyl clad aluminum pipe, 8-inch diameter, will be installed in the frost zone with 3-foot minimum cover. Approximately 900 feet of 10- and 12-inch diameter low head PVC pipe and about 660 feet each of 8- inch diameter high (head 100 psi) PVC and vinyl clad aluminum pipe will be used. Repetitive lengths of 8-inch PVC pipe will be installed with different types of pipe joints, including as a minimum solvent- cement welded joints, threaded joints, and rubber gasket joints.

Pipe installations will be evaluated for installation procedures; flow charactdristics, corrosion resistance; bedding conditions; and overall performance relative to existing installations of nonreinforced concrete and asbestos-cement pipe.

Representative samples of new pipe and of bedding material will be furnished the Bureau of Reclamation laboratories for testing. Standard lengths of installed pipe will be removed in the future for examination and measurement.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0272, CONCRETE DITCH LINING AND PIPE FOR IRRIGATION SYSTEMS

***H. HOLMEN*, North Dakota State University, Agricultural Experiment Sta. , *Fargo, North Dakota* 58102**

Objectives: 1. To determine the potential useful life of different thicknesses of nonreinforced concrete linings placed in a farm irrigation ditch and the potential useful life of a non-reinforced low pressure concrete pipe placed 12 to 30 inches below ground surface. 2. To compare the economic factors of lined and/or closed conduit distribution systems with an open unlined system.

Description: About 650 feet of concrete lined ditch and 1775 feet of low pressure concrete pipe will be installed and studied to determine durability, frost action, action of machinery traffic, installation and maintenance costs, and water losses. A camera will be used to check internal condition of pipe. Surveying instruments will be used to check movement of pipe and lining due to frost action and other sources.

SUPPORTED BY North Dakota State Government

8.0273, SHEAR EVALUATION OF WEAK ROCK FOUNDATIONS

C.K. HOFFMEYER, U.S. Army, Ordnance Res. & Dev. Labs. , *Cincinnati, Ohio* 45227

The strengths of weak rocks such as indurated clays and shales in the Ohio River Basin are being determined in the field by in situ testing by special direct shear rigs. Comparison rock core specimens drilled with standard drilling equipment are being obtained and tested in the laboratory in direct shear blocks. The bond strength of concrete placed and cured on shales is also being tested in the field and laboratory. Different methods for preparing the rock surface preparatory to concrete placement are being investigated. The field testing is primarily accomplished at Ohio River Division navigation and flood control dam sites as they become available during early stages of construction.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0274, IMPROVEMENT OF WATER SUPPLY SOURCES AND STORAGE FACILITIES IN THE CORN BELT

R.C. REEVE, Ohio State University, Agricultural Experiment Sta. , *Columbus, Ohio* 43210

Object: To develop design criteria for ponds and other surface and subsurface water storage facilities. To investigate methods of suppressing evaporation and seepage losses from farm ponds.

Plan of Work: Study methods of reducing water losses by compaction, dispersion and other treatments on the hydraulic conductivity of the soil. Investigate the possibility of using the soils adjacent to the reservoirs for blanket materials. Test various dispersants as possible sealing materials for soils. Also, investigations are directed toward determining the rate of evaporation from ponds in relation to climatic factors. Study the probable amounts of runoff that could be expected for use as irrigation water.

Cooperation: Missouri Agricultural Experiment Station; SCS and other agencies.

SUPPORTED BY U.S. Dept. of Agriculture

8.0275, INVESTIGATIONS OF SHORE EROSION ALONG THE OHIO SHORELINE OF LAKE ERIF

C.E. HERDENDORF, State Geol. Survey Div. , *Sandusky, Ohio* 44870

Each year shore erosion removes approximately 3,000,000 cubic yards of bluff and beach material from the Ohio shoreline of Lake Erie. This study will provide information of the character of the shoreline, shore processes in areas of critical shore erosion and recommended methods of shore protection. Sixteen areas of critical erosion will be studied in detail. Methods of investigation will include: (1) repetitive, profiles of bluff, beach and nearshore areas, (2) current measurements, (3) repetitive aerial photographs, (4) observations of experimental shore protection structures, and (5) installation of water level gauging stations along the shoreline.

SUPPORTED BY Ohio State Government

8.0276, THE HYDRAULICS AND MEASUREMENT OF CHANNEL, FLOOD PLAIN, AND OVERLAND FLOW IN THE SOUTHERN PLAINS

W.O. REE, U.S. Dept. of Agriculture, *Stillwater, Oklahoma*

Object: To provide an understanding of the hydraulic phenomena associated with the flow of water in channels on flood plains and overland; to develop procedures for the application of basic physical principles to the solution of problems involving overland flow and unsteady hydraulics; to determine the flow retarding properties of various channel roughnesses in natural and artificial channels and flood plains; and to develop or adapt devices for the precise measurement of flow in streams, channels and constructed works.

Plan of Work: This work is carried on at the Outdoor Hydraulic Laboratory, Stillwater, Oklahoma, through investigations on natural channels and by means of model studies.

SUPPORTED BY U.S. Dept. of Agriculture

8.0277, HYDRAULIC DESIGN OF STRUCTURES FOR WATER USE AND CONTROL IN THE SOUTHERN PLAINS

W.O. REE, U.S. Dept. of Agriculture, *Stillwater, Oklahoma*

Object: To develop new and improved structures for water control, conveyance, and disposal; and to determine the hydraulic criteria for their safe, efficient, and economical design.

Plan of Work: This research seeks to establish principles and develop dimensionless designs for various water control structures which can be adapted to various site situations and size requirements on individual farms and ranches and in upstream watersheds. Studies are carried on principally by means of model studies at the Outdoor Hydraulic Laboratory, Stillwater, Oklahoma, and in close coordination with related research at the St. Anthony Falls Hydraulic Laboratory, Minneapolis, Minnesota.

SUPPORTED BY U.S. Dept. of Agriculture

8.0278, STUDY OF DISCREPANCY IN FISH COUNTS BETWEEN COLUMBIA RIVER DAMS

L.C. FREDD, State Fish Commission, *Clackamas, Oregon* 97015

Description: Work consists of a statistical review of past counting records, fish catch, spawning escapement, hatchery return records and other pertinent observations.

Purpose: To determine the extent and possible causes of discrepancies in counts of adult salmonids between Columbia River Dams.

Results: Average percent of the adjusted Bonneville 1957 through 1965 counts that were recounted at The Dalles, McNary and Priest Rapids - Ice Harbor Dams were as follows: Spring chinook, 80%, 70%, 46%; summer chinook, 78%, 78%; 66%; fall chinook, 78%, 57%, 28%; sockeye, 97%, 100%, 106%; and steelhead trout, 97%, 83%, 46%.

A. Differences in counts of a particular species at successive dams are proportional to the abundance of that species. B. Average differences in counts usually exceed estimates of numbers of fish spawning in intermediate tributaries. C. Counting error cannot be used to logically explain observed differences in counts. Rates of re-ascent by fallbacks probably do not differ greatly by species or dam, or from year to year. D. A common factor affects the survival of spring and summer chinook between dams, its effect changes little from year to year. A common factor also controls survival of fall chinook and steelhead between McNary and Priest Rapids - Ice Harbor dams; its effects are changing -- inter-dam survival has worsened each year since 1962. E. Physical size may influence survival of chinook between Bonneville and McNary dams; most mortality may be inflicted on large chinook.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0279, EVALUATION OF UPSTREAM AND DOWNSTREAM ANADROMOUS FISH PASSAGE AT RIVER MILL AND FARADAY DAMS ON THE CLACKAMAS RIVER, OREGON

L. KORN, State Fish Commission, *Clackamas, Oregon* 97015

Upstream salmon and steelhead trout migrations past River Mill Dam on the Clackamas River will be evaluated by observations of any blocked fish and counts of fish passing through the ladder. Records of past movements will be examined and timing and successful passage of adults will be recorded during the study period. Movements of downstream migrating juveniles will be followed by a mark-and-recapture program to determine the portion of the population which is shunted into a side canal leading to Faraday Reservoir. Results of these investigations will be used to recommend the most efficient fish management practices or modifications to the Portland General Electric Company.

SUPPORTED BY Portland General Electric Company

8.0280, EVALUATION OF ANADROMOUS FISH PASSAGE FACILITIES AT FALL CREEK DAM, BIG FALL CREEK, OREGON

L. KORN, State Fish Commission, *Clackamas, Oregon* 97015

This study will test and evaluate the efficiency of fish passage facilities for anadromous fish at Fall Creek Dam. We will determine the effect of the reservoir on survival, growth, and passage of juvenile salmonids and monitor the environment for changes. Results from this study will be used to recommend operating procedures for the fish facilities, if passage is successful. If passage is unsuccessful, alternate methods of maintaining the salmon and steelhead populations will be proposed.

SUPPORTED BY Oregon State Government
U.S. Dept. of Interior - Bu. Comm. Fish.
U.S. Dept. of Interior - Bu. Sport Fish.
U.S. Dept. of Defense - Army

8.0281, DETROIT TEST CHUTE

L.R. METCALF, U.S. Army, Corps of Engineers, *Portland, Oregon* 97205

The test chute has been provided to measure the amount of bulking effect on the depth of flow that occurs in a full-scale, high-head, spillway chute due to entrainment of air. The effect of air entrainment on velocity of flow will also be studied. The approximately 350-foot- high spillway was partitioned during construction to form a 42-foot- wide chute. The chute walls are surmounted by a traveling carriage upon which a staff gage is mounted to measure water-surface profiles. Nine sets of electrodes spaced 50 feet apart are mounted on the chute walls. Passage of a salt cloud will be observed electronically in order to determine mean velocities. Future test objectives will include measurement of velocity distribution and variation in air entrainment concentration with depth.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0282, DETROIT TEST CONDUIT

L.R. METCALF, U.S. Army, Corps of Engineers, *Portland, Oregon* 97205

The test conduit has been provided as a general purpose high-head test facility for testing control valves, resistance of concrete to cavitation and or erosion, steel liner requirements downstream of regulating gates, and multiple gated regulating outlet transitions. The initial program (1964 thru approximately 1969) involves the testing of high quality concrete slabs with special surface treatments. The primary objective is to determine if any surface treatment, other than steel lining, downstream from a regulating outlet slide gate open 20 per cent will resist the cavitational and or erosional forces due to operation with 300 to 320 feet of head. A secondary aim is to provide a comparison of the relative durability of surface treatments such as steel troweled, epoxy grout, epoxy mortar and rubber coated. The test gate (17 by 30 inches) discharges into a 21-inch wide by 4-foot high by 40-foot-long flume, of which the first 10-foot-long base panel is the test section.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0283, OPEN-CHANNEL TRANSITIONS IN SUPERCRITICAL FLOW

C.H. MCCONNELL, Penn. State University, School of Engineering, *University Park, Pennsylvania* 16802

Investigation of supercritical flow phenomena in open-channel transitions between an upstream rectangular cross-section and a downstream trapezoidal section, in a straight channel at constant and continuous invert slopes. Three types of transitions, one warped and two composed of plane wall, are being tested. The experiments with each of the three shapes cover combinations of at least three transition lengths and three depths with Froude numbers varing up to 3.0, Design criteria will be determined based on the test results.

SUPPORTED BY Pennsylvania State Government

8.0284, DYNAMIC BEHAVIOR OF SOILS

V.A. NACCI, Univ. of Rhode Island, School of Engineering, *Kingston, Rhode Island* 02881

The study of the behavior of soil under moderate static loading has evolved to the point where nearly every facet of the phenomena can be controlled, tested and usefully protected into practical soil mechanics. Many structures such as high dams that are built today subject soils to very high stresses and in addition dynamic problems associated with powerful blasts, seismic forces, and vibrations have extended the need for strength and behavior, characteristics far beyond the point where static parameters may be extrapolated.

The proposed study, therefore, will attempt to develop new theories, and to predict the behavior of soil masses to high pressure, transient and cyclic loadings and impact stresses. The work will include:

1. Examination of strength and deformation characteristics under impact loading. 2. Development of a pulsating or vibrating device. 3. Investigation of liquifaction phenomenia of soils under vibration and impact loads. 4. Correlations of laboratory work with field model studies.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Rhode Island

8.0285, INVESTIGATION OF SOIL FREEZING

G.L. RODERICK, Univ. of Rhode Island, School of Engineering, *Kingston, Rhode Island* 02881

Frost heaving of underlying soils can cause damage to canal and spillway linings, slope protection material of dikes and dams, and road surfaces. Such damage can lead to serious seepage losses, erosion and costly maintenance. The freezing of a soil-water system is a complex process affected by a large number of factors. The objectives of this study are to determine, for various soil types and freezing rates: the effects of initial moisture content, void ratio and saturation on the degree of ice segregation which occurs; the density required to resist heaving during freezing at near saturation; and migration of moisture and void ratio changes during freezing. Results should contribute to a more complete understanding of the soil freezing phenomena. Results will be correlated with common soil properties to establish criteria for evaluation of the frost susceptibility of soils.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Rhode Island

8.0286, COMPUTER MODELS FOR WATER DISTRIBUTION SYSTEMS

M.L. WOLLA, Clemson University, School of Engineering, *Clemson, South Carolina* 29631

The project entails an analytic study of water distribution systems operating under steady-flow conditions. The objective is the formulation of a class of mathematical models and related numerical solution algorithms which would provide flexible and efficient computer techniques for predicting the characteristics of existing or proposed water distribution systems. The project consists of three stages: Phase I is concerned with the theoretical study to devise secondary models and determine their properties in as broad and general a form as possible, and to consider specializations of these models as required to solve present and future problems arising in the operation or design of water distribution systems. The initial effort will be directed toward those models which are best suited for formulation and solution with digital computers. Phase II is concerned with the investigation of suitable numerical solution algorithms and their implementation on the digital computer; Phase III is concerned with a study of the feasibility of using the analog computer, either separately or in a hybrid configuration, as a means of obtaining desired solutions to the mathematical model.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Clemson University
South Carolina State Government

8.0287, TURBINE RATING FRAME INTERFERENCE STUDY

R.A. ELDER, U.S. Tennessee Valley Auth., *Knoxville, Tennessee*

TVA has underway a project to determine accurate discharge ratings for turbines in the nine dams on the Tennessee River by traversing the flow at the turbine intake gate slots of each unit with frames on which are mounted Ott cosine-component current meters. This study will consist of laboratory tests to determine what effect, if any, the current meter frame has on the accuracy of the measured flows through the turbines. Some tests were conducted during 1966. Further testing will be done in 1969 and 1970.

SUPPORTED BY U.S. Tennessee Valley Auth.

8.0288, SMALL RESERVOIR SEALING

J.I. SEWELL, Univ. of Tennessee, Agricultural Experiment Sta., *Knoxville, Tennessee* 37916

Phase I involved the making of permeability tests of the effects of various chemicals on seepage rates of soils representative of areas where pond leakage is prevalent. In the laboratory tests, nine chemicals were tested on five soils. The variables of the tests are: soil type, horizons in soil types, type of chemical, rate of chemical, soil density, cation exchange capacity, and soil acidity. After approximately 500 permeability tests, the sodium carbonates and phosphates appear to be the most promising sealing agents.

Phase II involved the making of field tests of the most promising sealing techniques. Ponds which were constructed for one or more years and which leaked excessively were treated. Stage height data were recorded. From this, the effectiveness of the treatments were evaluated.

Nine ponds have been treated. Eight of these held well, and one holds to a depth of only six feet.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
University of Tennessee

8.0289, PERFORMANCE OF CIRCULAR CULVERTS ON STEEP GRADES

UNKNOWN, Univ. of Texas, Graduate School, *Austin, Texas* 78712

Objective: (1) To determine the effects of outlet channel and culvert flow characteristics upon the formation of hydraulic jumps in the barrel of a circular culvert, and the effects of the jump upon culvert efficiency. (2) To investigate a new type of energy dissipator for reduction of erosion at the outlet of culverts on steep slopes. A hydraulic jump formed on a platform of circular sector plan is to be evaluated.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Texas State Government

8.0290, EVALUATION OF ENGINEERING PROJECTS AND ESTUARINE DATA (ESTUARINE PROGRAM)

R.J. HOOGLAND, U.S. Dept. of Interior, Biological Laboratory, *Fort Crockett - Galveston, Texas*

Estuarine-dependent species of the Gulf of Mexico coast comprise several of the nation's most valuable fishery resources. If the nursery grounds in the estuaries are to be preserved, it is essential that the estuarine habitat of these species be protected during and following construction of water-development projects in upland basins, estuarine systems, and coastal marshes. The increasing number, as well as complexity, of construction projects require a detailed understanding of estuaries.

It is the purpose of this project to (1) assist the Branch of River Basin Studies (BSFW) by reviewing all proposed construction and water-development projects affecting western Gulf estuaries and, when warranted, recommend remedial measures to reduce adverse project effects; (2) where practical, recommend changes in water-development projects whereby the habitat would be enhanced for the fishery resources; (3) inventory, organize, and keep current all published and unpublished data related to western Gulf estuaries; and (4) recommend basic research needed for protecting estuarine fishery resources.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

8.0291, CONTROL OF SEEPAGE FROM WATER CONVEYANCE AND STORAGE STRUCTURES IN THE INTERMOUNTAIN AREA

P.R. NIXON, Utah State University, Agricultural Experiment Sta., *Logan, Utah* 84321

Objective: To develop methods, materials, and devices for control of seepage from conveyance, storage, and application structures.

Plan of Work: Continue laboratory and field evaluation of effectiveness, suitability, and durability of various materials for seepage control in canals and reservoirs and for use in water distribution devices or systems. Develop installation and maintenance techniques using existing materials and new materials as they become available.

SUPPORTED BY U.S. Dept. of Agriculture

8.0292, FACILITIES AND SYSTEMS FOR WATER HARVEST IN THE INTER-MOUNTAIN BASIN

P.R. NIXON, Utah State University, Agricultural Experiment Sta., *Logan, Utah* 84321

Objective: To develop methods of collecting and storing precipitation, including installation procedures, construction materials, durability, performance, and maintenence requirements.

Plan of Work: Evaluation of durability of materials by accelerated aging, exposure tests, and in actual field test installations, will continue. Other factors under study are: slope of collecting surface, storage structures, evaporation control measures, maintenance requirements and construction techniques. Materials scheduled for testing include metal, asphalt, plastic film, synthetic rubber, and soil cements.

SUPPORTED BY U.S. Dept. of Agriculture

8.0293, SHORE-LINE ENGINEERING STUDIES ON GREAT SALT LAKE

W.P. HEWITT, Univ. of Utah, State Geolog. & Min. Surv., *Salt Lake City, Utah* 84112

The object of this study is to determine the effect of currents, storm waves, and heavy brine on engineering structures that might be built on Great Salt Lake, or upon its shores. A contour-map of the brine-lake bed contact is to be built, currents are to be studied and reefs are to be plotted.

This project is to commence in the summer of 1965.

Status: Lakewide survey involving current measurements, water depths, water temperatures and water densities are under way. Fathometer on loan from U.S. Navy will be tested this summer. Photography of Lake, obtained cooperatively in 1965 and 1966 with U.S. Geological Survey, will be studied for reef distribution and shoreline features.

SUPPORTED BY Utah State Government

8.0294, ENGINEERING CHARACTERISTICS OF THE BOTTOM SEDIMENTS OF GREAT SALT LAKE

W.P. HEWITT, Univ. of Utah, State Geolog. & Min. Surv., *Salt Lake City, Utah* 84112

The object of this study is to develop data that will aid in the design of structures that might be founded on the sediments that underlie Great Salt Lake's excessively dense brine. Therefore, in order to determine the bearing capacities of Great Salt Lake sediments, a series of 100-foot deep holes are to be drilled into the bottom sediments of the lake. Penetration and shear vane tests will be conducted in the field; Shelby tube samples will be collected for standard laboratory testing, and constituent properties of the sediments are to be identified.

The work is to be started in the summer of 1965.

Status: work on this project postponed.

SUPPORTED BY Utah State Government

8.0295, USE OF LARGE ROUGHNESS ELEMENTS FOR HYDRAULIC ENERGY DISSIPATION

H.M. MORRIS, Virginia Polytechnic Institute, Engineering Experiment Station, *Blacksburg, Virginia* 24061

General Design Criteria for flow regimes and energy dissipation in steep channels with large roughness elements are being developed. The characteristics of the tumbling flow regime are of special interest. Design application for chutes, culverts, and other highway drainage structures are in view. Experimental studies are being made both in a large laboratory tilting flume and in field installations.

SUPPORTED BY U.S. Dept. of Transportation - Public Rds.
Virginia State Government

8.0296, HIGH POWERED FLOATING NUCLEAR POWER PLANT CONCEPTUAL STUDY

P.D. ARROWSMITH, U.S. Army, Nuclear Power Field Off., *Fort Belvoir, Virginia*

Objective: Develop a conceptual design for a high power, high reliability nuclear power floating electrical generating station (40 MWE) with simultaneous capability of furnishing one million gallons of desalted water per day.

Approach: Work is being carried out in three phases (1) preliminary investigation of suitable reactor types, desalination concepts, evaluation of plant configurations and establishment of recommended configurations for reactor and desalination concepts for further study. (2) Conceptual design of nuclear desalination, power conversion, steam to electric systems - and evaluation and selection of a floating mount - capital costs, plant layout, weighs and overall evaluation of systems will be included. (3) Final selection of system plant integration, final capital and other costs estimates, layout of a plant procurement program and preparation of a final report.

Draft report reflects cost and sizing criteria that require updating. Additional effort will be expended to produce final report using latest maritime design and current nuclear and shipyard prices. This extends scope by twenty percent and will result in August 68 completion.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0297, DEVELOP DESIGN DATA FOR LIGHT WEIGHT WATER PURIFICATION UNIT

R.J. GAINEY, U.S. Army, Engineer Research & Dev. Labs., *Fort Belvoir, Virginia* 22060

Technical Objective: Develop design data for a water purification unit which will be used for production of drinking water in the field to support dispersed tactical forces of the Air Mobile Division.

Approach: Perform studies to determine feasibility of vacuum diatomite filters, hydraulically operated agitators, and chemical feeders and evaluate new materials applicable to the required characteristics of the new equipment.

A prototype model was fabricated in-house, including a pressure diatomite filter, coagulation basin, storage and accessories weighing less than 1000 pounds. Engineering design tests have been completed. Procurement data package was prepared for limited production. A contract has been awarded for 45 equipment sets.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0298, RESISTANCE OF CONCRETE TO SULPHATE WATERS

G.I. OWENS, U.S. Dept. of Interior, Civil & Structural Sect., *Coulee Dam, Washington*

This test was established and is being continued to determine the effect of alkline waters on reinforced concrete. Test specimens were made using various admixtures, several types of cement; 4-1/2, 6, and 7-1/2 sack mixes, and one aggregate source. The information gathered is of value in connection with construction of irrigation works where sulfate contact is anticipated.

The last tests, including photographs, were taken during the Fall of 1959. The next tests will be taken in the Fall of 1965 and thereafter on a five year basis. Interim work consits of routine observations, repairing minor leaks in the ponds, and maintaining the desired salt concentration therein.

SUPPORTED BY U.S. Dept. of Interior - Bu. Reclamation

8.0299, COLLECTION OF JUVENILE SALMON IN TURBINE INTAKES

J.R. GAULEY, U.S. Dept. of Interior, Fisheries Engin. Res. Lab., *North Bonneville, Washington*

Description: Fish are passed through a simulated portion of a penstock and their reaction to various gatewall slot configurations is measured.

Purpose: Other research has indicated mortalities as high as 11% to juvenile salmon that pass through turbines of Columbia River Dams. It has also been noted that many of these seaward migrants collect in the gatewall slots at existing projects. These studies are to determine if the gatewall slots can be modified and utilized as deflection and by-pass systems to prevent or reduce fish loss in turbines.

Results: These studies just initiated. Preliminary data collected have not yet been analyzed.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0300, MIGRATORY RESPONSE OF ADULT SALMONIDS TO WATER TEMPERATURE

J.R. GAULEY, U.S. Dept. of Interior, Fisheries Engin. Res. Lab., *North Bonneville, Washington*

Description: Fish are given choice of water of two variable temperature regimes. Reaction is measured.

Purpose: To obtain background data needed for locating and operating fish collection facilities at high storage projects where waters of different temperatures are released through turbines, regulating outlets and other facilities.

Results: Preliminary work on chinook, coho and sockeye salmon given a choice between existing river temperatures and water heated 3 degreess F, 7 degrees F, and 15 degrees above river temperature shows that a temperature increase of 3 degrees F had little effect on the response of migrating adult salmonids, but when the temperature was increased 7 degrees F above that of river flow, a number of fish rejected the heated water. River temperatures during these observations declined from 69.5 degrees to 63.8 degree F. Future research will include response to chilled as well as heated water.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0301, PASSAGE OF ADULT SALMONIDS THROUGH PIPES

J.R. GAULEY, U.S. Dept. of Interior, Fisheries Engin. Res. Lab., *North Bonneville, Washington*

Description: Adult salmonids are subjected to several hydraulic and light conditions in various lengths and configurations of 1-foot, 2-foot and 3-foot diameter pipes to determine fish passage potential of such transportation media.

Purpose: More efficient and less costly fish passage through difficult areas at dams than by conventional concrete channels. Modification of existing fishway exits to prevent loss of fish through adjacent spillways, temporary passage situations during project construction and the transportation of fish from point to point within a dam are examples of possible application of this work.

Results: These studies now in progress. Preliminary results indicated that salmon and steelhead will pass through dark, horizontal pipes up to 270 feet in length, including several 180 degrees bends. A 2-foot diameter pipe provided best results. Experiments were conducted in an endless horizontal 2-foot diameter pipe in FY 1966. The best test conditions for chinook salmon were a dark pipe with a water velocity of 2.5 f.p.s.; 100 percent completed 800-feet and 50 percent completed 1 mile. Sockeye salmon and steelhead trout made their best performances in a lighted pipe with a velocity of 2.5 f.p.s. At these conditions, all of the sockeye reached 2,335 feet, and 76 percent completed 1 mile; 100 percent of the steelnead attained 4,383 feet, and 90 percent completed 1 mile.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0302, MCNARY ARTIFICIAL SPAWNING CHANNEL STUDIES

J.S. CHAMBERS, State Dept. of Fisheries, *Olympia, Washington*

Description: A 2,400-foot channel, 30-feet in width with a designed flow of 60 cfs, was constructed on the basis of field criteria collected in earlier work. Adult Fall Chinook were placed in the channel annually over a nine-year period and the results measured.

Purpose: To determine if artificial spawning channels will provide a suitable replacement for natural spawning grounds inundated by dams.

Results: It has been demonstrated that fish will accept, spawn in and reproduce successfully in spawning channels when water conditions are adequate. Egg deposition has ranged between 27,000 and 2,100,000 annually with survival to seaward migrant varying from 5.2% to 36.6%. Adult returns to the channel have been small. Because high water temperatures during the incubating season are a limiting factor, production channels along the Columbia River below the mouth of the Snake River are not considered feasible. Several channels based on McNary data are being constructed by project developers on the Columbia River above the mouth of the Snake, where water temperatures are suitable.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0303, TEMPERATURE PREDICTION STUDIES RELATING TO THE DEVELOPMENT OF A POWER REACTOR SITE ON THE LOWER COLUMBIA RIVER

R.T. JASKE, Battelle Memorial Institute, *Richland, Washington* 99352

As a continuation of a previous program in which the dispersion characteristics adjacent to the site on river mile 72.8 were established along with installation of a temperature monitoring network, and a preliminary appraisal of the effects of the construction of Columbia Treaty dams on temperatures of the Columbia River, the following additional work was authorized: 1) Prepare a statistical probability analysis to determine the extent that time critical conditions may impose periods of shut-down (if any) of a proposed plant under the existing water management plans of control agencies and within the state water quality standards. 2) Extend this analysis to the downstream portion of the river to examine related effects involving flow transients from tides and river flow regulation for peak power requirement. 3) Technical supervision over the temperature collection network and analytical work involving analysis of recorded data.

SUPPORTED BY Portland General Electric Company

8.0304, FISH TRANSPORTATION

W.J. EBEL, U.S. Dept. of Interior, Biological Laboratory, *Seattle, Washington* 98102

One of the important techniques of fisheries management is the transportation of living fishes, sometimes for long distances. The solution of fish-passage problems in Columbia River Basin may require that anadromous fish be carried around dams or other obstructions, either as downstream migrant young or as adults migrating upstream to spawn. In either case, they are subjected to various hazards which may cause serious mortality, immediate or delayed. The purpose of this investigation will be to develop safe and efficient short- and long-range methods of transporting wild anadromous fish and to improve on contemporary methods of transportation.

Current efforts are concentrated on developing a system to detect magnetically tagged adult salmon and to separate them from untagged fish in a fishway. These tags, which are placed in juvenile migrants, will provide information on the survival of transported fish and their ability to home to natal streams when they return as adults. Subsequent research will be directed to the problems of holding fish in collection facilities prior to transport, transferring fish from holding to transport facilities, and reducing mortalities during transport and release operations. Predation, disease, and physiological effects during the various phases of transportation are receiving special attention.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

8.0305, ADULT SALMON BEHAVIOR STUDIES IN RIVERS AND AT DAMS (SONIC TRACKING)

J.H. JOHNSON, U.S. Dept. of Interior, Biological Laboratory, *Seattle, Washington* 98102

This project seeks information which will contribute to a sound assessment of the effect of reservoirs and dams on anadromous fish runs, specifically on adult salmonids returning to Columbia River system spawning areas. Such as assessment requires an accurate knowledge of migration timing and spawning area locations before dams are constructed, and of the amount and nature of mortality resulting directly from fish passage over dams.

The project's primary research tool at present is the sonic fish tag, a miniature high frequency sound transmitter attached directly to the fish. Since tagged fish can be tracked individually from boats, their continuous movements noted in precise detail, or their progress and dispersion upstream can be measured by means of automatic recording monitors placed at intervals along the shore above a tagging site.

Studies in progress are attempting to pinpoint the causes for losses of adult salmon between Bonneville, Priest Rapids, and Ice Harbor dams using sonic tracking devices and automatic recording monitors placed at strategic intervals along the Columbia River and tributary streams.

Studies are planned on the behavior of adult salmonids in estuaries, using sonic tracking techniques to examine migration in relation to tides, freshwater inflow, salinity, and other environmental factors.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

8.0306, PROTECTION OF FINGERLING SALMON IN TURBINES

C.W. LONG, U.S. Dept. of Interior, Biological Laboratory, *Seattle, Washington* 98102

This project is directed toward the assessment of losses of young salmon during passage through Kaplan turbines and the development of methods to reduce these losses.

The passage of juvenile salmon at dams on the Columbia-Snake river watershed is a problem of attrition. When all low-head dams are completed, some stocks of fish may have to pass as many as 10 projects to reach the sea. Problems of passage will be further compounded in the near future when many more turbines will be installed and fish now enjoying relatively safe passage through the spillways will be forced to use the turbines as their only means of egress to downstream areas.

Equipment and techniques are being used to investigate the causes of loss of fish in prototype facilities at Ice Harbor Dam and elsewhere in the Columbia Basin. Fish protection methods fall into three general categories: (1) Operating turbines to minimize mortality, (2) Eliminating lethal agents in turbines, and (3) Bypassing fish around turbines.

8. ENGINEERING WORKS

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

8.0307, FISH GUIDING

J.R. PUGH, U.S. Dept. of Interior, Biological Laboratory, *Seattle, Washington* 98102

Fish-guiding techniques examined by this project have included the use of electrical fields, louvers in combination with electricity, and large panel nets in conjunction with self-cleaning traps. Also studied was the distribution of fish in the natural environment as related to application of fish-guiding devices. Reports of these investigations are in final stages as project nears completion.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

8.0308, JUVENILE MIGRATION RATES

H.L. RAYMOND, U.S. Dept. of Interior, Biological Laboratory, *Seattle, Washington* 98102

This project is aimed at assessing the effects of dams and impoundments on the timing and survival of juvenile salmonids migrating to the sea. Extensive marking of fish is being done in tributary streams of the Columbia and Snake Rivers, using thermal brands. Recovery of marked fish from turbine intake gatewells at dams in the Columbia and Snake Rivers and from the estuary by purse seines and beach seines is providing data on rates of movement, timing of migration, and survival of young fish in relation to the changing environment.

Information being gathered will be used to identify areas in which delays and mortalities are occurring as the result of environmental changes. These findings would then be applied to implement management practices designed to enhance survival of seaward migrating salmonids.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

8.0309, SALMON PRODUCTION IN AREAS MADE INACCESSIBLE BY DAMS

G.R. SNYDER, U.S. Dept. of Interior, Biological Laboratory, *Seattle, Washington* 98102

Researchers will assess available spawning and rearing areas, condition of gravels, productive capacity of lakes and reservoirs, availability of re-seeding stock with desired racial characteristics, existing predator-competitor species, and demonstrate productive potential experimentally.

Prospects for successful reestablishment of salmon runs in areas blockaded by dams are to be evaluated in the light of expanding Indian fisheries and industrial developments in the Columbia Basin.

SUPPORTED BY U.S. Dept. of Interior - Bu. Comm. Fish.

8.0310, FISHERIES-TURBINE RESEARCH COMPENDIUM COMPILATION

M.C. BELL, Univ. of Washington, Graduate School, *Seattle, Washington* 98122

Description: Much research has taken place in recent years in a number of countries to determine the mortality or survival levels of juvenile fish that must pass through hydroelectric turbines on their migration routes to the sea and the possible causes of any mortalities. This project will compile and analyze these various tests utilizing automatic data processing techniques and attempt to inter-relate various test data to specific turbine characteristics.

Purpose: To compile and summarize in a single volume for ready reference all fisheries-turbine test data, experience records and allied test data. To analyze in a manner that will facilitate development of prediction techniques for survivals through any turbine. To determine the need for additional expensive field tests.

Results: This project is about 40% complete. Contacts have been made with all known researchers in this field to secure test results. (Interviews have been held with turbine design experts and fisheries specialists in such work). A form for compiling test data that can be easily coded for automatic data processing methods has been designed and compilation of test data is in progress.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0311, GUIDING JUVENILE AND ADULT MIGRANT SALMONIDS BY NON-ELECTRICAL MEANS

P.E. FIELDS, Univ. of Washington, Graduate School, *Seattle, Washington* 98122

Description: This research area, investigated over a 10-year period by the University of Washington, involves dozens of individual studies conducted in the laboratory and in the field. Primary emphasis has been on the reaction of fish to lights and water velocities. Tests were designed and conducted to scientifically measure the response of fish to many light-velocity situations.

Purpose: To determine the reaction of fish to the tested stimuli and provide, if possible, criteria for the design of deflection or attraction devices to aid in the collection or protection of fish at dams.

Results: Early in the work many visual stimuli were eliminated for various reasons. Flashing lights and colored lights were no more effective than steady white lights. Multiple light arrays appeared more effectively than single lights. Field tests at McNary Dam and The Dalles Dam in recent years provided general conclusions that: a. Under some conditions, artificial light can repel fish and divert them from certain areas. Such situations require the balancing of various stimuli so that light intensity overrides velocity, turbidity, depth and temperature. b. Under other conditions, artificial light can attract fish and concentrate them in particular areas. Some degree of light adaption is necessary before attraction will occur. These studies have been completed and a final report fully discussing the many tests and the complex reaction relationships has been prepared. These studies will be considered in future fish facility design situations, but it is questionable whether the positive reaction of fish to light possesses the required simplicity for practical application.

SUPPORTED BY U.S. Dept. of Defense - Army

8.0312, FISH PASSAGE THROUGH TURBINES

F.K. CRAMER, U.S. Army, Corps of Engineers, *Walla Walla, Washington*

Description: Juvenile fish were passed through model and prototype Francis and Kaplan turbines at the Allis Chalmers Plant, Pennsylvania, Cushman Power station, Washington, Shasta Dam, California and Big Cliff Dam, Oregon under a variety of operating conditions. Mortality rates were measured.

Purpose: To secure design and operating guidelines for improved survival of fish that must pass through turbines and to determine if safe fish passage through turbines is possible.

Results: Survivals as high as 89.6% through Francis turbines were achieved. It was determined that desirable Francis turbine characteristics for maximum fish survival are: a. Low runner speed. b. High efficiency. c. Deep setting of centerline of runner in tailwater to minimize cavitation. d. Maximum clearance between gates and blades and between blades. Other complex relationships were also established.

Survivals as high as 95.5% were achieved in Kaplan turbines. Maximum survival occurred at highest turbine efficiency, and is related to lowest cavitation index. Work is continuing in this field to determine if Kaplan and Francis turbines can be designed and operated to minimize or eliminate juvenile fish mortalities.

SUPPORTED BY U.S. Dept. of Defense - Army

9. MANPOWER, GRANTS, AND FACILITIES

Education-extramural; Education-in House; Research Facilities; Grants, Contracts, and Research Act Allotments.

9.0001, HYDROLOGY TRAINING AND METHODOLOGY

B.B. EICHERT, U.S. Army, Engineer District, *Sacramento, California* 95814

Activities: a. Methods systemization projects in which procedures currently in use in hydrologic engineering will be reviewed with purpose of developing step-by-step sequences, convenient formats, and other instructions necessary to increase efficiency of use, in order to reduce cost of studies and improve quality of results. New procedures will be developed for systematic applications. b. 'Training Courses', (16 weeks) group participation, classroomntype instruction, related to various phases of hydrologic engineering. c. 'Short Conferences or Seminars', (3-5 days) following planned agendas for guidance of open discussions and lecture-type presentations related to various phases of hydrologic engineering. d. 'Individual or Small Group Training Assignments', instruction and supervision of trainees assigned to the Center for two weeks or longer. Services performed will consist of supervision and necessary advice on methods, with reliance being placed on the trainee for actual analyses and solutions. Training is systematic with emphasis placed on subject areas of special importance to each trainee. Basic data and problem situations related to the trainee's home area will be utilized insofar as practicable.

SUPPORTED BY U.S. Dept. of Defense - Army

9.0002, ECONOMICS OF WATER TRANSFER - AN APPRAISAL OF INSTITUTIONS

D. SECKLER, Colorado State University, Agricultural Experiment Sta. , *Fort Collins, Colorado* 80521

Objectives: A. To investigate and compare various organizations and administrative procedures, which control the use of water in terms of their respective achievement and potentiality for allocative efficiency in water use among users and uses. Examine the factors that lead to flexibility, security, rigidity in water use. Also examine the role of water changes and prices in achieving allocative efficiency.

Consider: 1) Role of Northern Colorado Water Conservancy District in water use and transfer. 2) State water agencies and water organizations in Wyoming, Montana, Idaho and/or other states.

B. To investigate and estimate demand function for water in various uses and investigate complimentarity and competitive relationships between uses with emphasis on implications of these relationships for transfers between uses and organizational arrangements.

SUPPORTED BY U.S. Dept. of Agriculture
Colorado State Government

9.0003, SUPPORT OF THE COMMITTEE ON WATER

E.F. COOK, Natl. Academy of Sciences, *Washington, District of Columbia*

Funds are requested for partial support of the National Academy's Committee on Water. The Committee has three panels concerned respectively with scientific hydrology, water management, and education. These panels will investigate water resources needs with a principal objective of making recommendations for carrying forward national programs in the fields of scientific hydrology, water management and education. Committee activities will build upon previous investigations of needs in water resources research, such as the 1963 study for the Federal Council for Science and Technology, which was restricted to Federal Agency programs. Close coordination will be maintained with other groups, such as the Universities Council on Water Resources and the Committee on Status and Needs of the American Geophysical Union's Section on Hydrology, which may be investigating specific aspects of water resources research and education.

SUPPORTED BY U.S. National Science Foundation

9.0004, SUPPLY OF AND DEMAND FOR TRAINED WATER RESOURCES PERSONNEL - A PILOT STUDY

J. FISHER, Surveys & Research Corporation, *Washington, District of Columbia*

The project undertakes to develop the mthodology required to carry out a national survey, to be done at a later date, of the supply and utilization of and the current and future demand for trained water resources personnel. Key problems to be resolved include the identification of types of personnel working in the field of water resources, methods for collecting data as to their training, experience and utilization, capability of universities and other establishments to train the required manpower and the identification of establishments that employ these personnel. The work will be done by means of a developmental study through interviews with selected establishments, development of a survey instrument and a pre-test of it. The final output will be a questionnaire ready for a full-scale survey, instructions and definitions for respondents and a sampling plan so that a national survey that would be Phase II could be carried out.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch

9.0005, PARTIAL SUPPORT OF THE U. S. NATIONAL COMMITTEE FOR THE INTERNATIONAL HYDROLOGICAL DECADE

L.A. HEINDL, U.S. Dept. of State, *Washington, District of Columbia*

Brief Description of Research Project: Funds are requested for support of the National Committee for the International Hydrologic Decade. This committee will study the needs and make recommendations for U. S. participation in the program of the International Hydrologic Decade which is being developed by UNESCO.

SUPPORTED BY U.S. National Science Foundation

9.0006, AIDS FOR WASTEWATER SYSTEM PERSONNEL SAFETY AND ADVANCEMENT

G.W. BURKE, Water Pollution Control Fed. , *Washington, District of Columbia* 20016

In this project expert consultants will prepare informational materials describing the use of recommended practices in maintaining safety and in testing and certifying qualified personnel in water pollution control facilities. The consultants will study selected programs and evaluate the pros and cons on each program.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
Water Pollution Control Federation

9.0007, WATER RESOURCES RESEARCH, MANPOWER AND TRAINING NEEDS FOR INDIANA

D. WIERSMA, Purdue University, Water Resources Research Ctr. , *Lafayette - West Lafayette, Indiana* 47907

The project will be an attempt to study the water resources research needs of Indiana, the manpower required to adequately staff the research, planning, operating and management water resources programs in the State, and to develop training facilities, including the academic curriculum, which will fulfil these needs.

The resources of all the universities, State and Federal Agencies, and private organizations will be utilized.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Purdue University

9.0008, AN INVESTIGATION OF MANPOWER RESOURCES FOR WATER RESOURCES RESEARCH AND OTHER WATER-RELATED ACTIVITIES

J.E. LEWIS, Louisiana State University, Graduate School, *Baton Rouge, Louisiana* 70803

Can we satisfy the demand for water resources personnel during the period to 1985? Four principal intermediate objectives constitute the basic outline of the plan of work in this study:

1. identification of estimated levels of production of professional, technical, and other elements of the national labor force on a year-by-year basis to 1985; 2. identification of estimated manpower requirements in major scientific and technical programs and in industrial and occupational categories on the national level; 3. comparison of estimated manpower requirements with estimated manpower production at the pertinent educational and skill levels; 4. evaluation of the impact of the more general manpower supply and demand patterns on the availability of water resources personnel.

No attempt will be made to collect new data. The focus of the study will be on the analysis and interpretation of data currently available from the U.S. D.L., N.S.F. other government agencies and professional associations. A realistic understanding of the interplay of supply and demand in the national manpower situation is a prerequisite to planning for optimal utilization of water resources personnel and funds.

SUPPORTED BY U.S. Dept. of Interior - O. Water Res. Rch
Louisiana State University

9.0009, LOGISTIC SUPPORT AND MAINTENANCE OF FACILITIES

C.E. WILDE, Mount Desert Island Biol. Lab, *Salsbury Cove, Maine*

The Mt. Desert Island Biological Laboratory is one of very few independent marine biological research stations in the United States. It was founded in 1898 at South Harpswell, Maine, incorporated in 1914 and has functioned as a seasonal field station at Salisbury Cove, Maine. The laboratory has operated uniquely by cooperative voluntary efforts of its investigators. At the present time the yearly paid employees are in full time maintenance men and part time assistant director. The officers serve without renumeration.

Located on Frenchmen Bay, there is immediate access to organisms of the cold Atlantic waters as well as to environments of rocky shores, fresh water lakes, bogs, meadows and spruce forests. Acadia National Park is close by. The individual research programs carried out at the Laboratory represent a broad spectrum of marine biological research. The advantages of the later summer breeding seasons of certain invertebrates, the greater availability of other organisms throughout the season and special ecological aspects of the location have led to emphasis on certain kinds of research: comparative physiology of fish (especially renal and respiratory physiology); various aspects of development using marine eggs; problems of ion transport, cell division, regeneration, botanical ecology, fine structure, organ biochemistry, hemodynamics and general comparative physiology.

SUPPORTED BY U.S. National Science Foundation

9.0010, THE APPLICATION OF PROGRAMMED LEARNING TECHNIQUES TO WATER CHEMISTRY

K.H. MANCY, Univ. of Michigan, School of Public Health, *Ann Arbor, Michigan*

A series of programmed units on selected topics in water chemistry will be developed. This involves the careful definition of goals, precise instructional design and intensive testing and revision. The programmed material, together with carefully developed tests, will be distributed to different Federal, State and educational institutions for evaluation. Test results will be processed and analyzed and conclusions will be drawn. A comprehensive report on the feasibility of using programmed learning and the methods by which it can be applied in the field of water pollution control will be prepared.

SUPPORTED BY U.S. Dept. of Interior - F. Water Pol. Ctl
University of Michigan

9.0011, SUMMER RESEARCH AT THE UNIVERSITY OF OKLAHOMA BIOLOGICAL STATION

C.D. RIGGS, Univ. of Oklahoma, Graduate School, *Norman, Oklahoma* 73069

The University of Oklahoma Biological Station is located on the Oklahoma-Texas boundary at Lake Texoma, an artificial impoundment of approximately 93,000 acres created in 1942 by construction of a flood control and power dam on the Red and Washita Rivers. The area surrounding the Biological Station contains a variety of both aquatic and terrestrial environments for biological investigation including tall grass prairie, blackjack-post oak forests, and variety of hill, plain and valley vegetation available to this laboratory.

This interesting natural environment together with the substantial physical facilities of this field station provide the basic requirements for the excellent summer research and research training programs which have developed there. Although the Biological Station is maintained for use on a year round basis, summer is its season of peak activity. During this period its staff or faculty of 11, approximately half of whom come from institutions other than the University of Oklahoma, and 70-75 pre- and postdoctoral researchers and a group of advanced undergraduate and beginning graduate students assemble for 10 weeks of intensive study. Postdoctoral participants carry out their research independently whereas predoctoral and younger students receive appropriate supervision and some didactic training.

SUPPORTED BY: U.S. National Science Foundation

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HERBICIDE EVALUATION FOR PHREATOPHYTE CONTROL ...Consumptive Use, Herbicides -non-specific, Modified Water Use, Saltcedar, Tamarisk, Water Loss Control, ...**3.0132**

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CONTROL OF WOODY PLANTS ...Aerial - Airplane, Herbicides -non-specific, New Mexico, Rio Grande River, ...**3.0121**

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DISTRIBUTION, LIFE HISTORY, AND ECOLOGY OF EURASIAN WATERMILFOIL ...Chesapeake Bay, Range Or Territorial Distr. , Submerged Plants, Water Milfoil, Waterweed... , ...**6.0263**

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Weeds -physiological Studies

METHODS OF CONTROLLING CLUBMOSS (SELAGINELLA DENSA RYDB) AND REDEVELOPING THE PRODUCTIVE CAPACITY OF RANGES FOLLOWING CLUBMOSS CONTROL ...Applied Ecology, Lycopsida, Management and Fertility, ...**4.0160**

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WATERFOWL STUDY-EVALUATION OF PHYSICAL CHANGES IN MARSH PONDS ON THE WISNER AND BILOXI DEVELOPMENT ...Land Use, Mississippi, Physical-general, Survey Studies, Swamps-marshes, Water Fowl, N.s. , ...**4.0128**

EFFECTS OF WATERSHED MANIPULATION ON DEER AND ELK USE ...Cover Crops, Habitat Studies, Population Dynamics, Water Yield, Watersheds-general, ...**4.0003**

WATERFOWL MANAGEMENT THROUGH WATER-LEVEL CONTROL ...Depth,water Level, Fluctuation, Drawdown, Management -other, Water Fowl, N.s. , Wetlands, ...**4.0133**

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CHEMICAL CHARACTERIZATION OF WATERS OF PRAIRIE AND FOREST WETLANDS ...Chemical-general, Habitat Studies, ...1.0092

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SMALL-SCALE CIRCULATIONS OF THE SAN FRANCISCO BAY AREA ...Inversion, Land-sea Breezes, Model Studies, Orographic Effects, San Francisco Bay, ...2.0154

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CONVECTIVE CLOUD SYSTEMS, NORTHERN GREAT PLAINS, ATMOSPHERIC WATER RESOURCES ...Cloud Structure, Clouds-precipitation, Cumulus, Great Plains Province, Model Studies, ...2.0193

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AN EXPERIMENTAL STUDY OF EDDY DIFFUSION COEFFICIENTS, EVAPOTRANSPIRATION AND WATER USE EFFICIENCY ...Eddies, Evaporation, Evapotranspiration, Natural Variation of Water USE, Transpiration , Wind Or Air Movement, ...2.0437

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AIRFLOW AND DIFFUSION PARAMETERS IN CONNECTION WITH ATMOSPHERIC WATER RESOURCES PROGRAM ...Model Studies, Orographic Effects, Topographic Influences, Weather Modification-other, Wind Tunnels, ...2.0167

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PACIFIC OCEAN INFLUENCE UPON CALIFORNIA RAINFALL ...California, Forecasting, Pacific Ocean-general, Rain-other, Temperature, ...2.0104

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Turbulence-other

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CLIMATE RELATED TO PLANT RESPONSE IN THE MATANUSKA VALLEY ...Alaska, Evaporation, General Synoptic Observations, Sunshine, Transpiration and Evap, Velocity, ...2.0029

Land-sea Breezes

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Orographic Effects

SMALL-SCALE CIRCULATIONS OF THE SAN FRANCISCO BAY AREA ...Air Motion-general, Inversion, Land-sea Breezes, Model Studies, San Francisco Bay, ...2.0154

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HYDROMETEOROLOGY ...Mountains-alpine, Snowpack, Topographic Influences, Turbulence-other, Velocity, ...2.0218

TOPOGRAPHIC INFLUENCES ON PRECIPITATION ...Alaska, Patterns, Runoff, Topographic Influences, ...2.0028

PARK RANGE ATMOSPHERIC WATER RESOURCES PROGRAM ...Clouds-precipitation, Colorado, Nucleation Physics, Patterns, Technique Development, ...2.0164

THE DEVELOPMENT OF SNYOPTIC CLIMATOLOGY AND STATISTICAL FORECASTING METHODS AND OROGRAPHIC PRECIPITATION ...Patterns, ...2.0205

ATMOSPHERIC WATER RESOURCES RESEARCH UNIVERSITY OF WYOMING ...Cloud Formation and Evolution, Cloud Physics, Nucleation Physics, Snowpack, Wyoming, ...2.0162

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GREAT LAKES RESEARCH - LAKE WAVES ...Great Lakes-general, Waves, ...2.0641

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TROPICAL STORM RAINFALL AND HURRICANE WIND FIELDS ...Forecasting, Gulf of Mexico, Pressure-density, Tropical Cyclones, ...2.0595

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RADIO METHODS FOR DETERMINING WATER VAPOR CONTENT OF AIR ...Evaporation, Heat Budget, Humidity, Humidity Instruments, Oklahoma, Reservoirs and Impoundments, Transmission Characteristics, Water Loss Control, ...**3.0114**

SUPPRESSION OF EVAPORATION FROM WATER SURFACES ...Energy, Evaporation, Storage of Water, Temperature, Water Loss Control, ...**2.0034**

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MICROMETEOROLOGICAL INVESTIGATIONS OF THE ENERGY BUDGET - EFFECT OF SUMMER WINDS ...Evapotranspiration, Heat Budget, Heat Flow, Micrometeorology, Semi - Arid, ...**2.0516**

EVAPORATION OF WATER AS RELATED TO WIND BARRIERS ...Evaporation, Heat Exchange, Modified Water Use, Moisture Tension, Water Loss Control, ...**3.0138**

GREAT LAKES RESEARCH - HARBOR CURRENTS ...Currents - water, Great Lakes-general, Harbors, Model Studies, Pressure-density, Water Level Fluctuation, ...**2.0642**

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WIND EFFECTS ON THE DISPERSION OF PARTICULATE POLLUTANTS IN TURBULENT OPEN-CHANNEL FLOW ...Dispersion -water, Flow of Dispersed Solids, Open Channel Flow, Sediments, Turbulent Flow, ...**2.0220**

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EXPERIMENTAL STUDIES OF AIR AND WATER INTERFACIAL INTERACTION ...Pollutants - Path of , Turbulence-general, Waves, Wind-water Interaction, ...**2.0246**

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CONFERENCE ON SANITARY ENGINEERING EDUCATION ...Atmpopheric Pollution-general, Education and Training, Management, Meetings, Water Quality-general, ...**5.1152**

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Other

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Air Temperature Instruments

THE HYDROLOGIC SIGNIFICANCE OF CHEMICALLY DERIVED MEAN BASIN TEMPERATURES ...Aldose and Ketose, Evaporation, Forecasting-prediction, Heat Measurement, Pennsylvania, ...**2.0924**

WMO EVAPORATION PAN DATA ...Atmosphere Radiation, Evaporation, Standards, Specifications, ...**2.1113**

Air-earth Interface

Boundary Layer Studies

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OXYGEN TRANSFER TO WATER DROPLETS ...Diffusion-other, Oxygen, Water, ...**1.0038**

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Heat and Radiation Transfer

SURFACE TEMPERATURE STUDIES USING RADIOMETRY TECHNIQUES ...Aircraft, Infrared Radiation, Microwave Radiation, Surface Environments, Temperature, ...**6.0270**

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A STUDY OF PROBLEMS RELATED TO WIND-GENERATED WAVES ...Fluid-properties-other, Free Surface Waves, Laminar - Turbulent, Turbulent, ...**2.0132**

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RESIDENCE TIMES OF WATERS BEHIND BARRIER ISLANDS ...Bays, Circulation General, Simulation Theory, Tides, ...**5.0253**

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GREAT LAKES RESEARCH - LAKE WAVES ...Great Lakes-general, Waves, ...**2.0641**

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EVALUATION OF NEW TECHNIQUES IN ELECTRICAL RESISTIVITY SURVEYING IN THE PIEDMONT AREA, ALABAMA ...Electric Logging, Groundwater, Piedmont Province, Survey Studies, ...**2.0005**

WATER POLLUTION BY DAIRY FARM WASTES AS RELATED TO METHOD OF WASTE DISPOSAL ...Animal Waste Removal-treatment, Bacterial Pollutant Sources, Chemical Oxygen Demand, Farm Wastes, Management, Sewage Lagoons, Waste Disposal-general, ...**5.0011**

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COAL STRIP MINE WATERSHED DEMONSTRATION--JACKSON COUNTY, ALABAMA ...Aquatic Ecology, Coal-general, Mining Industry, Pollution - Effects of , Water Quality-general, ...**5.1124**

WRAGG SWAMP CANAL INVESTIGATION, ALABAMA ...Amount, Canals, Control Factors-general, Runoff, Urban Environments, ...**4.0001**

PROJECT 2203 EFFECTS ON PHYSIOLOGY WORK UNIT 53 CHRONIC EFFECTS OF ENDRIN ON BLUEGILLS ...Bluegills, Bream, Computer Matching Code, Endrin, Residue Analysis - other, Wildlife, ...**5.0022**

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INVESTIGATION OF SCOUR AT BRIDGES IN ALASKA ...Bridges & Culverts, Channel Geometry, Drainage, Erosion Control, Scouring, Suspension, ...**2.0285**

A STUDY OF TECHNOLOGIES FOR REDUCING WINTER WEATHER COSTS ...Benefit-cost Analysis, Forecasting-prediction, Great Lakes-general, Meteorological Extremes, Northeast, ...**2.0256**

CONTINUATION OF GLACIOLOGICAL INVESTIGATIONS ON THE CASEMENT GLACIER, ALASKA ...Floor Properties, General Synoptic Observations, Rate, Rheology - Flowage, ...**2.0858**

FOREST AND BOG OF SOUTH COASTAL ALASKA - INTRATYPE VARIATION AND ASSOCIATED HABITAT FEATURES ...Forests, Habitat Studies, Peat, Swamps-marshes, Variation, ...**2.0023**

REGIMEN OF THE MARTIN RIVER AND SIOUX GLACIERS, ALASKA ...Streams, ...**2.0849**

STUDY OF RED SALMON IN THE NUSHAGAK DISTRICT ...Chemical-general, Physical-general, Salmon -coho,chinook,sockeye.., Spawn Or Nesting Sites, ...**6.0622**

OBSERVATIONS ON RED SALMON IN THE KVICHAK RIVER SYSTEM ...Aquatic Ecology, Population Dynamics, Reproduction Studies (general), Salmon -coho,chinook,sockeye.., Streams, ...**6.0628**

INVESTIGATION OF SPAWNING GROUND POTENTIALS AND GROWTH AND SURVIVAL OF JUVENILE SOCKEYE SALMON IN FRAZER LAKE SYSTEM ...Censusing, Lakes, Nets, Salmon -coho,chinook,sockeye.., Spawn Or Nesting Sites, Tags, ...**6.0009**

MONITORING THE EFFECTS OF LAND USE ON SALMON PRODUCTION ...Construction Land Use Effects, Land Use, Logging, Transport, Equipment, Pulp, Paper , and Logging, Water Sampling, ...**5.0039**

RESTORATION AND REHABILITATION OF EARTHQUAKE DAMAGED PINK AND CHUM SALMON STUDIES IN PRINCE WILLIAM SOUND ...Aquatic Ecology, Data Acquisition-general, Earthquakes, Flow Characteristics -water, Salmon -coho,chinook,sockeye.., Spawn Or Nesting Sites, Stream Rehabilitation, Tectonics-general, ...**2.0026**

WATER QUALITY REQUIREMENTS IN ALASKA CAMPGROUNDS WITH PROJECTIONS OF RECREATION DEMANDS AND BENEFIT/COST ANALYSIS FOR SITE SELECTION ...Benefit-cost Analysis, Recreation Sites, Types of Resources, Water Quality-general, ...**6.0007**

A GROUNDWATER QUALITY SUMMARY FOR ALASKA ...Atlases-maps, Document & Literature Info, Groundwater, Water Quality-general, ...**7.0001**

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THE EFFECTS OF EXTREME FLOODS AND PLACER MINING ON THE BASIC PRODUCTIVITY OF SUBARCTIC STREAMS ...Benthic Fauna, Bottom Sampling, Floods, Meteorological Extremes, Placer, Productivity - Food Chain, ...**2.0022**

A STUDY OF THE FREEZING CYCLE IN AN ALASKAN STREAM ...General, Ice Properties-general, Sampling, Streams, ...**2.0018**

A WATER QUALITY COMPUTER MODEL OF COOK INLET (PHASE ONE - THE HYDRAULIC MODEL) ...Computers-general, Estuaries, Hydraulics-general, Model Studies, Water Quality-general, ...**7.0002**

ECONOMIC CONSIDERATIONS IN RESOURCES UTILIZATION CONFLICTS WITH PARTICULAR REGARD TO THE COOK INLET BASIN ...Benefit-cost Analysis, Conflicts, Economic Efficiency, Economics-general, Risk & Uncertainty, Survey Studies, Water Resources Development, ...**6.0008**

ORGANIC COMPOUNDS IN ALASKA PERMAFROST GROUNDWATER ...Gas, Organic, Permafrost-frozen, Spectroscopy-general, Thin Layer, ...**1.0005**

CLIMATE RELATED TO PLANT RESPONSE IN THE MATANUSKA VALLEY ...Direction, Evaporation, General Synoptic Observations, Sunshine, Transpiration and Evap, Velocity, ...**2.0029**

RESPONSE OF ALASKA'S ADAPTED CROPS TO SUPPLEMENTAL WATER ...Benefit-cost Analysis, Irrigation, Irrigation-general, Soil-water-plant Relationships, Water Sources -general, ...**2.0030**

OPTIMUM ESCAPEMENT STUDIES OF CHIGNIK SOCKEYE SALMON ...Aquatic Ecology, General Synoptic Observations, Lakes, Salmon -coho,chinook,sockeye.., Water Properties-general, ...**6.0623**

STUDIES OF SOCKEYE SALMON, ONCORHYNCHUS NERKA, IN THE KVICHAK RIVER SYSTEM, ALASKA ...Commercial Fishing, Productivity - Food Chain, Salmon -coho,chinook,sockeye.., Watersheds-other, ...**6.0627**

ARCTIC ECOSYSTEMS ...Aquatic Ecology, Energy Budgets, Freshwater Ecology, Polar, Productivity - Food Chain, ...**5.0236**

FROZEN GROUND INVESTIGATIONS, BARROW, ALASKA ...Frost and Permafrost, Hydrology-general, Ice Content, Permafrost-frozen, Runoff, Small Watersheds, ...**2.0748**

HYDROLOGIC STUDY OF A SMALL ALASKAN WATERSHED ...General, General Synoptic Observations, Hydrology-general, Small Watersheds, Water Sampling, ...**2.0749**

GEOHYDROLOGY OF THE ANCHORAGE AREA, ALASKA ...Groundwater, Surface Water, Urban Environments, Water Quantity-general, Water Resources Development, ...**2.0011**

WATER RESOURCES OF THE GREATER JUNEAU BOROUGH, ALASKA ...Observation Wells, Unconsolidated Aquifers, Urban Environments, Water Resources Development, Water Table Fluctuation, ...**2.0014**

WATER RESOURCES OF THE KENAI PENINSULA BOROUGH AREA, ALASKA ...Aquifers-general, Gaging, Groundwater Basins, Runoff, Water Resources Development, ...**2.0012**

TOPOGRAPHIC INFLUENCES ON PRECIPITATION ...Orographic Effects, Patterns, Runoff, Topographic Influences, ...**2.0028**

BRISTOL BAY ESTUARINE ECOLOGY ...Estuaries, Fishing Gear, Life History Studies, Migration, Salmon -coho,chinook,sockeye.., Water Mass & Ocean Fronts, ...2.0016

COASTAL AND INSHORE OCEANOGRAPHY ...Estuaries, General, Marine Biology, Other Sea Water Properties, Shoreline - Coastline, ...2.0015

PINK SALMON INVESTIGATIONS - FRESHWATER ECOLOGY ...Aquatic Ecology, Salmon -coho,chinook,sockeye.., Spawn Or Nesting Sites, Streams, Water Properties-general, ...6.0005

ESTUARINE STUDIES OF SOUTHEASTERN ALASKA ...Benthic Fauna, Environmental Ecology, Estuaries, Number Or Density, Vertical Distribution, ...2.0017

TOTAL ORGANIC CARBON AS A POLLUTION CONTROL PARAMETER IN SUB-ARCTIC WATE ...Chemical Identification, Infrared, Organic Matter, Oxidation-general, Technique Development, ...5.0031

DEVELOPMENT OF WASTE STABILIZATION LAGOONS FOR APPLICATION IN ALASKA ...Lagoon, Pilot Plant, Process Design, Sewage Lagoons, Storage-retention-facilities, ...5.0026

EFFECTS OF LARGE SCALE FOREST FIRES ON WATER QUALITY IN THE INT. AK ...Fire Damage, Recovery, Forest Watersheds, Soil Analysis, Soils and Fertilizer, Water Quality-general, ...5.0030

ORGANISMS RESPONSIBLE FOR TOXICITY OF ALASKAN CLAMS ...Biological Pollutants -general, Clams, Food Spoilage Detection, Microbiological, Pollutants-general, ...5.0032

Algae- Blue-green

Aphanizomenon

AN INVESTIGATION OF APHANIZOMENON FLOS-AQUAE, A TOXIC BY-PRODUCT OF EUTROPHICATION ...Algal Metab.(non-specific &ot), Eutrophication, ...5.0717

AUTECOLOGICAL STUDIES ON SOME DOMINANT PHYTOPLANKTON SPECIES OF LAKE CHAMPLAIN ...Algae-Diatoms, Cyanophyta (non-specific & Ot), Eutrophication, Freshwater Ecology, Vermont, ...2.1084

Cyanophyta (non-specific & Ot)

ECOLOGY AND PHYSIOLOGY OF THERMORPHILIC BLUE-GREEN ALGAE ...Adaptation , Habitat Studies, High Temp. - 85f Or Above, Hot Springs, ...2.0898

BLUE-GREEN ALGAE POISONING ...Algal Pollutant Sources, Algal Toxins, Arizona, Range Or Territorial Distr. , Vegetable Origin, ...5.0041

AUTECOLOGICAL STUDIES ON SOME DOMINANT PHYTOPLANKTON SPECIES OF LAKE CHAMPLAIN ...Algae-Diatoms, Aphanizomenon, Eutrophication, Freshwater Ecology, Vermont, ...2.1084

THE AUTECOLOGY OF SOME BLUE-GREEN PLANKTON ALGAE ...Algal Culture, Eutrophication, Mixed Culture, Nutrition Studies, Phytoplankton, ...5.0955

RELATIONS OF NUISANCE ALGAE TO FISH IN KLAMATH LAKE ...Algal Toxins, Bioassays, Fish -non-specific, Lakes, Oregon, ...5.0937

CULTURING AND PROPAGATION OF SELECTED INVERTEBRATES AND ASSOCIATED FOOD ORGANISMS ...Algal Culture, Chlorophyceae (non-specif.&ot), Chrysophyceae (non-specif.&ot), Food Supply, Invertebrate Cultures, ...5.0591

STRUCTURE OF THE BLUE-GREEN ALGA TOXIN ...Gas, Glucagon X Hor, Mass, Natural Occurring, Organic, ...5.0127

Oscillatoria

THE INCORPORATION OF C14 BICARBONATE INTO PIGMENTS OF A NATURALLY OCCURRING BLUE-GREEN ALGAE COMMUNITY WITH RESPONSE TO WAVELENGTH ...Chlorophyll, Phycobilins, Physiological Ecology, Pigments, Vitamins, ...6.0432

THE INCORPORATION OF C14-BICARBONATE INTO THE PIGMENTS OF BLUE-GREEN ALGAE POPULATION ...Carotenoid Pigments, Chlorophyll, Nutrients, Phycobilins, Pigments, ...6.0433

Algae- Brown

Phaeophyta (non-specific & Ot)

PRIMARY PRODUCTION AND DECOMPOSITION IN ESTUARINE WATER ...Estuaries , Florida, Methane Bacteria (non-specif.), Primary Productivity, Rhodophyta (non-specific & Ot), Turnover (metabolic), ...5.0257

PHYTOCHEMISTRY OF NARCOTIC PRINCIPLES IN CAULERPA ...Biochemical, Biochemical Analysis, Caulerpa, Cyclopropane, Medicinal Plants, ...6.0172

Algae- Diatoms

DISTRIBUTION OF DIATOMS IN DESERT WATERS ...Branchiopoda -other, Deserts, Plant Prod. (non-specific), Playas, Respiratory System, ...2.0138

ECOLOGICAL-PHYSIOLOGICAL INVESTIGATIONS OF LITTORAL DIATOM COMMUNITIES OF THE YAQUINA RIVER ESTUARY ...Environment, Intertidal Areas, Oregon, Physiological Ecology, ...5.0949

VARIABILITY IN DIATOM MORPHOLOGY AND WATER POLLUTION ...Algal Culture, Bioindicators, Environment, Pollution - Effects of , Water Quality-general, ...5.0217

AUTECOLOGICAL STUDIES ON SOME DOMINANT PHYTOPLANKTON SPECIES OF LAKE CHAMPLAIN ...Aphanizomenon, Cyanophyta (non-specific & Ot), Eutrophication, Freshwater Ecology, Vermont, ...2.1084

DIATOM POPULATIONS CHANGES IN LAKE GEORGE ...Eutrophication, New York, Plankton Sampling, Plant Succession, Recreation Sites, ...2.0816

FACTORS AFFECTING THE STRUCTURE OF DIATOM COMMUNITIES ...Acidity, Chemical Analysis (water), Environment, Mineral Content -water, pH -water, ...5.1008

ECOLOGY OF DIATOMS IN HARDWATER HABITATS ...Algae, Environmental Changes, Habitat Studies, Paleoecology, Pollen, ...5.0406

DIATOM REMOVAL BY FLOCCULATION ...Algal Pollutant Sources, Flocculation, Plankton (non-specific), Sand, ...5.0353

Algae- General

A STUDY OF THE PRIMARY PRODUCTIVITY OF NEW AND OLDER RESERVOIRS ...Climate-general, Fish -non-specific, Primary Productivity, ...2.0149

EXCHANGE OF PHOSPHORUS SPECIES BETWEEN LIVING AND NONLIVING SYSTEMS IN FRESH WATER ENVIRONMENTS ...Bioindicators, Biological Treatment-general, Nutrients, Waste Water Treatment-general, ...5.0812

DETERMINATION OF THE FEASIBILITY OF REMOVAL OF ALGAL NUTRIENTS IN LAKE WATERS BY ION-EXCHANGE ...Eutrophication, Ion Exchange-other, Lakes, Nutrients, Phosphate, Phosphite, ...2.0610

EFFECTS OF ZOOPLANKTON ON PHOTOSYNTHESIS BY ALGAE IN LAKES ...Interbiotic Relat.(non-specif), Lakes, Migration, Photosynthesis, Zooplankton, ...2.1103

DISPERSAL OF VIABLE ALGAE AND PROTOZOA BY AQUATIC INSECTS ...Aquatic Ecology, Insects -non-specific, Interbiotic Relat.(non-specif), Invertebrates, Protozoa -other, ...5.1170

INORGANIC-ORGANIC INTERACTIONS IN NATURAL WATERS ...Chemical-general, Color, Organic-general, Physical-general, ...5.0603

TAXONOMY AND ECOLOGY OF INSHORE MARINE MICROBIOTA ...Animal Taxonomy, Aquatic Ecology, Plant Taxonomy, Protozoa -other, Range Or Territorial Distr. , ...7.0024

BACTERIDAL EFFECTS OF ALGAE ON ENTERIC ORGANISMS ...Algal Culture, Bactericides -non-specific, Intestinal Bacteria, Sanitation, Sewage, ...5.1151

THE FRESHWATER ALGAE OF SOUTH CAROLINA - FLORISTICS AND ECOLOGY ...Freshwater Ecology, Plant Taxonomy, South Carolina, Streams, ...6.0487

THE ALGAE AND ZOOPLANKTON OF PROTECTED AND EXPLOITED LENTIC HABITATS IN NORTHEASTERN OHIO ...Aquatic Ecology, Freshwater Ecology, Habitat Studies, Ohio, Zooplankton, ...6.0431

ALGAE IN ILLINOIS WATERS ...Illinois, Plant Taxonomy, Water Sampling, ...6.0184

ALGAL GROWTH POTENTIAL OF ILLINOIS WATERS ...Bioindicators, Growth (non-specific & Ot.), Growth and Differentiation, Illinois, Other, ...6.0199

THERMAL AND BIOLOGICAL CHARACTERISTICS OF LAKES ...Evaporation, Indiana, Lakes, Stratification, Temperature, ...2.0452

MEASUREMENT OF THE RATE OF CARBON DIOXIDE (C14) FIXATION INTO SUBCELLULAR FRACTIONS OF ALGAE ...Algal Culture, Bioindicators, Carbon, Carbon Dioxide Fixation, Growth Rate, Intracellular Localization, ...5.1090

A STUDY OF MICROORGANISMS INDUCING TASTES AND ODORS IN WATER ...Actinomycetes -non-specific, Gas, Mass, Taste and Odor, ...5.0212

Algae- Golden-brown

Chrysophyceae (non-specif.&ot)

CULTURING AND PROPAGATION OF SELECTED INVERTEBRATES AND ASSOCIATED FOOD ORGANISMS ...Algal Culture, Chlorophyceae (non-specif.&ot), Cyanophyta (non-specific & Ot), Food Supply, Invertebrate Cultures, ...5.0591

Prymnesium

STUDY OF TOXIN SYNTHESIS IN SYNCHRONIZED PRYMNESIUM ...Algal Toxins, Biosynthesis, Cell Cycle, Hemolysins - non-specific, Synchronization, ...1.0089

Algae- Grass-green

Caulerpa

PHYTOCHEMISTRY OF NARCOTIC PRINCIPLES IN CAULERPA ...Biochemical, Biochemical Analysis, Cyclopropane, Medicinal Plants, Phaeophyta (non-specific & Ot), ...6.0172

Chlorella

NUCLIDE UPTAKE BY ALGAE AND ZOOPLANKTON ...Cladocera, Environment, Ionic Effect, Organic Matter Content - water, Radioisotopes -non-specific, ...6.0048

Chlorophyceae (non-specif.&ot)

A STUDY OF INHIBITORY COMPOUNDS PRODUCED BY FRESH-WATER ALGAE ...Algal Pollutant Sources, Chemicals (incl. algacides), Eutrophication, Metabolic Inhibitors, of Aquatic Plants, ...5.0446

CULTURING AND PROPAGATION OF SELECTED INVERTEBRATES AND ASSOCIATED FOOD ORGANISMS ...Algal Culture, Chrysophyceae (non-specif.&ot), Cyanophyta (non-specific & Ot), Food Supply, Invertebrate Cultures, ...5.0591

Cladophora

CLADOPHORA AS RELATED TO POLLUTION IN WESTERN LAKE ERIE ...Algal Pollutant Sources, Bioindicators, Chemical Analysis, Lake Erie, Mapping, ...5.0883

RHEOTAXIS IN ALGAL METABOLISM AND PHOTOSYNTHESIS ...Algal Pollutant Sources, Lake Erie, Motility and Migration, Photosynthesis, Respiration, ...6.0377

Algae- Red

Rhodophyta (non-specific & Ot)

PRIMARY PRODUCTION AND DECOMPOSITION IN ESTUARINE WATER ...Estuaries , Florida, Methane Bacteria (non-specif.), Phaeophyta (non-specific & Ot), Primary Productivity, Turnover (metabolic), ...5.0257

Algal Physiology

Environment

NUCLIDE UPTAKE BY ALGAE AND ZOOPLANKTON ...Chlorella, Cladocera, Ionic Effect, Organic Matter Content - water, Radioisotopes -non-specific, ...6.0048

ECOLOGICAL-PHYSIOLOGICAL INVESTIGATIONS OF LITTORAL DIATOM COMMUNITIES OF THE YAQUINA RIVER ESTUARY ...Algae- Diatoms, Intertidal Areas, Oregon, Physiological Ecology, ...5.0949

TOLERANCE AND CYTOLOGICAL RESPONSE OF ALGAE TO MINE WATER ...Histology and Cytology, Mining Activities, pH , pH -water, Pollution - Effects of , ...5.1276

THE ECOLOGIC IMPACT OF THE INTERACTIONS AMONG MICROORGANISMS AND AQUATIC CONTAMINANTS IN LAKE ERIE ...Lake Erie, Pollution - Effects of , Primary Productivity, Sediments, Water Bacteria, ...6.0427

VARIABILITY IN DIATOM MORPHOLOGY AND WATER POLLUTION ...Algae- Diatoms, Algal Culture, Bioindicators, Pollution - Effects of , Water Quality-general, ...5.0217

COPPER TOXCITY ON ALGAE OF THE BIG BLACKFOOT RIVER ...Contamination, Pollution-water, Copper, Mining Activities, Montana, Pollution - Effects of , ...5.0701

FACTORS AFFECTING THE STRUCTURE OF DIATOM COMMUNITIES ...Acidity, Algae- Diatoms, Chemical Analysis (water), Mineral Content -water, pH -water, ...5.1008

EUTROPHICATION - PHYSICAL ECOLOGICAL CONTROL ...Destratification, Eutrophication, of Aquatic Plants, Physical Control, Primary Productivity, ...5.0972

DETERMINATION OF SELECTED ENVIRONMENTAL REQUIREMENTS OF IMPORTANT MARINE PHYTOPLANKTON SPECIES ...Axenic Culture, Growth and Differentiation, Marine Biology, Marine Plants, Phytoplankton, ...5.1094

INTEGRATED FIELD AND LABORATORY SYSTEM FOR ASSAYING THE EFFECTS OF POLLUTANTS AND TOXICANTS UPON WATER QUALITY ...Algal Culture, Axenic Culture, Phytoplankton, Pollution - Effects of , ...5.1087

Growth and Differentiation

ALGAL GROWTH AND DECOMPOSITION - EFFECTS ON WATER QUALITY ...Algal Culture, Algal Pollutant Sources, Cell Injury and Autolysis, Mineral Composition, Model Systems, Water Quality-general, ...5.0443

DETERMINATION OF CRITICAL PHOSPHATE AND NITRATE CONCENTRATIONS FOR ALGAL BLOOM CONDITIONS IN LAKE ERIE ...Algal Pollutant Sources, Eutrophication, Nitrogen, Phosphorus, ...6.0086

STUDY OF EUTROPHICATION IN LAKES MAGOG & BROME ...Algal Pollutant Sources, Canada, Eutrophication, Freshwater Ecology, Nutrition Studies, ...5.0166

ALGAL GROWTH POTENTIAL OF ILLINOIS WATERS ...Algae- General, Bioindicators, Growth (non-specific & Ot.), Illinois, Other, ...6.0199

DETERMINATION OF SELECTED ENVIRONMENTAL REQUIREMENTS OF IMPORTANT MARINE PHYTOPLANKTON SPECIES ...Axenic Culture, Environment, Marine Biology, Marine Plants, Phytoplankton, ...5.1094

Metabolism

Algal Metab.(non-specific &ot)

AN INVESTIGATION OF APHANIZOMENON FLOS-AQUAE, A TOXIC BY-PRODUCT OF EUTROPHICATION ...Eutrophication , ...5.0717

MARINE TOXINS OF THE TROPICAL PACIFIC ...Animal Origin, Fish -non-specific, Other, Polynesia, Toxicology, ...5.0315

Chemicals (incl. algacides)

A STUDY OF INHIBITORY COMPOUNDS PRODUCED BY FRESH-WATER ALGAE ...Algal Pollutant Sources, Chlorophyceae (non-specif.&ot), Eutrophication, Metabolic Inhibitors, of Aquatic Plants, ...5.0446

EFFECT OF NITRILOTRIACETIC ACID (NTA) UPON THE TOXICITY OF METALS TO SELECTED SPECIES OF ESTUARINE PHYTOPLANKTON ...Acids, Carbon, Estuaries, Phytoplankton, Radioisotopes, ...5.1085

Enzymes

STUDY OF NITROGEN METABOLISM IN MARINE ALGAE ...Bioindicators, Marine Plants, Microbiological Analysis, Pollution - Effects of , Quantitative & Qualitative, ...5.1089

Mineral Composition

ECOLOGICAL PERIODICITIES OF NITROGEN AND PHOSPHORUS IN SALT MARSH FLORA AND SURROUNDING WATERS ...Swamps-marshes, ...6.0118

NUTRITIONAL ECOLOGY AND COMMUNITY STRUCTURE OF THE PHYTOPLANKTON OF GREEN BAY ...Bays, Nutrition Studies, Physiological Ecology, Phytoplankton, Wisconsin, ...5.1290

ALGAL GROWTH AND DECOMPOSITION - EFFECTS ON WATER QUALITY ...Algal Culture, Algal Pollutant Sources, Cell Injury and Autolysis, Growth and Differentiation, Model Systems, Water Quality-general, ...5.0443

Nitrogen Fixation

DYNAMICS OF THE NITROGEN CYCLE IN LAKES ...Denitrification, Lakes, Nitrogen, Respiration, ...5.0033

Nutrition Studies

A STUDY OF ALGAL POPULATIONS ASSOCIATED WITH DIFFERENT LEVELS OF WATER QUALITY IN NEW HAMPSHIRE ...Algal Pollutant Sources, Bioindicators, Eutrophication, New Hampshire, Water Quality-general, ...5.0712

NUTRITIONAL ECOLOGY AND COMMUNITY STRUCTURE OF THE PHYTOPLANKTON OF GREEN BAY ...Bays, Mineral Composition, Physiological Ecology, Phytoplankton, Wisconsin, ...5.1290

DETECTION OF LIMITING AND SURPLUS NUTIENTS IN ALGAE ...Nitrogen, Nutrients, Nutrition, Repression, ...5.1303

THE AUTECOLOGY OF SOME BLUE-GREEN PLANKTON ALGAE ...Algal Culture, Cyanophyta (non-specific & Ot), Eutrophication, Mixed Culture, Phytoplankton, ...**5.0955**

COMPARATIVE STUDY OF PHYTOPLANKTON IN NEW AND RECLAIMED ACID MINE DRAINAGE PONDS ...Acidity, Mining Activities, Phytoplankton, Ponds, Waste Water Treatment-general, ...**6.0437**

STUDY OF EUTROPHICATION IN LAKES MAGOG & BROME ...Algal Pollutant Sources, Canada, Eutrophication, Freshwater Ecology, Growth and Differentiation, ...**5.0166**

pH

TOLERANCE AND CYTOLOGICAL RESPONSE OF ALGAE TO MINE WATER ...Environment, Histology and Cytology, Mining Activities, pH -water, Pollution - Effects of , ...**5.1276**

Respiration

RHEOTAXIS IN ALGAL METABOLISM AND PHOTOSYNTHESIS ...Algal Pollutant Sources, Cladophora, Lake Erie, Motility and Migration, Photosynthesis, ...**6.0377**

Pathological Physiology

PHYCOVIRUSES - THEIR NATURE, OCCURRENCE, AND APPLICATION ...Algal Pollutant Sources, Algal Virus, Biocontrol, Eutrophication, Isolation, ...**5.0859**

Photosynthesis

ENERGY SOURCES OF HETEROTROPHIC MICROORGANISMS IN AN AQUATIC ENVIRONMENT ...Bioenergetics, Glycolic Acid Cpds, Heterotrophic Bacteria, Phytoplankton, ...**2.0622**

REOXYGENATION OF IOWA STREAMS ...Aeration, Iowa, Self-purification, Streams, ...**5.0417**

EFFECTS OF ZOOPLANKTON ON PHOTOSYNTHESIS BY ALGAE IN LAKES ...Algae- General, Interbiotic Relat.(non-specif), Lakes, Migration, Zooplankton, ...**2.1103**

RHEOTAXIS IN ALGAL METABOLISM AND PHOTOSYNTHESIS ...Algal Pollutant Sources, Cladophora, Lake Erie, Motility and Migration, Respiration, ...**6.0377**

PRIMARY PRODUCTION IN LEWIS AND CLARK LAKE ...Phytoplankton, Primary Productivity, Reservoirs and Impoundments, South Dakota, ...**6.0525**

Pigments

THE INCORPORATION OF C14 BICARBONATE INTO PIGMENTS OF A NATURALLY OCCURRING BLUE-GREEN ALGAE COMMUNITY WITH RESPONSE TO WAVELENGTH ...Chlorophyll, Oscillatoria, Phycobilins, Physiological Ecology, Vitamins, ...**6.0432**

THE INCORPORATION OF C14-BICARBONATE INTO THE PIGMENTS OF BLUE-GREEN ALGAE POPULATION ...Carotenoid Pigments, Chlorophyll, Nutrients, Oscillatoria, Phycobilins, ...**6.0433**

Algebra

Systems of Equations

LABORATORY TESTING OF HYDRAULIC FORMULATIONS FOR OPEN CHANNEL FLOW ...Channel Geometry, Channel Roughness, Open Channel, Routing, Transition Sections, Velocity, ...**2.0573**

Alkali Metals-general

THERMODYNAMICS OF MIXING OF SALT SOLUTIONS ...Salt, Solution, ...**1.0090**

SOLID COORDINATION COMPOUNDS OF ALKALI METAL SALTS ...Amines, Chelation, Electronic Structure-other, Precipitation, ...**3.0432**

SCATTERING MEASUREMENTS ON ALKALI - WATER SYSTEMS ...Atomic & Molecular Beams, Atomic Collisions, Atomic Forces and Potentials, Multipole Interactions, ...**1.0021**

SCATTERING MEASUREMENTS ON ALKALI - WATER SYSTEMS ...Atomic Collisions, Molecular Collisions, Other, Water, ...**1.0022**

CEMENT - AGGREGATE REACTION ...Aggregates, Extenders, Fillers, Cement, Concrete, Dimensions, Expansion, Reaction-general, ...**8.0236**

Alkaline Earth-general

THE HEATS OF MIXING OF STRONG ELECTROLYTES ...Electrolytes, Salt, Solution, Water, ...**1.0029**

Alternative Planning

THE ECONOMICS AND ADMINISTRATION OF WATER RESOURCES ...Administrative Structures, Colorado, Water - Alternative Uses, Water Costs, Watersheds-general, ...**6.0107**

ALTERNATIVE ECONOMIC RESPONSES TO THE ACID MINE DRAINAGE PROBLEM IN SOUTHEASTERN OHIO ...Acidity, Benefit-cost Analysis, Drainage, Mining Activities, Water Treatment -- General, ...**5.0887**

AN EXPLORATION OF COMPONENTS AFFECTING AND LIMITING POLICYMAKING OPTIONS IN LOCAL WATER AGENCIES ...Administrative Structures, Colorado, Economic Impact, Local Government, State-local Government, ...**6.0104**

ECONOMICS OF GROUND WATER DEVELOPMENT IN THE HIGH PLAINS OF COLORADO ...Economic Impact, Economics, Groundwater Basins, Model Studies, Water Resources Development, ...**6.0108**

PHYSICAL TECHNIQUES AND INSTITUTIONAL MECHANISMS FOR INTEGRATED ADJUSTMENT IN THE FLOOD PLAIN THROUGH SOIL SURVEYS ...Floodplains, Floodproofing, Land Use, Mapping, Soil Survey, ...**6.0647**

ALTERNATE METHODS OF MOSQUITO CONTROL TO REDUCE CHEMICAL POLLUTION OF WATERS FOR RECHARGE OF THE OGALALLA FORMATION ...Aquifers-general, Chlorinated Hydrocarbons, Insecticides -non-specific, Mosquitoes -non-specific, Playas, Pollution Abatement, ...**5.1180**

ECONOMIC ANALYSIS OF ALTERNATIVE WATER POLLUTION CONTROL MEASURES ...Economics-general, Model Studies, Waste Water Treatment-general, Water Quality Control-general, ...**6.0231**

METHODS OF ANALYSIS AND DETERMINATION OF EFFECTS OF ALTERNATIVE USES OF FORESTED LANDS ON STREAMFLOW ...Forest Watersheds, Land Use, Other, River Basins, Washington, ...**4.0272**

PUBLIC INVESTMENT CRITERIA FOR WATER-ORIENTED RECREATION IN THE LAKE ERIE BASIN ...Costs, Finance, Fiscal, Pollution Abatement, Projected Demand, Recreation Sites, ...**6.0428**

AN OPTIMAL WATER MANAGEMENT PLAN FOR THE MIAMI VALLEY ...Artificial Recharge, Augmentation-general, Conjunctive Use, Floodproofing, Optimization Technique, Systems Analysis, ...**6.0467**

INSTITUTIONAL DESIGN FOR WATER QUALITY MANAGEMENT - A CASE STUDY OF THE WISCONSIN RIVER BASIN ...Administrative Structures, Economics-general, Regional Areas, Water Law-general, Water Quality-general, ...**5.1306**

STOCHASTIC MODELS FOR WATER RESOURCES MANAGEMENT ...Application, Management, Runoff, Stochastic Models, Streams, ...**6.0383**

THEORETICAL AND EMPIRICAL STUDIES OF STOCHASTIC MODELS FOR THE ANALYSIS OF FLOOD CONTROL AND RELIEF POLICIES ...Floodproofing, Intergovernmental Relations, Model Studies, Other, Policy Making, ...**6.0047**

AN EVALUATION OF ALTERNATIVES FOR WATER RESOURCES REGULATION IN MISSOURI ...Law Enforcement, Legal Review, Missouri, State Government, ...**6.0321**

THE POTOMAC RIVER BASIN DEMONSTRATION PROJECT IN GEORGES CREEK ...Multiple-purpose Projects, Potomac River, River Basins, State-local Government, ...**6.0261**

WATER UTILIZATION AND WASTE CONTROL IN THE TEXTILE INDUSTRY ...Material Recovery Wastes, Recycle, Textile Wastes, Waste Water Pre-treatment, ...**3.0377**

CASE STUDY OF REMEDIAL FLOOD MANAGEMENT IN AN URBAN AREA-PHASE I ...Floodplains, Floods, Management, Planning, Urban Environments, ...**6.0166**

AN APPRAISAL OF FLOOD REGULATIONS IN THE STATES OF ILLINOIS, INDIANA, IOWA, MISSOURI AND OHIO ...Central, Floodplains, Floodproofing, Management, Water Rights-other, ...**6.0209**

A CASE STUDY OF WATER RESOURCES DEVELOPMENT - AN ANALYSIS OF A PROPOSED PROJECT ON THE MISSOURI RIVER ...Benefit-cost Analysis, Economic Impact, Land Use, Missouri River, Social Aspects, Water Resources Development, ...**6.0389**

WATER RIGHTS RELATED TO WATER QUALITY STORAGE ...Conflicts, Flow Augmentation, Reservoirs and Impoundments, Riparian Rights, Storage of Water, ...**6.0606**

DEVELOP AND DEMONSTRATE A METHOD FOR ASSESSING THE EXTENT OF POLLUTION FROM STORM WATER RUNOFF IN AN URBAN AREA ...Combined Sewer, Iowa, Nutrients, Storm Water, Urban Environments, ...**5.0705**

INVESTIGATION FOR CONTROL OF WATER POLLUTION FROM COMBINED SEWERS IN ROANOKE, VIRGINIA ...Combined Sewer, Model Studies, Rain Fall Intensity, Runoff, Sanitary Sewage Quantity-other, Storm Water, Water Quality Control-general, ...**5.1220**

THE ECONOMICS OF WATER TRANSFER - AN APPRAISAL OF INSTITUTIONS ...Administrative Structures, Economic Efficiency, Legal Review, Model Studies, Water Transfer, Welfare Economics, ...**4.0169**

ECONOMICS OF WATER SUPPLY-PORTALES VALLEY, NEW MEXICO ...Available Water, Economic Impact, Projections and Estimations, Water Costs, Water Transfer, ...**6.0363**

ECONOMIC ANALYSIS OF SMALL WATERSHED DEVELOPMENT IN TEXAS. ...Benefit-cost Analysis, Economic Impact, Small Watersheds, Texas, Water Resources Development, ...**4.0241**

ALTERNATIVE DEVELOPMENT PATTERNS, PLANS, CONTROLS AND IMPACT ASSOCIATED WITH NEW RESERVOIRS ...Administrative Structures, Optimization, Reservoirs and Impoundments, Texas, Types of Resources, ...**6.0561**

EFFICIENT SYSTEM OF WATER QUALITY MANAGEMENT FOR THE MIAMI BASIN ...Economic Efficiency, Management, Ohio, River Basins, Water Quality Control-general, ...**5.1015**

ECONOMICS OF WATER QUALITY IN A REGIONAL SYSTEM ...Benefit-cost Analysis, Delaware Bay, Estuaries, Management, Water Quality-general, ...**5.1011**

THE IMPACT OF THE NORTHEASTERN DROUGHT ON THE PLANNING AND PROVISION OF MUNICIPAL WATER SUPPLIES ...Administrative Structures, Economic Impact, Meteorological Extremes, Northeast, Water Supply-general, ...**4.0136**

THE ECONOMICS OF PUBLIC INVESTMENT IN RESOURCES DEVELOPMENT ...Benefit-cost Analysis, Land, Price & Value, Water Resources Development, ...**6.0049**

ECONOMIC GROWTH AND OPTIMUM WATER RESOURCE DEVELOPMENT ...Economics-general, Optimization, Water Allocation, Water Demand, Water Resources Development, ...**6.0043**

ECONOMICS OF GROUNDWATER DEVELOPMENT IN THE HIGH PLAINS OF COLORADO ...Administrative Structures, Colorado, Economics-general, Groundwater, Water Resources Development, ...**2.0207**

WATER RESOURCE DEVELOPMENT AND MANAGEMENT MODEL ...Available Water, Model Studies, State-local Government, Systems Analysis, Water Resources Development, ...**6.0201**

WATER RIGHTS AND WATER LAW ...Eminent Domain, Riparian Rights, Water Allocation, Water Resources Development, Water Utilization -general, ...**6.0386**

AN ECONOMIC EVALUATION OF WATER POLLUTION CONTROL, YAQUINA BAY, ORE ...Bays, Benefit-cost Analysis, Model Studies, Oregon, Systems Analysis, Water Quality Control-general, ...**6.0454**

SIMULATION AS A MEANS OF STUDYING RESOURCE ALLOCATIONS ...Economics-general, Model Studies, River Basins, Simulation Theory, Water Allocation, ...**6.0456**

SYSTEMS STUDY - MARYLAND PROJECT ...Hydrology-general, Management, Maryland, Planning, Water Resources Development, ...**6.0603**

QUANTITATIVE WATER-BUDGET ANALYSIS OF WESTERN LONG ISLAND, NEW YORK ...Groundwater Basins, Management, New York, Water Balance-budget, Water Resources Development, ...**2.0809**

WATER RESOURCES, COLUMBUS, INDIANA AREA ...Clastic Aquifers, Groundwater, Indiana, Model Studies, Water Development, ...**2.0456**

TECHNOLOGY AND ECONOMICS OF CONSERVATION ...Benefit-cost Analysis, Conservation-general, Erosion-general, Land Use, Sediments, ...**4.0106**

Aluminum

PROTECTIVE FILMS FORMED BY PLASMA ANODIZATION ...Anodic, Brines, Desalination, Iron, Passivation, ...**3.0263**

CORROSION AND MASS TRANSFER FROM CYLINDERS OF METALS ROTATING IN SEAWATER AT HIGH TEMPERATURES AND PRESSURES ...Desalination, High, Water, ...**3.0247**

DEMONSTRATION OF ALUMINUM IN SEAWATER DESALTING ...Desalination, Flash Distillation, Oxygen Containing, Scale Formation, Sulfate, Sulfite, ...**3.0481**

EVALUATION OF POLYVINYL CHLORIDE (PVC) AND VINYL CLAD ALUMINUM PIPE USED FOR CARRYING IRRIGATION WATER WHEN BURIED WITHIN THE FROST ZONE ...Cladding, Irrigation-general, Joining, Bonding-general, Pipe, Tube, Polyvinyls-other, Soils, ...**8.0271**

VIRUS REMOVAL BY CHEMICAL FLOCCULATION ...Coagulation, Complexing, Flocculation, Viral Pollutant Sources, Virus, ...**5.0364**

REMOVAL OF PHOSPHATE FROM WATER BY ALUMINUM AND IRON ...Complexes, Iron, Mechanisms, Phosphate, Phosphite, Waste Water Treatment-general, ...**5.0732**

INTERACTIONS OF SILICA WITH IRON AND ALUMINUM ...Analysis and Detection, Coagulation, Complexing, Iron, Water Treatment -- General, ...**5.0557**

PHOSPHORUS REMOVAL BY ADDITION OF ALUMINUM TO THE ACTIVATED SLUDGE PROCESS ...Activated, Phosphate, Phosphite, Waste Treatment-economics, ...**5.0109**

PHOSPHORUS REMOVAL IN THE ACTIVATED SLUDGE PLANT ...Activated, Aeration, Phosphate, Phosphite, Precipitation, Sewage - Domestic, ...**5.0788**

PARAMETRIC STUDY OF THE KINETICS OF PRECIPITATION AND NATURE OF THE PRECIPITATE OBTAINED IN PHOSPHATE REMOVAL USING IRON AND ALUMINUM SALT ...Iron, Phosphate, Phosphite, Precipitation, Solubility, Tertiary Treatment, ...**5.0075**

ALUMINA COLUMNS FOR THE SELECTIVE REMOVAL OF PHOSPHORUS FROM WASTEWATERS AND THE ULTIMATE DISPOSAL OF PHOSPHORUS AS CALCIUM PHOSPHATE ...Material Recovery Wastes, Phosphate, Phosphite, Process Design, Regeneration-other, Selective-removal, ...**5.1243**

SOLUBLE PHOSPHORUS REMOVAL IN THE ACTIVATED SLUDGE PROCESS ...Activated, Aeration, Chemical Treatment, Digestion, Filter-other, Phosphate, Phosphite, ...**5.1037**

REMOVAL OF PHOSPHATE FROM WATER BY ALUMINUM AND IRON ...Chemical Treatment, Chemical Treatment-general, Iron, Phosphate, Phosphite, Reaction-general, ...**5.0738**

CHEMISTRY OF HYDROSOLIC METALS IN NATURAL WATER ...Aeration, Demineralization, Geochemical Analysis, Iron, Manganese, Solution Chemistry, ...**5.0119**

Ammonia

ENGINEERING ECONOMICS OF WATER DESALTING IN COMBINATION WITH NITROGEN FIXATION FOR AGRICULTURAL CHEMICALS MANUFACTURE ...Cost Analysis, Desalination, Fixation, Nuclear, Statistical, ...**3.0347**

AMMONIA REMOVAL FROM AGRICULTURAL RUNOFF BY SELECTIVE ION EXCHANGE ...Ammonium, Ion Exchange-other, Process Design, Runoff, Waste Water Treatment-general, Zeolite, ...**5.1247**

THE USE OF INERT GASES TO ELIMINATE POLLUTION FROM ABANDONED MINES ...Acid Mine Wastes, Air-general, Chlorine, Mine Atmosphere Conditions, Nitrogen, ...**4.0205**

A STUDY OF THE EFFECT OF ULTRASONIC ENERGY ON WASTE WATER ...Disinfection, Organics, Ultrasonics, ...**5.0104**

ULTIMATE DISPOSAL OF PHOSPHATE FROM WASTEWATER BY RECOVERY AS FERTILIZER ...Activated, Disposal, Fertilizers, Material Recovery Wastes, Nutrients, Phosphate, Phosphite, ...**5.0342**

THE ELECTRO-OXIDATION OF AMMONIA IN SEWAGE TO NITROGEN ...Electrode, Electrolytic, Waste Water Treatment-general, Waste Water Treatment-other, ...**5.0538**

AMMONIA STRIPPING MATHEMATICAL MODEL FOR WASTE WATER TREATMENT ...Aeration, Finance, Mathematical Analysis, Model Studies, Waste Treatment-economics, ...**5.0337**

Ammonium

FISH TOXICANT STUDIES ...Control of Nuisance Species, Evaluation, Fish -non-specific, Piscicides -non-specific, Screening Potential Pesticides, ...**5.1147**

AMMONIA REMOVAL FROM AGRICULTURAL RUNOFF BY SELECTIVE ION EXCHANGE ...Ammonia, Ion Exchange-other, Process Design, Runoff, Waste Water Treatment-general, Zeolite, ...**5.1247**

Amphibious Vehicles

CHARACTERISTICS OF RIVER BANKS RELATED TO VEHICLE PERFORMANCE WHEN ENTERING & EXITING STREAMS ...Statistics-general, Stream Banks, Streams, Synthetic Hydrology-general, Water Vessel, ...**7.0058**

EXPLORATORY DEVELOPMENT OF WATER PROPULSION FOR COMBAT VEHICLES ...Marine, Other, Streams, Systems Analysis, ...**8.0215**

Analysis

Differential Equations

Differential Equations General

DISPERSION DURING FLOW IN HETEROGENEOUS POROUS MEDIA ...Dispersion -water, Model Studies, Porous Media - Flow Through, Seepage, Statistical Models, ...**5.0394**

Animal Characteristics

Adaptation

GROWTH, CONDITION, AND SURVIVAL OF SHELLFISH ...Environmental Physiology, Maryland, Oysters, Water Quality-general, Water Salinity, ...**6.0269**

Age

YOUNG-OF-THE-YEAR FISH IN LAKE FRANCIS CASE ...Fish - non-specific, Nets, Reservoirs and Impoundments, South Dakota, Water Environment -other, ...**6.0505**

ABUNDANCE OF YOUNG-OF-THE-YEAR FISHES IN OAHE RESERVOIR ...Aquatic Ecology, Fish -non-specific, Population Dynamics, Reservoirs and Impoundments, South Dakota, ...**6.0499**

COMPOSITION OF THE SPAWNING STOCKS IN OAHE RESERVOIR AND LAKE SHARPE ...Fertility, Fish -non-specific, Size, South Dakota, Spawn Or Nesting Sites, ...**6.0519**

EXPLORATORY SAMPLING PROGRAM FOR YOUNG-OF-THE-YEAR FISH ...Fish -non-specific, Nets, Population Dynamics, Reservoirs and Impoundments, ...**6.0022**

ACUTE TOXICITY OF PESTICIDES TO FRESHWATER INVERTEBRATES ...Bioassay, Chemical Measurements -water, Chemical-general, Laboratory Animals, Water Temperature-non-specific, ...**5.0662**

Environmental Response

EXPERIMENTAL REARING OF SALMON AND STEELHEAD IN BRACKISH WATER IMPOUNDMENTS ...Brackish Water, Captive Rearing, Mortality Rates, Rainbow Trout, Steelhead Trout, Stocking of Fish & Shellfish, ...**6.0461**

Fertility

COMPOSITION OF THE SPAWNING STOCKS IN OAHE RESERVOIR AND LAKE SHARPE ...Age, Fish -non-specific, Size, South Dakota, Spawn Or Nesting Sites, ...**6.0519**

BIOCHEMISTRY OF FISH SEMEN ...Cutthroat Trout, Endrin, Male Gametes, Mode of Action -animal, ...**5.0627**

Growth Rate

RELATIONSHIPS BETWEEN DRIFT DENSITY AND PRODUCTION, GROWTH, CROPPING EFFICIENCY AND CONSUMPTION IN A NATURAL BROOK TROUT POPULATION ...Lake Trout, Brook Trout, Number Or Density, Predation, Productivity (agricultural), Streams, ...**7.0094**

STREAM BIOLOGY AND ITS RELATION TO FISH PRODUCTION ...Food Supply, Mississippi River, Shiners, Streams, Vertical Distribution, ...**6.0223**

THE EFFECT OF EVAPORATION BARRIERS ON FISH GROWTH AND LIMNOLOGY ...Antitranspirants, Aquatic Ecology, Environmental Ecology, Fish -non-specific, ...**2.0060**

SPORT FISHERY POTENTIAL IN RECLAIMED WASTEWATER ...Channel Catfish, Other, Salmon & Trout - Non-specific, Stream Rehabilitation, Tilapia, Cichlids, ...**5.0050**

DISTRIBUTION AND GROWTH PATTERNS OF THE GIZZARD SHAD (DOROSOMA CEPEDIANU) AND THREADFIN SHAD (DOROSOMA PETENENSE) IN RESERVOIRS ...Alewife,menhaden,shad,herring, Arkansas, Number Or Density, Reservoirs and Impoundments, Temporal Distribution, ...**6.0029**

FLATHEAD CATFISH STUDY ...Aquatic Ecology, Behavior - animal, Food Supply, Ictaluridae -other, Reproduction Studies (general), Texas, ...**6.0539**

THE EVALUATION OF ENVIRONMENTAL ALTERATION BY THERMAL LOADING AND ACID POLLUTION IN THE COOLING RESERVOIR OF A STEAM-ELECTRIC STATION ...Acidity, Mining Activities, Reservoirs and Impoundments, Thermal Pollution, Warm Water, ...**5.0681**

TEMPERATURE REQUIREMENTS OF SALMONIDS IN RELATION TO THEIR FEEDING, BIOENERGETICS, GROWTH AND BEHAVIOR ...Behavior -animal, Energy, Rainbow Trout, Steelhead Trout, Salmon -coho,chinook,sockeye.., Water Temperature-non-specific, ...**5.0942**

GROWTH OF THE BROWN BULLHEAD, ICTALURUS NEBULOSUS (LESUEUR), IN MINE ACID POLLUTED WATER ...Acidity, Bullheads, Contamination - Water, Mining Activities, Ph, Acidity -water, Pollution Effects, ...**5.1278**

SUBLETHAL INFLUENCE OF POLLUTANTS ON FISH METABOLISM ...Contamination - Water, Fish -non-specific, Metabolism -animal, Pollution - Effects of , Pollution Effects, ...**5.0901**

WATER QUALITY REQUIREMENTS FOR AQUATIC INSECTS ...Oxygen, ...**5.0699**

A STUDY OF A WATER TOXICITY PROBLEM ...Bioassays, Bioindicators, Management, Potable Water, Toxins and Poisons - other, ...**5.0197**

A COMPARISON OF THE GROWTH RATE OF BLUE CATFISH AND CHANNEL CATFISH FINGERLINGS FOR A PELLETED COMMERCIAL FEED ...Aquaculture & Fish-farming, Channel Catfish, Pelleted, ...**5.1179**

VITAL STATISTICS OF NORTHERN PIKE IN LAKE SHARPE ...Mortality Rates, Pikes, Pickeral, Muskellunge, Population Dynamics, Reservoirs and Impoundments, South Dakota, ...**6.0502**

VITAL STATISTICS OF WALLEYE IN LAKE SHARPE ...Mortality Rates, Population Dynamics, Reservoirs and Impoundments, South Dakota, Walleyes, ...**6.0503**

GROWTH AND MORTALITY RATES OF YOUNG YELLOW PERCH IN OAHE RESERVIOR ...Aquatic Ecology, Mortality Rates, Reservoirs and Impoundments, South Dakota, Yellow Perch, Darters, ...**6.0498**

MORTALITY RATES AND RECRUITMENT ...Arkansas, Fish - non-specific, Mortality Rates, Population Dynamics, Reservoirs and Impoundments, ...**4.0014**

EFFECTS OF CHRONIC EXPOSURE TO METHOXYCHLOR ON THE GROWTH AND REPRODUCTION OF GUPPIES - CHRONIC TOXIEITY OF PESTICIDES TO FISH ...Killifishs - Cyprinodon, Maturity & Growth Stages, Methoxychlor, ...**5.0650**

CULTURE OF SHELLFISH IN ARTIFICIAL AND NATURAL SALT PONDS ...Captive Rearing, Commercial Fishing, Maryland, Oysters, Ponds, ...**6.0267**

Hatchability

EFFECTS OF WATER QUALITY ON HATCHING SUCCESS ...Basses -sea,white, White Perch, Captive Rearing, Louisiana, Pollution - Effects of , Water Properties-general, ...**5.0453**

Longevity

ECOLOGY OF NEMATODES IN IRRIGATION WATER ...Animal Wastes - Feed Lots, Bioindicators, Irrigation-general, Nematoda - other, Pollution - Effects of , ...**5.1232**

Maturity & Growth Stages

ACUTE TOXICITY OF PESTICIDES TO FRESHWATER FISH AND OTHER VERTEBRATES ...Insecticides -non-specific, Mode of Action -animal, Pollution - Effects of , Pollution Effects, Wildlife, ...**5.0649**

THE ROLE OF FOOD IN THE MORTALITY OF LARGEMOUTH BASS LARVAE ...Environmental Physiology, Fasting - Starvation, Food Supply, Largemouth Bass, Mortality Rates, ...**7.0079**

PREDATION ON LARGEMOUTH BASS DURING THEIR FIRST YEAR OF LIFE ...Behavioral Ecology, Largemouth Bass, Predation, Strontium, Tags, ...**7.0080**

AN EVALUATION OF THE LAMPREY IN LAKE CHAMPLAIN ...Lakes, Lampreys, Predation, Spawn Or Nesting Sites, Vermont, ...**6.0598**

STATEWIDE FISHERIES RESEARCH ...Basses -sea,white, White Perch, Environmental Physiology, Incubation, Low Temp. -but Above 32f, Temperature, ...**5.0818**

HYBRID SUNFISH STUDIES ...Centrarchidae -other, Laboratory, Ponds, Selection & Breeding, ...**6.0195**

DDT RESIDUE ACCUMULATION IN WISCONSIN FISH AND THE EFFECT ON REPRODUCTION ...DDT , Reproduction Studies (general), Walleyes, Wildlife, Wisconsin, ...**5.1292**

RELATIVE ABUNDANCE OF ADULT FISH IN LAKE FRANCIS CASE ...Number Or Density, Reservoirs and Impoundments, South Dakota, ...**6.0504**

DISTRIBUTION OF YOUNG STAGES OF COASTAL FISHES ...Continental Shelf, Estuaries, Fish -non-specific, Number Or Density, Ships and Cruises, ...**6.0345**

INFLUENCE OF THE PHYSICAL ENVIRONMENT ON DISTRIBUTION OF YOUNG STAGES OF COASTAL GAME FISH ...Continental Shelf, Environmental Ecology, Fish -non-specific, Physical-general, Range Or Territorial Distr. , ...**6.0346**

EARLY LIFE HISTORY OF WALLEYE IN LAKE FRANCIS CASE ...Aquatic Ecology, Life History Studies, Reservoirs and Impoundments, South Dakota, Walleyes, ...**6.0506**

VARIATIONS IN SPAWNING OF FISHES IN RELATION TO TEMPERATURE ...Biological Rhythms, Fish -non-specific, South Dakota, Temperature, Water Temperature-non-specific, ...**6.0518**

SEXUAL MATURATION AND SPAWNING OF NORTHERN PIKE ...Biological Rhythms, Pikes, Pickeral, Muskellunge, Reservoirs and Impoundments, South Dakota, Spawn Or Nesting Sites, ...**6.0520**

DEVELOPMENT OF IDENTIFICATION KEYS TO LARVAL, AND JUVENILE RESERVIOR FISHES ...Animal Taxonomy, Captive Rearing, Fish -non-specific, Photography-other, Reservoirs and Impoundments, ...**6.0018**

EFFECTS OF CHRONIC EXPOSURE TO METHOXYCHLOR ON THE GROWTH AND REPRODUCTION OF GUPPIES - CHRONIC TOXIEITY OF PESTICIDES TO FISH ...Growth Rate, Killifishs - Cyprinodon, Methoxychlor, ...**5.0650**

EARLY LIFE HISTORY OF COREGONIDS ...Cisco, Lake Herring, Environmental Ecology, Life History Studies, Technique Development, Water Environment -other, ...**6.0295**

EFFECTS OF TEMPERATURE ON MATURATION, EMBRYONIC DEVELOPMENT AND CONDITION OF FRY IN YELLOW PERCH - LAKE HERRING, SMELT AND WALLEYE ...Basic Embryology, Environmental Physiology, Temperature, Thermal Pollution, Water Temperature-non-specific, Yellow Perch, Darters, ...**5.0590**

Metabolic Efficiency

PHYSIOLOGICAL EFFECTS OF SUBLETHAL LEVELS OF ACID WATER ON FISH ...Acidity, Mining Activities, Ph, Acidity -water, Water Quality-general, West Virginia, ...**5.1281**

Mortality Rates

FISHERIES-TURBINE RESEARCH COMPENDIUM COMPILATION ...Electric Power Plants, Fish -non-specific, Migration, Turbine-other, ...**8.0310**

COLLECTION OF JUVENILE SALMON IN TURBINE INTAKES ...Columbia River, Control Gate, Electric Power Plants, Salmon & Trout - Non-specific, Turbine-other, ...**8.0299**

THE ROLE OF FOOD IN THE MORTALITY OF LARGEMOUTH BASS LARVAE ...Environmental Physiology, Fasting - Starvation, Food Supply, Largemouth Bass, Maturity & Growth Stages, ...**7.0079**

EFFECTS OF DISSOLVED OXYGEN CONCENTRATION ON SURVIVAL OF LARGEMOUTH BASS EMBRYOS ...Basic Embryology, Gases, Dissolved -water, Largemouth Bass, Oxygen, Water Movement, Currents,, Water Temperature-non-specific, ...**5.0771**

MASS MORTALITY OF PACIFIC OYSTERS ALONG THE WASHINGTON COAST ...Bays, Environmental Ecology, Oysters, Pathology, Puget Sound, ...**5.1230**

MASS MORTALITY OF OYSTERS ALONG THE OREGON COAST ...Bays, Invertebrate Pathology, Oregon, Oysters, Pathology, ...**5.0985**

EVALUATION OF METHODS DESIGNED TO PREVENT WINTER-KILL ...Aeration, Chemical-general, Circulation -water, Lakes, North Dakota, ...**5.0828**

PREDICTING AND PREVENTING FISH KILLS ...Chemical Analysis (water), Ponds, Stratification, ...**5.0012**

EFFECT OF WATER QUALITY ON FIRST-YEAR MORTALITY OF LARGEMOUTH BASS ...Aquatic Ecology, Environmental Ecology, Largemouth Bass, Pollution - Effects of , Water Properties-general, ...**5.0772**

DISTRIBUTION OF DEMERSAL FISHES IN INSHORE WATERS ...Environmental Ecology, Fish -non-specific, Marine Biology, Nets, Vertical Distribution, ...**5.1260**

BIOCHEMICAL AND ECOLOGICAL RELATIONSHIPS OF PESTICIDES AND THE BIOLOGICAL CONSTITUENTS OF AQUATIC COMMUNITIES ...Applied Ecology, Bioenergetics, Cell Injury and Autolysis, Pesticides -non-specific, Sterility, ...**5.0566**

STUDIES IN OYSTER PATHOLOGY ...Histology and Cytology, Oysters, Pathology, ...**6.0630**

EXPERIMENTAL REARING OF SALMON AND STEELHEAD IN BRACKISH WATER IMPOUNDMENTS ...Brackish Water, Captive Rearing, Environmental Response, Rainbow Trout, Steelhead Trout, Stocking of Fish & Shellfish, ...**6.0461**

FISH PASSAGE THROUGH TURBINES ...Fish -non-specific, Hydraulic, Management -other, Power Development, Stamina, ...**8.0312**

VITAL STATISTICS OF NORTHERN PIKE IN LAKE SHARPE ...Growth Rate, Pikes, Pickeral, Muskellunge, Population Dynamics, Reservoirs and Impoundments, South Dakota, ...**6.0502**

VITAL STATISTICS OF WALLEYE IN LAKE SHARPE ...Growth Rate, Population Dynamics, Reservoirs and Impoundments, South Dakota, Walleyes, ...**6.0503**

GROWTH AND MORTALITY RATES OF YOUNG YELLOW PERCH IN OAHE RESERVIOR ...Aquatic Ecology, Growth Rate, Reservoirs and Impoundments, South Dakota, Yellow Perch, Darters, ...**6.0498**

TEMPERATURE TOLERANCE OF MARINE ANIMALS THROUGH BEHAVORIAL RESPONSES ...Behavior -animal, Environment Resistance, Thermal, Water Temperature-non-specific, ...**6.0344**

MORTALITY RATES AND RECRUITMENT ...Arkansas, Fish - non-specific, Growth Rate, Population Dynamics, Reservoirs and Impoundments, ...**4.0014**

SHELLFISH MORTALITY - CHESAPEAKE BAY ...Chesapeake Bay, Computer Matching Code, Oysters, Pathology, Protozoa, ...**6.0264**

PINK SALMON INVESTIGATIONS - FRESHWATER ECOLOGY ...Aquatic Ecology, Environmental Ecology, Estuaries, Physical-general, Salmon -coho,chinook,sockeye.., ...**4.0002**

EFFECT OF SUPERSATURATION OF DISSOLVED NITROGEN ON MIGRATING SALMONIDS ...Gases, Dissolved -water, Nitrogen, Pathology, Salmon & Trout - Non-specific, ...**6.0614**

PROTECTION OF FINGERLING SALMON IN TURBINES ...Construction Land Use Effects, Engineering Structures-general, Migration, Salmon & Trout - Non-specific, Snake River, ...**8.0306**

PACIFIC OYSTER MORTALITY STUDIES ...Invertebrate Pathology, Invertebrates, Oysters, Pathology, ...**6.0266**

EPIZOOTICS IN EXPERIMENTAL MARINE SHELLFISH POPULATIONS ...Epizootic, Freshwater Mussels, Scallops, Oysters, Pathology, ...**6.0631**

Number Or Density

STUDY OF DISCREPANCY IN FISH COUNTS BETWEEN COLUMBIA RIVER DAMS ...Censusing, Columbia River, Rainbow Trout, Steelhead Trout, Salmon -coho,chinook,sockeye.., ...**8.0278**

RELATIONSHIPS BETWEEN DRIFT DENSITY AND PRODUCTION, GROWTH, CROPPING EFFICIENCY AND CONSUMPTION IN A NATURAL BROOK TROUT POPULATION ...Growth Rate, Lake Trout, Brook Trout, Predation, Productivity (agricultural), Streams, ...**7.0094**

THE DISTRIBUTION OF FISH IN PENNSYLVANIA AS RELATED TO MINE ACID DRAINAGE ...Acidity, Contamination - Water, Fish -non-specific, Mining Activities, Pennsylvania, ...**5.1026**

CHANGES IN STREAM COMMUNITIES ASSOCIATED WITH EFFLUENT - INDUCED EUTROPHICATION ...Aquatic Plants (non-specific), Eutrophication, Invertebrates -non-specific, Pennsylvania, Streams, ...**5.1029**

ABUNDANCE AND DISTRIBUTION OF BENTHIC MACRO-INVERTEBRATES IN A STREAM RECEIVING OILFIELD WASTEWATERS ...Benthic Fauna, Bioindicators, Contamination - Water, Industrial Wastes, Vertical Distribution, ...**5.1028**

DISTRIBUTION AND ABUDANCE OF JUVENILE AMERICAN SHAD, ALOSA SAPIDISSIMA (WILSON), IN THE CONNECTICUT RIVER ABOVE HOLYOKE DAM, MASSACHUSETTS ...Alewife,menhaden,shad,herring, Connecticut River, Engineering Structures-general, Massachusetts, Migration, ...**3.0271**

COVER AS A LIMITING FACTOR IN TROUT PRODUCTION ...Colorado, Environmental Ecology, Salmon & Trout - Non-specific, Soil (wildlife) Cover, Streams, ...**4.0070**

DISTRIBUTION AND GROWTH PATTERNS OF THE GIZZARD SHAD (DOROSOMA CEPEDIANU) AND THREADFIN SHAD (DOROSOMA PETENENSE) IN RESERVOIRS ...Alewife,menhaden,shad,herring, Arkansas, Growth Rate, Reservoirs and Impoundments, Temporal Distribution, ...**6.0029**

FLATHEAD CATFISH INVESTIGATIONS IN THE MISSOURI RIVER ...Ictaluridae -other, Life History Studies, Missouri River, Population Dynamics, ...**6.0335**

A STUDY OF THE BENTHIC FAUNA OF MERLE COLLINS RESERVOIR (VIRGINIA RANCH RESERVOIR) ...California, Food Supply, Productivity - Food Chain, Reservoirs and Impoundments, ...**6.0071**

BOTTOM FAUNA STUDIES ...Benthic Fauna, Bottom Sampling, Depth,water Level, Fluctuation, Lakes, Water Level Fluctuation, ...4.0126

DETERMINATION OF THE MAGNITUDE AND AGE COMPOSITION OF THE HARVEST, HABITAT PREFERENCES AND FOOD HABITS ...Aquatic Ecology, Cutthroat Trout, Snake River, Wyoming, ...6.0649

LAKEBORGNE-CHANDELEUR SOUND SYSTEM ...Aquatic Ecology, Louisiana, Nets, Plankton Sampling, Tides, ...2.0543

BRETON SOUND - MOUTH OF MISSISSIPPI RIVER SYSTEM ...Aquatic Ecology, Mississippi River, Nets, Plankton Sampling, ...2.0544

ATCHAFALAYA RIVER - CALLIOU LAKE SYSTEM ...Lakes, Louisiana, Physical-general, Plankton (non-specific), Vertical Distribution, ...2.0545

VERMILION - CALCASIEU - SABINE SYSTEM ...Aquatic Ecology, Data Acquisition-general, Louisiana, Nets, Plankton Sampling, ...2.0546

TIMBALIER - TERREBONNE BAYS SYSTEM ...Aquatic Ecology, Data Acquisition-general, Louisiana, Nets, Plankton Sampling, ...2.0547

THE INSECT ORDER PLECOPTERA AS A BIOLOGICAL INDEX OF FRESH WATER QUALITY IN RHODE ISLAND ...Bioindicators, Environmental Ecology, Pollution - Effects of , Pollution Effects, Stone Flies, Plecoptera, Streams, ...5.1057

A RUN TIMING STUDY IN THE LOWER COLUMBIA RIVER BY MEANS OF A TESTFISHING PROGRAM ...Columbia River, Migration, Nets, Salmon -coho,chinook,sockeye.., Streams, ...2.0884

RELATIVE ABUNDANCE OF ADULT FISH IN LAKE FRANCIS CASE ...Maturity & Growth Stages, Reservoirs and Impoundments, South Dakota, ...6.0504

DISTRIBUTION OF YOUNG STAGES OF COASTAL FISHES ...Continental Shelf, Estuaries, Fish -non-specific, Maturity & Growth Stages, Ships and Cruises, ...6.0345

ABUNDANCE AND COMPOSITION OF ADULT FISH STOCK IN LAKE SHARPE ...Aquatic Ecology, Fish -non-specific, Population Dynamics, Reservoirs and Impoundments, South Dakota, ...6.0501

LIFE HISTORY OF CHANNEL CATFISH IN LEWIS AND CLARK LAKE ...Channel Catfish, Environmental Ecology, Life History Studies, Reservoirs and Impoundments, South Dakota, ...6.0530

DISTRIBUTION AND DENSITY OF BREEDING WATERFOWL POPULATIONS AS RELATED TO QUANTITY AND QUALITY OF WETLAND HABITAT IN NORTH DAKOTA ...Geography-physical, North Dakota, Spawn Or Nesting Sites, Water Fowl, N.s. , Wetlands, ...6.0420

BENTHOS IN LEWIS AND CLARK LAKE ...Aquatic Ecology, Bloodworms, Aquatic Midges, Mayflies, Reservoirs and Impoundments, South Dakota, ...6.0514

COOPERATIVE AGREEMENT FOR BEAVER RESERVOIR CREEL CENSUS STUDY ...Censusing, Fish -non-specific, Fishing, Reservoirs and Impoundments, Weight, ...4.0015

ESTIMATES OF COMPOSITION, ABUNDANCE AND FLUCTUATION IN FISH POPULATIONS IN BULL SHOALS AND BEAVER RESERVOIRS ...Aquatic Ecology, Arkansas, Fish -non-specific, Population Dynamics, Reservoirs and Impoundments, ...4.0017

LIFE HISTORY OF CYCLOPS BICUSPIDATUS ...Aquatic Ecology, Copepods, Life History Studies, Reservoirs and Impoundments, South Dakota, ...6.0527

ESTUARINE STUDIES OF SOUTHEASTERN ALASKA ...Alaska, Benthic Fauna, Environmental Ecology, Estuaries, Vertical Distribution, ...2.0017

DISTRIBUTION, ABUNDANCE, TAXONOMY, AND BIOLOGY OF MOSQUITOES AFFECTING AGRICULTURE ...Animal Taxonomy, Insect Chemosterilants, N.s. , Mosquitoes -non-specific, Radiation, Range Or Territorial Distr. , ...6.0148

Productivity (agricultural)

RELATIONSHIPS BETWEEN DRIFT DENSITY AND PRODUCTION, GROWTH, CROPPING EFFICIENCY AND CONSUMPTION IN A NATURAL BROOK TROUT POPULATION ...Growth Rate, Lake Trout, Brook Trout, Number Or Density, Predation, Streams, ...7.0094

SPRING POND ECOLOGY AND MANAGEMENT ...Fishing, Habitat Studies, Management, Ponds, Salmon & Trout - Non-specific, ...3.0488

LIMESTONE DRUM PRODUCTIVITY STUDY ...Aquatic Ecology, Chemical-general, Limestone - General, Ph, Acidity -water, Population Dynamics, ...5.1273

FEASIBILITY OF TREATING AND RECYCLING USED FISH HATCHERY WATER ...Benefit-cost Analysis, Captive Rearing, Waste Water Treatment-general, Water Reuse, ...5.0753

TUSCON WASTEWATER RECLAMATION PROJECT ...Biological-general, Chemical-general, Filter-other, Fish -non-specific, Stream Rehabilitation, Water Standards, ...5.0043

FACTORS LIMITING WATERFOWL PRODUCTION ON THE SPRING-FED SALT MARSHES WEST OF THE GREAT SALT LAKE ...Mallard, Nutrition -other, Swamps-marshes, Utah, Viremia, ...5.1194

HIGH ANALYSIS FERTILIZER INVESTIGATIONS - FISHERIES ...Fertilizers -aquatic, Fish -non-specific, Reservoirs and Impoundments, Tennessee, ...6.0535

RELATIONSHIP BETWEEN MOURNING DOVE PRODUCTION AND WATER DISTRIBUTION IN THE SONORAN DESERT ...Arizona, Deserts, Dove, Habitat Studies, Water Utilization - animal, ...6.0262

Size

COMPETITION, PREDATION, AND BODY SIZE IN LAKE ZOOPLANKTON ...Aquatic Ecology, Competition, Lakes, Predation, Zooplankton, ...6.0115

FOOD INTAKE OF LARGEMOUTH BASS ...Food Supply, Lakes, Largemouth Bass, Malnutrition -other, ...6.0182

COMPOSITION OF THE SPAWNING STOCKS IN OAHE RESERVOIR AND LAKE SHARPE ...Age, Fertility, Fish -non-specific, South Dakota, Spawn Or Nesting Sites, ...6.0519

Sterility

BIOCHEMICAL AND ECOLOGICAL RELATIONSHIPS OF PESTICIDES AND THE BIOLOGICAL CONSTITUENTS OF AQUATIC COMMUNITIES ...Applied Ecology, Bioenergetics, Cell Injury and Autolysis, Mortality Rates, Pesticides -non-specific, ...5.0566

Stress

TOXIC ACTION OF WATER SOLUBLE POLLUTANTS ON FRESHWATER FISH ...Contamination - Water, Mineral Origin, Pollution Effects, Rainbow Trout, Steelhead Trout, ...5.0565

PESPONSES OF FISH TO ENVIRONMENTAL STRESSES ...Cardiovascular System, Environmental Physiology, Fish -non-specific, Kidney and Urinary System, Water Environment -other, ...5.1269

STUDY OF EXCRETORY PATTERNS IN CRAYFISHES ...Crayfish, All, Metabolism, Nitrogen, Osmoregulation, Urea, ...6.0376

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STUDIES ON THE METHANOGENIC BACTERIA IN SLUDGE ...Acids , Culture Collections, Digestion, Isolation From Nat. environ. , ...5.0259

PRIMARY PRODUCTION AND DECOMPOSITION IN ESTUARINE WATER ...Estuaries, Florida, Phaeophyta (non-specific & Ot), Primary Productivity, Rhodophyta (non-specific & Ot), Turnover (metabolic), ...5.0257

CONTROLLING FACTORS IN METHANE FERMENTATION ...Bacterial Culture, Cell. env.(non-specific & Ot.), Fermentation, Respiration, Saturated Hydrocarbons, ...5.0754

ACCLIMATION OF HIGH RATE ANAEROBIC DIGESTION ...Acetate, Anaerobic, Digestion, Fermentation, ...5.0366

Mycobacterium Tubercul

PRODUCTION AND DISPERSAL OF PATHOGENIC BACTERIAL AND VIRAL AEROSOLS BY AERATION OF CONTAMINATED WATERS ...Aeration, Aerosols, Biological Organisms, Effluents-waste Water, Monitoring-general, Wind Tunnels, ...5.0301

Myxobacteria

STUDIES ON AQUATIC MYXOBACTERIA ...Bacterial Pollutant Sources, Bioindicators, Degradation, Nutrition, Range Or Territorial Distr. , Streams, ...5.0952

STUDIES ON AQUATIC MYXOBACTERIA ...Applied Ecology, Bacterial Pollutant Sources, Fresh Water, Pollution Abatement, Range Or Territorial Distr. , ...5.0954

Nitrogen Bacteria

MICROBIAL ECOLOGY OF LAKE CHAMPLAIN AS INFLUENCED BY PESTICIDES ...Biodegradation, Freshwater Ecology, Lakes, Microorganisms (non-specific), ...5.1202

CONTROL OF BIOLOGICAL GROWTHS IN RAPID SAND FILTERS AS RELATED TO IRON REMOVAL ...Disinfection, Iron, Nitrification, Repression, Sand, ...5.0377

NITRIFICATION BY MARINE MICROORGANISMS ...Autotrophic, Bact. morphology (general), Bacterial Culture, Isolation From Nat. environ. , Marine Bacteria (non-specific), Nitrification, Range Or Territorial Distr. , ...1.0066

Salmonella (non-specific & Ot)

EFFECT OF POLLUTING AGENTS ON SURVIVAL OF INDICATOR ORGANISMS ...Bioindicators , Intestinal Bacteria, Pollution-water, Shigella (non-specific & Ot.), Zooplankton, ...5.1132

BACTERIOLOGICAL WATER QUALITY ANALYSES OF METHODS FOR DETECTING FECAL POLLUTION ...Bacterial Pollutant Sources, Bioindicators, Coliforms (non-specific), Microbiological Analysis, Streptococcus Fecalis, ...5.1113

DEMONSTRATION OF THE CHANNEL AERATION PROCESS IN TREATMENT OF SEWAGE ...Aeration, Applied Ecology, Enteroviruses of Animals, Enteroviruses of Humans, Nutrients, ...5.0596

STUDY OF GROWING AREA STANDARD BY EXAMINING ENTEROPATHOGENS AND INDICATOR ...Bioindicators, Enteroviruses of Humans, Microbiological Analysis, Number, Sewage, ...5.1069

Salmonella Typhimurium

THE DEVELOPMENT OF OPERATIONAL SHELLFISH DEPURATION AND RELAYING SYSTEMS ...Bacterial Pollutant Sources, Clams, Thermal Pollution, Trace Elements, ...5.1068

Sewage Bacteria

MICROBIOLOGY OF SEWAGE LAGOONS - EFFECTS OF INDUSTRIAL WASTES ON COLIFORM AND OTHER ENTERIC ORGANISMS ...Bacteria, Biochemical Oxygen Demand, Food Processing Industry, Industrial Waste-other, Lagoon, Sewage Lagoons, ...5.0837

EFFECTS OF AUDIO VIBRATIONS ON AERATED BIOLOGICAL SYSTEMS ...Activated, Aeration, Bubble, Sonic, Waste Water Treatment-general, ...5.0673

MICROBIAL DEGRADATION OF ORGANIC POLLUTANTS OF INDUSTRIAL ORIGIN ...Chemical, Industrial Wastes, Microbial-bacterial, Organic Matter, Toxic Substances -non-specific, ...5.0514

MICROBIOLOGICAL CHARACTERIZATION OF ACTIVATED SLUDGE IN A WASTEWATER TREATMENT PLANT CHEMICALLY MODIFIED FOR PHOSPHORUS REMOVAL ...Activated, Aerobic, Cell. env.(non-specific & Ot.), Chemical Treatment, Phosphorus, ...5.1046

DETECTION AND SIGNIFICANCE OF ENZOOTIC WATER POLLUTION ...Animal Wastes - Feed Lots, Bacterial Pollutant Sources, Bioindicators, Enzootic, Protozoa -other, ...5.0700

MICROBIOLOGY OF SLUDGE - DNA ANALYSES AND N2 REMOVAL ...Activated, Denitrification, ...5.0694

IDENTIFICATION OF LIMITING FACTORS IN THE BIOLOGICAL TREATMENT OF SEWAGE ...Activated, Biological Treatment-other, Other, Pilot Plant, ...5.0230

CHLORINATION OF WASTE WATER EFFLUENTS ...Activated, Bacteria, Chlorination, Effluent-standards, Illinois, ...5.0367

STUDY OF MICROBIOLOGICAL-BIOCHEMICAL PHOSPHATE SORPTION MECHANISM BY ACTIVATED SLUDGE ...Absorption-other, Activated, Mechanisms, Other, Phosphate, Phosphite, ...5.0907

Shigella (non-specific & Ot.)

EFFECT OF POLLUTING AGENTS ON SURVIVAL OF INDICATOR ORGANISMS ...Bioindicators, Intestinal Bacteria, Pollution-water, Salmonella (non-specific & Ot), Zooplankton, ...5.1132

Soil Bacteria

DEGRADATION OF SEWAGE AND SOIL MICROORGANISMS ...Catabolism and Degradation, Degradation, E Coli, Micro-organism Enz, Sewage, ...5.0524

BIOTRANSFORMATION OF ALDRIN AND DIELDRIN BY BACTERIA - INTERACTION BETWEEN MICROORGANISMS AND PESTICIDES ...Aldrin, Biodegradation, Cell. env.(non-specific & Ot.), Dieldrin, Other, Water Bacteria, ...5.0644

BIOTRANSFORMATION OF HEPTACHLOR BY BACTERIA - INTERACTION BETWEEN MICROORGANISMS AND PESTICIDES ...Bacterial Pollutant Sources, Biodegradation, Heptachlor, Other, Water Bacteria, ...5.0645

Sphaerotilus

THE BIOLOGY AND CHEMISTRY OF SPHAEROTILUS ...Autotrophic, Butyric Acid, Growth (non-specific & Ot.), Nutrition, Oxidation-general, ...5.1241

ECOLOGY OF SPHAEROTILUS IN ACTIVATED SLUDGE ...Activated, Cell. env.(non-specific & Ot.), Ecology, Identification, Microbial-bacterial, ...5.0341

EFFECT OF PAPER FIBER WASTES ON FISH EGGS AND JUVENILES ...Fish -non-specific, Minnesota, Oxygen, Pollution - Effects of , Pulp, Paper , and Logging, ...5.0614

SLIME CONTROL ASSOCIATED WITH PULP MILL EFFLUENTS ...Bacterial Pollutant Sources, Industrial Wastes, Nutrition, Pulp and Paper Wastes, ...5.0977

Streptococcus Fecalis

BACTERIOLOGICAL WATER QUALITY ANALYSES OF METHODS FOR DETECTING FECAL POLLUTION ...Bacterial Pollutant Sources, Bioindicators, Coliforms (non-specific), Microbiological Analysis, Salmonella (non-specific & Ot), ...5.1113

MICROBIOLOGICAL STUDIES IN AN OPEN AND A CLOSED WATERSHED ...Bacterial Pollutant Sources, Coliforms (non-specific), Montana, Recreation Sites, Watersheds-general, ...5.0696

ENTEROCOCCI, COLIFORM BACTERIA AND BACTERIOPHAGES IN LAKE WATER ...Bacterial Pollutant Sources, Bacteriophages (non-spec & Ot), Detection & Diagnosis, ...5.1315

Sulfur Bacteria

METABOLIC ROLE OF SULFATES AND SULFIDES PRODUCING BACTERIA IN THE POLLUTION OF WATERS ...Autotrophic, Bacterial Pollutant Sources, Budgets -other, Mine Drainage Control, Respiration, ...5.0438

WASTE WATER ODOR REDUCTION MECHANISMS IN SOIL FILTERS ...Biological, Growth (non-specific & Ot.), Pollutant-other, Soil, Taste and Odor, ...5.1258

MICROBIOLOGICAL REMOVAL OF IRON FROM MINE DRAINAGE WATERS ...Acid Mine Wastes, Iron, Microbial-bacterial, Oxidation-other, Reduction-other, ...5.0925

MICROBIOLOGICAL ASPECTS OF ACID MINE-DRAINAGE ...Acidity, Autotrophic, Indiana, Iron Bacteria, Mining Industry, ...5.0385

Vibrio N S

VIBRIO PARAHAEMOLYTICUS IN THE ESTUARINE ENVIRONMENT ...Crustacea -non-specific, Estuaries, Isolation From Nat. environ. , Mollusks -non-specific & Other, Temporal Distribution, ...2.1115

Water Bacteria

ZOOPLANKTON NUTRITION IN LARGE RESERVOIRS ...Nutrition - Invertebrate, Population Dynamics, Productivity - Food Chain, Reservoirs and Impoundments, Zooplankton, ...2.0515

FACTORS AFFECTING ZOOPLANKTON PRODUCTION IN FOUR ARIZONA LAKES ...Environmental Ecology, Lakes, Productivity - Food Chain, Trace Element Analysis, Zooplankton, ...5.0047

SEASONAL VARIATIONS IN THE PHYTOPLANKTON - BACTERIA POPULATIONS AND THE NUTRIENT CONCENTRATION IN BEAVER RESERVOIR ...Nitrogen, Phosphorus, Phytoplankton, Reservoirs and Impoundments, Temporal Distribution, ...6.0027

ECOLOGICAL RELATIONSHIPS OF ORGANIC MATTER AND BACTERIA IN TUTTLE CREEK RESERVOIR ...Food Chains, Freshwater Ecology, Kansas, Organic Matter, Reservoirs and Impoundments, ...5.0428

ECOLOGY OF SELECTED AQUATIC BACTERIA IN THE SNAKE RIVER ...Bacterial Pollutant Sources, Pollution - Effects of , Pulp, Paper , and Logging, Sewage, Snake River, ...5.1236

BIOLOGICAL DEGRADATION OF WASTES UNDER PSYCHROPHILIC ENVIRONMENTS ...Bacterial Pollutant

Sources, Biological, Low Temp. - But Above 32f, Mixed Culture, Polar, ...5.0036

MICROBIAL INTERVENTION IN THE EUTROPHICATION PROCESS ...Eutrophication, Food Chains, Nutrients, Organic, Phytoplankton, ...5.0515

THE ECOLOGY OF STREAM BIOTA IN WASTE ASSIMILATION ...Degradation, Organic Matter, Periphyton, Self-purification, Streams, ...5.0675

THE ECOLOGIC IMPACT OF THE INTERACTIONS AMONG MICROORGANISMS AND AQUATIC CONTAMINANTS IN LAKE ERIE ...Environment, Lake Erie, Pollution - Effects of , Primary Productivity, Sediments, ...6.0427

EFFECT OF AN ACID-WATER ENVIRONMENT UPON THE SYNTHESIS OF GROWTH FACTORS BY BACTERIA ...Biosynthesis, Industrial Wastes, Ionic Effect, Mining Activities, Waste Water Treatment-general, ...5.1285

STUDIES ON AQUATIC STALKED BACTERIA ...Bacterial Culture, Classification Or Taxonomy, Ecology, Growth (non-specific & Ot.), Stalks and Buds, ...5.1280

RAPID IDENTIFICATION OF MICROBIAL POPULATIONS IN WATER ...Biological Pollutants -general, Fresh Water, Identification, Membrane, ...5.1167

SEDIMENT-WATER-BACTERIA INTERACTIONS IN EUTROPHICATION ...Deposits-other, Eutrophication, Lakes, Nutrients, Oregon, ...5.0953

BIOTRANSFORMATION OF ALDRIN AND DIELDRIN BY BACTERIA - INTERACTION BETWEEN MICROORGANISMS AND PESTICIDES ...Aldrin, Biodegradation, Cell. env.(non-specific & Ot.), Dieldrin, Other, Soil Bacteria, ...5.0644

BIOTRANSFORMATION OF HEPTACHLOR BY BACTERIA - INTERACTION BETWEEN MICROORGANISMS AND PESTICIDES ...Bacterial Pollutant Sources, Biodegradation, Heptachlor, Other, Soil Bacteria, ...5.0645

RECOVERY OF INDICATOR BACTERIA ON SELECTIVE MEDIA DURING DECREASE OF VIABLE COUNTS ...Bacteria (non-specific), Bioindicators, Media, Tests of Cell Viability, ...5.0587

Zooglia

INVESTIGATIONS OF ZOOGLOEAL FLOCS ...Adhesion, Classification Or Taxonomy, Diffusion, Nutrients, Other, ...5.1313

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Classification Or Taxonomy

OCCURENCE OF PROSTHECATE BACTERIA IN A GRADIENT-POLLUTED RIVER ...Bact. morphology(other Specif), Bacterial Pollutant Sources, Freshwater Ecology, Number, Streams, ...5.0571

INVESTIGATIONS OF ZOOGLOEAL FLOCS ...Adhesion, Diffusion, Nutrients, Other, Zooglia, ...5.1313

STUDIES ON AQUATIC STALKED BACTERIA ...Bacterial Culture, Ecology, Growth (non-specific & Ot.), Stalks and Buds, Water Bacteria, ...5.1280

THE ECOLOGY OF CLOSTRIDIUM BOTULINUM TYPE E ...Bacterial Exotoxins, Clostridium Botulinum, Ecology, Estuaries, Serology, ...5.1070

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STUDIES ON AQUATIC STALKED BACTERIA ...Bacterial Culture, Classification Or Taxonomy, Growth (non-specific & Ot.), Stalks and Buds, Water Bacteria, ...5.1280

ECOLOGY OF SPHAEROTILUS IN ACTIVATED SLUDGE ...Activated, Cell. env.(non-specific & Ot.), Identification, Microbial-bacterial, Sphaerotilus, ...5.0341

THE ECOLOGY OF CLOSTRIDIUM BOTULINUM TYPE E ...Bacterial Exotoxins, Classification Or Taxonomy, Clostridium Botulinum, Estuaries, Serology, ...5.1070

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STUDY OF WATERFOWL BOTULISM ...California, Clostridium Botulinum, Growth (non-specific & Ot.), Pathology, Water Fowl, N.s. , ...6.0070

BIOCHEMICAL EFFECTS OF MICROORGANISMS UPON THE SALT MARSH ENVIRONMENT -...Bacterial Pollutant Sources, Laboratory, Marine Bacteria (non-specific), Salinity, Swamps-marshes, ...1.0025

A STUDY OF COLIFORM BACTERIA AND ESCHERICHIA COLI ON POLLUTED AND UNPOLLUTED OYSTER BOTTOMS OF MISSISSIPPI ...Coliforms (non-specific), Mississippi River, Sewage, Vertical Distribution, Water Sampling, ...5.0619

ACID MINE DRAINAGE MICROBIOLOGICAL STUDIES ...Acidity, Bacterial Pollutant Sources, Mining Activities, Mining Industry, Sewage, ...5.1284

ECOLOGY OF SPHAEROTILUS IN ACTIVATED SLUDGE ...Activated, Cell. env.(non-specific & Ot.), Ecology, Microbial-bacterial, Sphaerotilus, ...5.0341

RAPID IDENTIFICATION OF MICROBIAL POPULATIONS IN WATER ...Biological Pollutants -general, Fresh Water, Membrane, Water Bacteria, ...5.1167

SURVEY OF CLOSTRIDIUM BOTULINUM TYPE E ...Bacterial Exotoxins, Clostridium Botulinum, Infra Red, Mutagens, ...5.0957

WATER POLLUTION ...Bacterial Pollutant Sources, Cell. env.(non-specific & Ot.), Self-purification, Septic Tanks, Streams, ...5.0730

ORGANIC DEBRIS ON CONNECTICUT BEACHES AND SHORES ...Catabolism and Degradation, Connecticut, Organic Matter, Physical-general, Shoreline - Coastline, ...5.0204

ROLE OF ENTERIC MICROORGANISMS IN DETOXIFICATION - INTERACTION BETWEEN MICROORGANISMS AND PESTICIDES ...Bacterial Culture, Biodegradation, Fish -non-specific, Insecticides -non-specific, Intestinal Bacteria, ...5.0641

ECOLOGY OF C. BOTULINUM IN THE COMMERCIAL FISHERIES ENVIRONMENT ...Clostridium Botulinum, Productivity - Food Chain, Serology, ...6.0291

Isolation From Nat. environ.

STUDIES ON THE METHANOGENIC BACTERIA IN SLUDGE ...Acids, Culture Collections, Digestion, Methane Bacteria (non-specif.), ...5.0259

VIBRIO PARAHAEMOLYTICUS IN THE ESTUARINE ENVIRONMENT ...Crustacea -non-specific, Estuaries, Mollusks - non-specific & Other, Temporal Distribution, Vibrio N S, ...2.1115

NITRIFICATION BY MARINE MICROORGANISMS ...Autotrophic, Bact. morphology (general), Bacterial Culture, Marine Bacteria (non-specific), Nitrification, Nitrogen Bacteria, Range Or Territorial Distr. , ...1.0066

Morphology

Bact. morphology (general)

NITRIFICATION BY MARINE MICROORGANISMS ...Autotrophic, Bacterial Culture, Isolation From Nat. environ. , Marine Bacteria (non-specific), Nitrification, Nitrogen Bacteria, Range Or Territorial Distr. , ...1.0066

Bact. morphology(other Specif)

OCCURENCE OF PROSTHECATE BACTERIA IN A GRADIENT-POLLUTED RIVER ...Bacterial Pollutant Sources, Classification Or Taxonomy, Freshwater Ecology, Number, Streams, ...5.0571

Capsule and Slime Layer

ECONOMIC OPTIMIZATION OF SECONDARY TREATMENT AND DETERMINATION OF LOAD TO CONTROL BIOLOGICAL GROWTHS IN A STREAM ...Aeration, Lagoon, Optimization, Pulp and Paper Wastes, Storage-retention-facilities, ...5.1222

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THERMAL DESTRUCTION OF TYPE E CLOSTRIDIUM BOTULINUM ...Cell Injury and Autolysis, Clostridium Botulinum, Heat Resistance, Microbiological, Toxicological and Allergy, ...5.0233

SPORULATION AND GERMINATION OF CLOSTRIDIUM BOTULINUM ...Bacterial Exotoxins, Cell. env.(non-specific & Ot.), Clostridium Botulinum, Growth (non-specific & Ot.), Media, ...5.0568

Stalks and Buds

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Serology

ECOLOGY OF C. BOTULINUM IN THE COMMERCIAL FISHERIES ENVIRONMENT ...Clostridium Botulinum, Identification, Productivity - Food Chain, ...6.0291

THE ECOLOGY OF CLOSTRIDIUM BOTULINUM TYPE E ...Bacterial Exotoxins, Classification Or Taxonomy, Clostridium Botulinum, Ecology, Estuaries, ...5.1070

Bacteriophage

Bacteriophages (non-spec & Ot)

APPLICATION OF BACTERIOPHAGES TO ELIMINATE MINE ACIDS ...Acidity , Bacterial Pollutant Sources, Isolation, Mining Industry, ...**5.0995**

ENTEROCOCCI, COLIFORM BACTERIA AND BACTERIOPHAGES IN LAKE WATER ...Bacterial Pollutant Sources, Detection & Diagnosis, Streptococcus Fecalis, ...**5.1315**

Escherichia Coli

ADSORPTION OF VIRUSES ON MINERAL SURFACES ...Adsorption, Adsorption Capacity, Control of Viruses, Mineralogy, Viral Pollutant Sources, ...**5.0474**

Barium

SOLUBILITIES OF THE SULFATES OF BARIUM AND STRONTIUM IN OILFIELD WATERS ...Brines, Fluid Properties, Radioisotopes, Solution Chemistry, Strontium, Thermal Properties-other, ...**1.0097**

Baseflow

TRACING STORM AND BASE FLOW TO VARIABLE SOURCE AREAS ON FORESTED HEADWATERS ...Floods, Forest Watersheds, Georgia, Hydraulic Structures, Runoff, Subsurface Flow, ...**2.0339**

EFFECTS OF GROUNDWATER SEEPAGE ON STREAM REGIMEN ...Flume Studies, Groundwater, North Dakota, Seepage, Suspension, ...**2.0832**

OPTIMUM UTILIZATION AND MANAGEMENT OF WATER IN FORMATIONS HYDROLOGICALLY-CONNECTED TO A STRETCH OF THE CONNECTICUT RIVER ...Aquifers-general, Artificial Recharge, Connecticut River, Massachusetts, Water Yield, ...**4.0134**

A STUDY OF SUBSURFACE FLOW INTO MOUNTAIN STREAMS AS RELATED TO TOPOGRAPHY AND PARTIAL SOURCE AREAS ...Georgia, Japan, Mountains-alpine, Relief, ...**2.0340**

FACTORS AFFECTING WATER YIELDS FROM SMALL WATERSHEDS IN GEORGIA ...Georgia, Runoff, Small Watersheds, Statistics-general, Water Yield, ...**4.0083**

BASE FLOW ANALYSIS OF SELECTED DRAINAGE BASINS. ...Mathematical Analysis, New Hampshire, Seasonal, Small Watersheds, ...**2.0742**

TRACING STORM AND BASE FLOW TO VARIABLE SOURCE AREAS ON FORESTED HEADWATERS ...Flow Characteristics -water, Forest Watersheds, Georgia, Physical Properties -other, Sediment Yield, ...**2.0341**

FACTORS AFFECTING MINE DRAINAGE AND THE GROUND WATER INTERACTIONS IN SELECTED AREAS OF WESTERN PENNSYLVANIA (PART 2) ...Acidity, Groundwater Movement, Mine Drainage Control, Pyrite Group, Stratified Flow, ...**5.1044**

LOW-FLOW ANALYSIS, WASHINGTON STREAMS ...Discharge-general, Gaging, Hydrographs, Low Flow, Washington, ...**2.1134**

LOW-FLOW STUDY - WISCONSIN ...Data Acquisition-general, Flow Characteristics -water, Low Flow, Wisconsin, ...**2.1147**

SUBSURFACE AND GROUND WATER ACCRETION, DEPLETION, MOVEMENT AND CONTRIBUTION TO STREAMFLOW ...Agricultural Watersheds, Aquifers-general, Groundwater Movement, Mississippi, Natural Recharge, ...**2.0336**

AQUIFER AND SUBSURFACE RELATIONSHIPS IN THE HYDROLOGY OF UPSTREAM AGRICULTURAL WATERSHEDS ...Aquifers-general, Forecasting-prediction, Groundwater Movement, Natural Recharge, Streams, Technique Development, Water Yield, ...**3.0394**

Bathymetry

DEPTH CONTOURING BY COLOR SEPARATION ...Electronics - Applied, Marine Photography-television, Optical, Photogrammetry, Satellites, ...**6.0276**

TRANSVERSAL DRIFTS IN BOTTOM PROFILE ...Benthonic-bottom, Intertidal Areas, Ocean Waves - Currents, Waves, ...**5.0254**

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BAYOU LAFOURCHE SEDIMENTATION STUDY, LOUISIANA ...Channels, Louisiana, Morphology-general, Rate of Deposition, Sediment Yield, ...**2.0535**

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MASS MORTALITY OF PACIFIC OYSTERS ALONG THE WASHINGTON COAST ...Environmental Ecology, Mortality Rates, Oysters, Pathology, Puget Sound, ...**5.1230**

MASS MORTALITY OF OYSTERS ALONG THE OREGON COAST ...Invertebrate Pathology, Mortality Rates, Oregon, Oysters, Pathology, ...**5.0985**

THE EFFECTS OF ENGINEERING PROJECTS ON THE ECOLOGY OF JONES BAY ...Aquatic Ecology, Construction, Engineering Structures-general, Texas, Water Properties-general, ...**6.0543**

DETERMINATION OF SAFE LEVELS OF POLLUTION IN PUERTO RICO ...Contamination - Water, Meteorological Studies-general, Pollution - Effects of , Puerto Rico, Recreation Sites, Water Properties-general, ...**2.0937**

RESIDENCE TIMES OF WATERS BEHIND BARRIER ISLANDS ...Circulation General, Simulation Theory, Tides, Wind-water Interaction, ...**5.0253**

EUTROPHICATION OF SHELTERED BAYS IN A LARGE LAKE ...Chemical-general, Currents -water, Eutrophication, Freshwater Ecology, Utah, ...**5.1188**

NUTRITIONAL ECOLOGY AND COMMUNITY STRUCTURE OF THE PHYTOPLANKTON OF GREEN BAY ...Mineral Composition, Nutrition Studies, Physiological Ecology, Phytoplankton, Wisconsin, ...**5.1290**

EFFECTS OF RIVERS ON THE METABOLISM OF TEXAS BAYS ...Nutrients, Pollutants-general, Primary Productivity, Streams, Texas, Water Quality-general, ...**5.1182**

EFFECTS OF WATER POLLUTION IN SAN FRANCISCO BAY ...Economic Impact, Pollution - Effects of , Recreation Sites, San Francisco Bay, Social Aspects, Water Utilization -domestic, Welfare Economics, ...**5.0125**

STUDIES OF THERMAL POLLUTION IN BISCAYNE BAY ...Aquatic Ecology, Florida, Pollution - Effects of , Thermal Pollution, Warm Water, ...**5.0265**

SPRING CREEK AUXILIARY WATER POLLUTION CONTROL PROJECT ...Combined Sewer, Effluents-waste Water, New York, Overflow, ...**5.0759**

BIONOMICS OF FISHES AND SHELLFISHES ...Aquaculture & Fish-farming, Economics-general, Environmental Ecology, Oregon, Productivity - Food Chain, ...**2.0896**

SEASONAL VARIATIONS OF SOME LIMNOLOGICAL FACTORS IN LITTLE SODUS BAY, NEW YORK ...Chemical-general, Eutrophication, Lake Ontario, New York, Productivity - Food Chain, ...**3.0355**

THE ANALYSIS AND GEOCHEMISTRY OF TRACE ELEMENTS IN THE HYDROSPHERE ...Activation Analysis, Chemical Analysis (water), Chemical Reactions, Gamma, Trace Element Analysis, ...**1.0109**

SAND TRACING AT SPECIFIC INLETS AND AREAS ON THE LOWER EAST COAST OF FLORIDA ...By-passing, Florida, Longshore Currents, Shoreline - Coastline, Tracers, ...**8.0161**

AN ECONOMIC EVALUATION OF WATER POLLUTION CONTROL, YAQUINA BAY, ORE ...Alternative Planning, Benefit-cost Analysis, Model Studies, Oregon, Systems Analysis, Water Quality Control-general, ...**6.0454**

SOCIO-ECONOMIC STUDY OF NARRAGANSETT BAY, RHODE ISLAND ...Benefit-cost Analysis, Estuaries, Land Use, Rhode Island, Social Aspects, Water Quality Control-general, ...**6.0485**

SEA NETTLE STUDIES IN CHESAPEAKE BAY, LIFE HISTORY AND ECOLOGY ...Aquatic Ecology, Biological Control, Chesapeake Bay, Jelly Fish, Life History Studies, ...**6.0127**

EFFECTS OF HEATED WATER IN A TIDAL ESTUARY ...Chesapeake Bay, Electric Power Plants, Pollution Effects, Thermal Pollution, Urban Environments, Water Properties-general, ...**4.0078**

QUALITY OF WATER OF THE TEXAS BAYS AND ESTUARIES ...Estuaries, Nutrients, Pollutants - Path of , Texas, Water Quality-general, ...**2.1003**

GEOCHEMISTRY OF SAN FRANCISCO BAY ...Clays, Distribution, Mineral Associations, San Francisco Bay, Trace Element Analysis, ...**2.0121**

HYDROLOGY OF UPPER OLD TAMPA BAY, FLORIDA ...Groundwater Movement, Hydrology-general, Lakes, Permeability, Water Harvesting, Water Quality-general, ...**2.0331**

INVENTORY OF THE GULF ESTUARY SYSTEM ...Data Acquisition-general, Estuaries, Fishing, Gulf of Mexico, Sedimentology-general, ...**2.0322**

SAN PABLO BAY STUDY ...Benthic Fauna, Bottom Sampling, Excavation, Spoil Banks, Water Sampling, ...**6.0038**

PRIMARY PRODUCTIVITY IN LAKE FRANCIS CASE ...Benthic Fauna, Phytoplankton, Primary Productivity, Reservoirs and Impoundments, Standing Crops, ...**6.0524**

ECOLOGY OF GREAT LAKES ESTUARIES ...Currents -water, Estuaries, ...**2.0626**

MODEL FOR DETERMINING THE MOST UNFAVORABLE CONDITIONS FOR AREA CLASSIFICATION ...Pollutants - Path of , Pollutants-general, Rhode Island, Shellfish, N.s. , Water Standards, ...**5.1067**

EFFECT OF THE EFFLUENT FROM AN ATOMIC POWER PLANT ON THE ADJACENT PORTION OF BARNEGAT BAY, NEW JERSEY ...New Jersey, Pollution - Effects of , Pollution Effects, Reactor Sites & Rad Waste, Thermal Pollution, Water Temperature-non-specific, ...**5.1076**

Beaches

DISPERSION OF WATER AND SEDIMENTS IN THE SURF ZONE ...Pollutants - Path of , Pollution-general, Shoreline - Coastline, Size, Waves, ...**5.0151**

DEVELOPMENT OF CRITERIA FOR ARTIFICIAL BEACHES ...Beach, Coastal Engineering-other, Design Criteria, Shoreline Structures, Statistics-general, ...**8.0155**

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Management

ANIMAL, FORAGE AND WATER RESOURCES FOR BEEF PRODUCTION ...Quality and Utilization, ...**5.0086**

EFFECT OF GRAZING MANAGEMENT ON RANGE LIVESTOCK NUTRITION AND ON THE RANGE RESOURCE ...Cattle, Cutting &/or Grazing Effects, Diet Or Ration -other, Management and Fertility, Quality and Utilization, ...**2.0971**

Behavior -animal

RELATIONSHIPS BETWEEN SUB-LETHAL PESTICIDES AND REPRODUCTION AND BEHAVIOR OF FISHES ...DDT , Killifishs - Cyprinodon, Pesticides -non-specific, Reproduction Studies (general), Wildlife, ...**5.0292**

FOOD HABITS OF LARGEMOUTH BASS LARVAE ...Aquatic Ecology, Food Supply, Largemouth Bass, Ponds, Zooplankton, ...**7.0082**

THE EFFECTS OF DIELDRIN ON MALLARD DUCKLING BEHAVIOR ...Dieldrin, Light Quality -non-specific, Mallard, Mode of Action -animal, Visual, ...**6.0580**

FLATHEAD CATFISH STUDY ...Aquatic Ecology, Food Supply, Growth Rate, Ictaluridae -other, Reproduction Studies (general), Texas, ...**6.0539**

TEMPERATURE REQUIREMENTS OF SALMONIDS IN RELATION TO THEIR FEEDING, BIOENERGETICS, GROWTH AND BEHAVIOR ...Energy, Growth Rate, Rainbow Trout, Steelhead Trout, Salmon -coho,chinook,sockeye.., Water Temperature-non-specific, ...**5.0942**

TEMPERATURE TOLERANCE OF MARINE ANIMALS THROUGH BEHAVORIAL RESPONSES ...Environment Resistance, Mortality Rates, Thermal, Water Temperature-non-specific, ...**6.0344**

THERMAL PREFERENCES OF MARINE FISHES AND INVERTEBRATES ...Fish -non-specific, Invertebrates -non-specific, Water Temperature-non-specific, ...**5.0720**

EFFECTS OF HOT WATER MASSES ON MARINE FISHES ...Atlantic Ocean-north, Fish -non-specific, High Temp. -85f Or Above, Thermal, ...**5.0721**

BEHAVIOR OF ESTUARINE ANIMALS ...Estuaries, Pesticides - non-specific, Pollution - Effects of , Pollution Effects, ...**2.0323**

FISH BEHAVIOR AND PHYSIOLOGY ...Engineering Structures-general, Environmental Physiology, Migration, Salmon & Trout - Non-specific, Thermal Pollution, ...**6.0615**

Beneficiation, Extraction

Beneficiation

IRON ORE FLOTATION ...Flotation, Industrial Processes-other, Mining Industry, Ores, Pollution Abatement, Recovery, Scrap and Wastes, ...**5.0616**

Electrolytic Processes

TREATMENT RECOVERY, AND REUSE OF COPPER WIRE MILL PICKLING WASTES ...Copper, Electrochemistry-other, Material Recovery Wastes, Metal Pickling Wastes, Regeneration-other, ...**5.0722**

Recovery, Scrap and Wastes

AN INVESTIGATION OF TECHNIQUES FOR THE REMOVAL OF CHROMIUM AND CYANIDES FROM ELECTROPLATING WASTES ...Chromium, Electroplated, Extraction, Flotation, Industrial Processes-other, Material Recovery Wastes, ...**5.0725**

ENCAPSULATION AND SOLIDIFICATION OF INTERMEDIATE LEVEL RADIOACTIVE WASTES IN THERMOPL ASTICS ...Accidental, Encapsulation, Fire Research-other, Instrumentation, Plant Equip. , Polymer-other, Radioisotopes, ...**5.1142**

IRON ORE FLOTATION ...Beneficiation, Flotation, Industrial Processes-other, Mining Industry, Ores, Pollution Abatement, ...**5.0616**

Separation

LEACHING AND RECOVERY OF COPPER FROM ORES AND WASTE DUMPS ...Copper, ...**3.0478**

Benthic Fauna

ABUNDANCE AND DISTRIBUTION OF BENTHIC MACRO-INVERTEBRATES IN A STREAM RECEIVING OILFIELD WASTEWATERS ...Bioindicators, Contamination - Water, Industrial Wastes, Number Or Density, Vertical Distribution, ...**5.1028**

COLONIZATION RATES OF BENTHIC INVERTEBRATES IN AN OHIO RESERVOIR ...Intertidal Areas, Ohio, Productivity - Food Chain, Reservoirs and Impoundments, Water Level Fluctuation, ...**6.0424**

BOTTOM FAUNA STUDIES ...Bottom Sampling, Depth,water Level, Fluctuation, Lakes, Number Or Density, Water Level Fluctuation, ...**4.0126**

WATER QUALITY - BENTHIC INVERTEBRATE RELATIONSHIPS IN ESTUARIES ...Benthonic-bottom, Estuaries, Maine, Pollution - Effects of , Pollution Effects, ...**5.0478**

THE EFFECTS OF EXTREME FLOODS AND PLACER MINING ON THE BASIC PRODUCTIVITY OF SUBARCTIC STREAMS ...Alaska, Bottom Sampling, Floods, Meteorological Extremes, Placer, Productivity - Food Chain, ...**2.0022**

BENTHONIC INVERTEBRATES AS AN INDEX OF WATER QUALITY ...Bioindicators, Gases, Dissolved -water, Oxygen, Water Quality Control-general, ...**5.0601**

THE MICRODISTRIBUTION OF STREAM BENTHOS ...Aquatic Ecology, Organic-general, Productivity - Food Chain, Streams, Vertical Distribution, ...**5.1020**

THE BIOLOGY OF THE INFAUNA OF A TROPICAL SOFT BOTTOM AREA ...Aquatic Ecology, Estuaries, Florida, Intertidal Areas, Pollution - Effects of , ...**5.0263**

BOTTOM FAUNA IN THE NORTH ST. VRAIN CREEK, COLORADO ...Aquatic Ecology, Colorado, Mountains-alpine, Streams, Vertical Distribution, ...**2.0158**

A COMPARATIVE STUDY OF THE MACROSCOPIC BENTHIC FAUNA OF TWO CENTRAL ADIRONDACK LAKES ...Animal Taxonomy, Comparative Physiology, Lakes, New York, Productivity - Food Chain, ...**2.0814**

SAN PABLO BAY STUDY ...Bays, Bottom Sampling, Excavation, Spoil Banks, Water Sampling, ...**6.0038**

PRIMARY PRODUCTIVITY IN LAKE FRANCIS CASE ...Bays, Phytoplankton, Primary Productivity, Reservoirs and Impoundments, Standing Crops, ...**6.0524**

BENTHOS IN LAKE FRANCIS CASE ...Aquatic Ecology, Reservoirs and Impoundments, South Dakota, ...**6.0515**

RESEARCH ON THE MACROBENTHOS OF THE GREAT LAKES ...Aquatic Ecology, Earthworms, Food Supply, Great Lakes-general, Water Quality-general, ...**6.0292**

ESTUARINE STUDIES OF SOUTHEASTERN ALASKA ...Alaska, Environmental Ecology, Estuaries, Number Or Density, Vertical Distribution, ...**2.0017**

Benthic Flora

BASIC RESEARCH IN THE AQUATIC ENVIRONMENT EFFECTS OF EUTROPHICATION ON PLANKTON ALGAE AND BENTHIC PLANTS COMMUNITIES ...Eutrophication, Nutrients, ...**2.0803**

Benthic Flora

COMPARATIVE STUDY OF THE BENTHIC MICROBIAL BIOTA IN SOME COASTAL AREAS OF PUERTO RICO ...Benthonic-bottom, Ocean Environment, Pollution - Effects of , Puerto Rico, Standing Crops, ...**6.0478**

SENSITIVITY OF BENTHIC MICROFLORA TO POLLUTION GRADIENTS ...Bioindicators, Estuaries, Marine Plants, Plant Prod. (non-specific), Water Standards, ...**5.1059**

FACTORS INFLUENCING THE PRODUCTION OF PLANKTONIC AND BENTHIC PLANTS ...Growth Rate, Nutrition, Phytoplankton, Secretions and Products, Standing Crops, ...**5.1119**

Benthic Organisms (non-specif)

THE APPLICATION OF RADIOISOTOPES TO STUDIES OF AQUATIC ECOSYSTEMS ...Aquatic Ecology, Freshwater Ecology, Productivity - Food Chain, Water Properties-general, Wisconsin, ...**6.0643**

LIMNOLOGY OF ROSS ISLAND, ANTARCTICA ...Antarctica, Chemical-general, Lakes, Plankton (non-specific), Pubilications - other, ...**2.0087**

LIMNOLOGY OF DESOTO BEND LAKE, IOWA AND NEBRASKA ...Iowa, Lakes, Nebraska, Plankton (non-specific), Stratification, ...**7.0040**

A BENTHIC COMMUNITY OF THE PENOBSCOT RIVER ESTUARY ...Aquatic Ecology, Estuaries, Industrial Wastes, Maine, Productivity - Food Chain, ...**5.0473**

FOOD HABITS STUDY ...Aquatic Ecology, Food Supply, Lakes, Mississippi, Plankton (non-specific), ...**6.0314**

THE LIMNOBIOCHEMISTRY OF DEVILS LAKE, NORTH DAKOTA ...Aquatic Ecology, Biological-general, Lakes, North Dakota, Salinity, ...**6.0417**

Benthonic-bottom

WATER QUALITY - BENTHIC INVERTEBRATE RELATIONSHIPS IN ESTUARIES ...Benthic Fauna, Estuaries, Maine, Pollution - Effects of , Pollution Effects, ...**5.0478**

CONTROL OF BENTHIC DEPOSITS IN LAKES ...Deposits-other, Eutrophication, Lakes, Water Quality Control-general, ...**5.0513**

COMPARATIVE STUDY OF THE BENTHIC MICROBIAL BIOTA IN SOME COASTAL AREAS OF PUERTO RICO ...Benthic Flora, Ocean Environment, Pollution - Effects of , Puerto Rico, Standing Crops, ...**6.0478**

TRANSVERSAL DRIFTS IN BOTTOM PROFILE ...Bathymetry, Intertidal Areas, Ocean Waves - Currents, Waves, ...**5.0254**

BENTHIC COMMUNITIES ...Engineering Structures-general, Environmental Ecology, Estuaries, Marine Biology, Productivity - Food Chain, ...**6.0156**

Bering Sea

ECOLOGY & NITROGEN CYCLE IN A MARINE PLANT COMMUNITY ...Nitrogen, Physiological Ecology, Potamogeton, Ruppia, Zostera.., Primary Productivity, Sewage, ...**5.0035**

Bioassays

THE BIOASSAY OF WATER POLLUTANTS WITH CULTURED MAMMALIAN CELLS ...Bioassay, Herbicides -non-specific, Toxicity Or Residues -other, ...**5.1055**

ALGAL BIOASSAY TO DETERMINE THE EXTENT OF NUTRIENT REMOVAL BY AWT AT THE WASTE TREATMENT PLANT AT ELY, MINNESOTA ...Algae, Denitrification, Nutrients, Pilot Plant, Waste Water Treatment-general, ...**5.1304**

A STUDY OF A WATER TOXICITY PROBLEM ...Bioindicators, Growth Rate, Management, Potable Water, Toxins and Poisons - other, ...**5.0197**

RELATIONS OF NUISANCE ALGAE TO FISH IN KLAMATH LAKE ...Algal Toxins, Cyanophyta (non-specific & Ot), Fish - non-specific, Lakes, Oregon, ...**5.0937**

SCREENING AQUATIC INVERTEBRATES TO DETECT AN ORGANISM SUITABLE FOR USE IN A MONITORING PROGRAM ...Bioindicators, Cholinesterase, Fish -non-specific, Invertebrates -non-specific, Metabolism, Monitoring Systems, ...**5.0639**

RELATIVE SUSCEPTIBILITIES OF FISH FAMILIES TO INSECTICIDES - ACUTE TOXICITY OF PESTICIDES TO FRESHWATER FISH AND OTHER VERTEBRATES ...Bioassay, Carbamates -non-specific, Chlorinated Hydrocarbons, Organophosphorous Cpds. , Wildlife, ...**5.0653**

CULTURING, PROPAGATION AND CONDITION EVALUATION OF FISHES ...Blood -other, Captive Rearing, Cisco, Lake Herring, Contamination - Water, Lake Trout, Brook Trout, Yellow Perch, Darters, ...**5.0586**

COMPARATIVE TOXICITIES OF METALS TO ESTUARINE FISHES ...Estuaries, Industrial Wastes, Killifishs - Cyprinodon, Mineral Origin, Solid Waste, ...**5.1084**

USE OF MARINE PLANKTONIC ORGANISMS FOR EVALUATING THE QUALITY OF MARINE AND ESTUARINE WATERS ...Estuaries, Phytoplankton, Pollution - Effects of , Pollution Effects, Zooplankton, ...**5.1093**

DEVELOPMENT OF A METHOD FOR CHRONIC TOXICITY BIOASSAY USING MARINE PLANKTONIC ALGAE ...Algal Culture, Marine Plants, Microbiological Analysis, Monitoring (long Term Studies), Phytoplankton, Technique Development, Toxicology, ...**5.1088**

COOPERATIVE STUDIES WITH FEDERAL AND STATE AGENCIES ...Crustacea -non-specific, Mollusks -non-specific & Other, Public Health Ecology, Survey Studies, Water Quality-general, ...**7.0111**

Biochemical Analysis

SEASONAL CHANGES IN ESTERASE ACTIVITY IN FISH AND INVERTEBRATES. INTERACTIONS BETWEEN PESTICIDES ON FISH ENZYME SYSTEMS ...Bluegills, Bream, Cholinesterase, Invertebrates -non-specific, Mode of Action - animal, Pesticides -non-specific, ...**5.0638**

PHYTOCHEMISTRY OF NARCOTIC PRINCIPLES IN CAULERPA ...Biochemical, Caulerpa, Cyclopropane, Medicinal Plants, Phaeophyta (non-specific & Ot), ...**6.0172**

Hormones

Other

THE INVESTIGATION AND ANALYSIS OF BIOCHEMICAL PROCESSES OF AQUATIC ORGANISMS UNDER STRESS ...Animal Origin, Aquatic Ecology, Fish -non-specific, Metabolism -animal, Stress, ...**5.0585**

Proteins and Amino Acids

Purif and Isol

STUDIES ON THE MOLECULAR STRUCTURE OF BIOLOGICAL MEMBRANES ...Active Transport, Desalination, Membranes-other, Plasma Membrane, Structure, ...**3.0388**

FACTORS AFFECTING FISH PRODUCTION PONDS ...Blood Proteins -non-specific, Bluegills, Bream, Electrophoresis -other, Environmental Physiology, Protein, ...**6.0221**

Biological Rhythms

ECOLOGICAL SIGNIFICANCE OF ORGANIC RELEASE PRODUCTS OF MARINE AND FRESHWATER ANIMALS ...Aquatic Ecology, Metabolism, Mucus, Productivity - Food Chain, ...**2.0342**

SAUGER AND WALLEYE INVESTIGATIONS IN THE MISSOURI RIVER ...Missouri River, Population Dynamics, Sauger, Walleyes, ...**6.0334**

LIFE HISTORY OF THE GOLDEYE (HIODON ALOSOIDES) IN GARRISON RESERVOIR, NORTH DAKOTA ...Life History Studies, Nets, North Dakota, Reservoirs and Impoundments, Spawn Or Nesting Sites, ...**5.0827**

VARIATIONS IN SPAWNING OF FISHES IN RELATION TO TEMPERATURE ...Fish -non-specific, Maturity & Growth Stages, South Dakota, Temperature, Water Temperature-non-specific, ...**6.0518**

SEXUAL MATURATION AND SPAWNING OF NORTHERN PIKE ...Maturity & Growth Stages, Pikes, Pickeral, Muskellunge, Reservoirs and Impoundments, South Dakota, Spawn Or Nesting Sites, ...**6.0520**

SPAWNING OF YELLOW PERCH ...Ovary, Reservoirs and Impoundments, South Dakota, Spawn Or Nesting Sites, Yellow Perch, Darters, ...**6.0521**

SPOTTED BASS REPRODUCTION IN BULL SHOALS ...Arkansas, Centrarchidae -other, Environmental Ecology, Reproduction Studies (general), Reservoirs and Impoundments, ...**6.0023**

LIFE HISTORY OF RESERVOIR FISHES, SPAWNING OF OAHE AND BIG BEND RESERVOIR FISHES ...Aquatic Ecology, Life History Studies, Reservoirs and Impoundments, South Dakota, Spawn Or Nesting Sites, ...**6.0523**

PHYSIOLOGY AND BEHAVIOR OF LARVAE (PHYSIOECOLOGY OF SHELLFISH PROGRAM) ...Aquatic Ecology, Environmental Ecology, Environmental Physiology, Water Properties-general, ...**6.0113**

SURVIVAL REQUIREMENTS OF JUVENILE AND ADULT BLUE CRABS ...Crabs, All, Environmental Physiology, Laboratory, Osmoregulation, Water Properties-general, ...**6.0401**

Biological Techniques

ENZYMATIC TECHNIQUE FOR DETECTION OF SURPLUS PHOSPHORUS UPTAKE BY ACTIVATED SLUDGE ...Activated, Nutrients, Phosphorus, ...**5.1149**

Biophysics & Molec. biology

PHYSICAL, METEOROLOGICAL, AND HYDROLOGIC ASPECTS OF EVAPOTRANSPIRATION ...Evapotranspiration, Forest Watersheds, Southeast, Transpiration and Evap, Water Yield, ...**2.0953**

Dipole and Dielectric

EFFECTS OF POLAR ORGANIC SOLVENTS ON ENZYME ACTION ...Enzymatic, Exobiology, Kinetics -other, Temperature, Water, ...**1.0063**

Ionic Effect

ACTIVE AND PASSIVE ION FLUXES ACROSS INTERFACES AND MEMBRANES ...Adsorption & Interface, Diffusion, Enzymes -non-specific, Membranes-other, Transport, ...**3.0348**

EFFECTS OF CHEMICAL IONS ON VIRUS INACTIVATION ...Animal Viruses (non-specific), Concentration, Inactivation, Ion Exchange-other, Virus, ...**5.0475**

Molecular Interaction

STUDY OF FACTORS WHICH DETERMINE THE IONIC SELECTIVITY OF BIOLOGICAL AND ARTIFICIAL MEMBRANES ...Ion Selective, Natural Occurring, Other, Permeability, ...**3.0371**

THE EFFECT OF WATER STRUCTURE ON BIOLOGICAL ACTIVITY ...Bacteria (non-specific), Corn, Water, Water Movement, ...**1.0047**

Structure

STUDIES ON THE MOLECULAR STRUCTURE OF BIOLOGICAL MEMBRANES ...Active Transport, Desalination, Membranes-other, Plasma Membrane, Purif and Isol, ...**3.0388**

Thermodynamics

EFFECTS OF WATER PROPERTIES IN THIXOTROPIC CLAY SYSTEMS ON BIOLOGICAL ACTIVITY ...Anaerobic Bacteria, Cell Cycle, Clay, Origin of Life, ...**6.0217**

ION TRANSPORT IN SOME HALOPHILIC ORGANISMS ...Active Transport, Halophytic, Ions (inorganic), ...**3.0232**

THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF THE MECHANISM OF FLOW OF WATER AND SOLUTES IN PLANT ROOTS ...Ionic Effect, Osmotic and Turgor Pressure, Pressure & Mech Stress, Ultrafiltration, Water Movement, ...**2.0497**

TRITIATED WATER STUDIES OF THE SIGNIFICANCE OF DEW AND VAPOR IN PLANT WATER ECONOMY ...Arid and Desert, Dew, Foliar Absorption, Humidity, Hydrogen, Osmotic and Turgor Pressure, ...**2.0112**

Birds

Anseriformes -other

STUDY OF BIOLOGICAL DESALINATION PHENOMENA AND SALT TRANSPORT MECHNAISMS OF SELECTIVE AVIAN SALT GLANDS ...Active Transport, Chemical Analysis, Ion Selective, Osmoregulation, Transport, ...**3.0479**

A STUDY OF SUSPECTED LEAD POISONING OF SWANS AND GEESE ...Lead, Ponds, Rhode Island, ...**5.1077**

Black Duck

AN ECOLOGICAL STUDY OF LAKE ST. PETER, QUEBEC ...Canada, Depth,water Level, Fluctuation, Interbiotic Relat.(non-specif), Lakes, Water Level Fluctuation, ...**4.0050**

Chickens

FARM ANIMAL WASTE DISPOSAL ...Animal Waste Removal-treatment, Sewage Lagoons, Swine, Waste Disposal-general, ...**5.0835**

Ciconiiformes - Wading Birds

ECOLOGY OF SOME WADING BIRD POPULATIONS AFFECTED BY THE INVASION OF THE CATTLE EGRET INTO ALABAMA ...Aquatic Ecology, Behavioral Ecology, Mark, Tag Or Capture -other, Migration, Water Utilization -animal, ...**6.0001**

Dove

RELATIONSHIP BETWEEN MOURNING DOVE PRODUCTION AND WATER DISTRIBUTION IN THE SONORAN DESERT ...Arizona, Deserts, Habitat Studies, Productivity (agricultural), Water Utilization -animal, ...**6.0262**

Galliformes - Fowl-other

FARM ANIMAL WASTE DISPOSAL ...Animal Waste Removal-treatment, Livestock -non-specific, Sewage Lagoons, Swine, Waste Water Treatment-general, ...**5.0407**

Mallard

THE EFFECTS OF DIELDRIN ON MALLARD DUCKLING BEHAVIOR ...Behavior -animal, Dieldrin, Light Quality -non-specific, Mode of Action -animal, Visual, ...**6.0580**

WATERFOWL UTILIZATION OF SAGO PONDWEED (POTAMOGETON PECTINATUS) ON A SELECTED MARSH IN NORTHERN UTAH ...Food Supply, Potamogeton, Ruppia, Zostera.., Storage, Swamps-marshes, Utah, ...**6.0588**

FACTORS LIMITING WATERFOWL PRODUCTION ON THE SPRING-FED SALT MARSHES WEST OF THE GREAT SALT LAKE ...Nutrition -other, Productivity (agricultural), Swamps-marshes, Utah, Viremia, ...**5.1194**

Mexican Duck

EFFECTS OF RESTORATION AND MANAGEMENT OF THE SAN SIMON MARSH ON ITS UTILIZATION BY MEXICAN DUCKS ...Food Supply, Management, Spawn Or Nesting Sites, Swamps-marshes, Water Utilization -animal, ...**6.0364**

Pintail, Anas Acuta

FOOD AND FOOD ENERGY REQUIREMENTS OF WILD DUCKLINGS ...Energy, Food Supply, Habitat Studies, Scaup, Lesser, Widgeon, American, ...**6.0583**

Scaup, Lesser

FOOD AND FOOD ENERGY REQUIREMENTS OF WILD DUCKLINGS ...Energy, Food Supply, Habitat Studies, Pintail, Anas Acuta, Widgeon, American, ...**6.0583**

Water Fowl, N.s.

EFFECTS OF EARLY WATER ON WATERFOWL PRODUCTION ...Benefit-cost Analysis, Irrigation-general, Spawn Or Nesting Sites, Water Supply-general, Water Utilization -animal, ...**2.0214**

PHYSICAL & CHEMICAL PROPERTIES OF WATER & SOILS OF MARSHES AS THESE PROPERTIES RELATE TO THE SUCCESS OF WATERFOWL FOODS & COVER. ...Biological-general, Food Supply, Soil (wildlife) Cover, Wetlands, ...**6.0371**

STUDY OF WATERFOWL BOTULISM ...California, Clostridium Botulinum, Growth (non-specific & Ot.), Identification, Pathology, ...**6.0070**

THE EFFECTS OF DREDGING AND SILTATION ON DIVING DUCK FOODS AND FEEDING HABITS ON THE MISSISSIPPI RIVER ...Food Supply, Mississippi River, Sediments, Silting, ...**5.0411**

IMPORTANCE OF TYPE I WETLAND COMMUNITIES TO WATERFOWL PRODUCTION ...Censusing, Land Use, Spawn Or Nesting Sites, Water Utilization -animal, Wetlands, ...**4.0218**

WATERFOWL STUDY-EVALUATION OF PHYSICAL CHANGES IN MARSH PONDS ON THE WISNER AND BILOXI DEVELOPMENT ...Land Use, Management, Mississippi, Physical-general, Survey Studies, Swamps-marshes, ...**4.0128**

EVALUATION OF HABITAT AND REPRODUCTIVE FACTORS WHICH INFLUENCE POPULATIONS OF NESTING WATERFOWL ...Habitat Studies, Mapping, Population Dynamics, Spawn Or Nesting Sites, Water Level Fluctuation, ...**4.0108**

UPDATING AND REPUBLICATION OF FACTORS INFLUENCING THE RESTORATION AND DEVELOPMENT OF OGDEN BAY REFUGE ...Mans Activities, Pubilications -other, Swamps-marshes, Water Demand, Water Utilization -animal, ...**6.0594**

THE EFFECT OF LIVESTOCK UTILIZATION ON WATERFOWL HABITAT AND PRODUCTION ...Cattle, Habitat Studies, Utah, Vasc. plant & Vert. -other, Wetlands, ...**6.0595**

RECREATION VALUE OF WATER FOR THE PRODUCTION OF WATERFOWL ...Benefit-cost Analysis, Recreation Sites, Utah, Wetlands, ...**6.0593**

BROOD PRODUCTION AND POND PREFERENCE OF DIVING DUCKS IN THE TURTLE MOUNTAINS OF NORTH DAKOTA ...Aquatic Plants (non-specific), Chemical-general, Habitat Studies, Land Use, Water Utilization -animal, ...**6.0410**

WATER TEMPERATURE AS A QUALITY FACTOR IN THE USE OF STREAMS AND RESERVOI ...Habitat Studies, Reservoirs and Impoundments, Streams, Temperature, Thermal Pollution, ...**5.0200**

WATERFOWL POPULATIONS AND RECREATIONAL USE PATTERNS IN THE PROPOSED SAYLORVILLE RESERVOIR AREA AS RELATED TO PRE-IMPOUNDMENT CONDITIONS ...Access, Frequency of Use, Iowa, Population Dynamics, Pre-impoundment Sites, User Patterns, ...**6.0227**

AN EVALUATION OF SOME MARSH MANAGEMENT TECHNIQUES ...Management, Potholes, Spawn Or Nesting Sites, Swamps-marshes, Water Utilization -animal, ...**4.0107**

WATER QUANTITY AND QUALITY REQUIREMENTS ON WESTERN SALINE MARSHLANDS ...Habitat Studies, Swamps-marshes, Utah, Water Allocation, Water Quality-general, ...**6.0582**

ECOLOGICAL STUDIES OF MANIPULATED MARSHES AT DELTA, MANITOBA, CANADA ...Amphibious Plants, Canada, Submerged Plants, Swamps-marshes, Water Depth, Water Levels, ...**4.0257**

THE EFFECTIVENESS OF WATERFOWL IN CARRYING PATHOGENIC MICRO-ORGANISMS ...Sewage, Swamps-marshes, Utah, Vertebrates, ...**5.1193**

MUSQUODOBOIT - METERING BASINS NOVA SCOTIA, CANADA ...Aquatic Ecology, Canada, Mammals -other, Mapping, Water Level Fluctuation, Wetlands, ...**4.0054**

AN ECOLOGICAL STUDY OF ILES-DE-LA-PAIX, LAKE ST. LOUIS, QUEBEC ...Canada, Interbiotic Relat.(non-specif), Islands, St. lawrence River, ...**4.0048**

MARSH EVALUATION AND ACQUISITION, QUEBEC ...Canada, Habitat Studies, Wetlands, ...**4.0049**

WETLANDS EVALUATION AND DEVELOPMENT - MARITIMES ...Canada, Habitat Studies, Species Evaluation, Wetlands, ...**6.0085**

MARSH EVALUATION AND ACQUISTION - ONTARIO ...Canada, Habitat Studies, Management, Management -other, Wetlands, ...**4.0046**

LITERATURE REVIEW ON FLOODED GREEN TIMBER AREAS ...Canada, Management, Site Index and Site Quality, Survey Studies, Wetlands, ...**4.0045**

WATERFOWL HABITAT INVESTIGATIONS - OTTAWA RIVER ...Canada, Floods, Habitat Studies, Water Level Fluctuation, ...**4.0051**

THE MANAGEMENT OF SHALLOW-WATER IMPOUNDMENTS FOR WATERFOWL ...Food Supply, Management, Reservoirs and Impoundments, Salinity, Water Level Fluctuation, ...**6.0247**

THE PHYSICAL AND CHEMICAL PROPERTIES OF WATER AND SOILS AS RELATED TO THE SUCCESSFUL GROWTH OF WATERFOWL FOOD AND COVER PLANTS ...Flooding, Food Supply, Oxygen, Phytotoxic, Soil (wildlife) Cover, Soil Conditions, ...**2.0799**

AQUATIC BIOLOGY INVESTIGATIONS ...Cricetidae -other, Lake Trout, Brook Trout, Lakes, New York, Streams, ...**2.0786**

EFFECTS OF REGULATED GRAZING ON WATERFOWL PRODUCTION ...Cutting &/or Grazing Effects, Productivity - Food Chain, Soil (wildlife) Cover, Swamps-marshes, ...**6.0584**

HYDROLOGY OF PRAIRIE POTHOLES ...Management -other, North Dakota, Potholes, Seepage, Water Balance-budget, Water Utilization -animal, ...**2.0170**

THE EFFECT OF OCEAN WATER INTRUSION INTO BACK BAY, VIRGINIA, AND CURRITUCK SOUND, NORTH CAROLINA, ON THE WATERFOWL AND FISH HABITAT ...Aquatic Ecology, Brackish Water, Fish -non-specific, Habitat Studies, Saline Water Intrusion, Water Salinity, ...**2.0585**

INTENSIVE COOPERATIVE INVESTIGATIONS OF SELECTED POTHOLES ON MISSOURI COTEAU IN DICKEY, WARD AND STUTSMAN COUNTIES, NORTH DAKOTA ...Hydrology-general, Natural Recharge, Potholes, Water Level Fluctuation, Water Loss-general, ...**6.0419**

WATERFOWL MANAGEMENT THROUGH WATER-LEVEL CONTROL ...Depth,water Level, Fluctuation, Drawdown, Management, Management -other, Wetlands, ...**4.0133**

LIMNOLOGICAL INVESTIGATIONS OF PRAIRIE POTHOLES ...Chemical-general, Habitat Studies, North Dakota, Potholes, ...**2.0850**

CHEMICAL CHARACTERIZATION OF WATERS OF PRAIRIE AND FOREST WETLANDS ...Chemical-general, Habitat Studies, Wetlands, ...**1.0092**

DISTRIBUTION AND DENSITY OF BREEDING WATERFOWL POPULATIONS AS RELATED TO QUANTITY AND QUALITY OF WETLAND HABITAT IN NORTH DAKOTA ...Geography-physical, North Dakota, Number Or Density, Spawn Or Nesting Sites, Wetlands, ...**6.0420**

Widgeon, American

FOOD AND FOOD ENERGY REQUIREMENTS OF WILD DUCKLINGS ...Energy, Food Supply, Habitat Studies, Pintail, Anas Acuta, Scaup, Lesser, ...**6.0583**

Blood Plasma and Serum

SERUM ANALYSIS OF CUTTHROAT TROUT EXPOSED CHRONICALLY TO METHOXYCHLOR PESTICIDE EFFECTS ON FISH ENDOCRINE FUNCTIONS ...Cutthroat Trout, Endocrine -other, Methoxychlor, Mode of Action -animal, ...**5.0629**

THE CONSTITUENTS AND PHVSICO-CHEMICAL PROPERTIES OF SERUM FROM GOLD-FISH EXPOSED CHRONICALLY TO MALATHION AND ENDRIN ...Endocrine -other, Endrin, Goldfish, Malathion, Mode of Action -animal, ...**5.0630**

PHYSIOLOGICAL EVALUATION OF TREATED TOXIC WASTES ...Bioindicators, Contamination - Water, Pollution Effects, Pulp, Paper , and Logging, Tissues -biological, ...**5.0976**

HEMATOLOGICAL CHANGES IN F. HETEROCLITUS UPON EXPOSURE TO TOXIC METALS ...Blood Cells, Cadmium, Killifishs - Cyprinodon, Lead, Mineral Origin, ...**5.1092**

Blood-lymph-re-system

Blood -other

CULTURING, PROPAGATION AND CONDITION EVALUATION OF FISHES ...Bioassays, Captive Rearing, Cisco, Lake Herring, Contamination - Water, Lake Trout, Brook Trout, Yellow Perch, Darters, ...**5.0586**

Blood Cells

SOLUTE AND WATER TRANSPORT ACROSS BIOLOGIC MEMBRANES ...Active Transport, Carbohydrates, Ionic Effect, Kidney and Urinary System, Natural Occuring, Sodium, ...**2.0706**

BLOOD OXYGEN AND CO2 CARRYING CAPACITY OF 4 FISH EXPOSED TO MALATHION AND ENDRIN - PESTICIDE EFFECTS ON FISH ENDOCRINE FUNCTIONS ...Endrin, Laboratory Animals, Malathion, Mode of Action -animal, Sevin, ...**5.0632**

HEMATOLOGICAL CHANGES IN F. HETEROCLITUS UPON EXPOSURE TO TOXIC METALS ...Blood Plasma and Serum, Cadmium, Killifishs - Cyprinodon, Lead, Mineral Origin, ...**5.1092**

Other

STUDY OF FACTORS WHICH DETERMINE THE IONIC SELECTIVITY OF BIOLOGICAL AND ARTIFICIAL MEMBRANES ...Ion Selective, Molecular Interaction, Natural Occurring, Permeability, ...**3.0371**

Protein

FACTORS AFFECTING FISH PRODUCTION PONDS ...Blood Proteins -non-specific, Bluegills, Bream, Electrophoresis -other, Environmental Physiology, Purif and Isol, ...**6.0221**

CHEMICAL RESPONSES BY MARINE ORGANISMS TO STRESS ...Environmental Changes, Environmental Ecology, Environmental Physiology, Salinity, Thermal, ...**5.1056**

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GEOLOGY AND HYDROLOGY OF THE PRESIDIO BOLSON, TEXAS AND ADJACENT MEXICO ...Groundwater, Hydrology-general, Local Stratigraphy, Sedimentary Basins, Water Yield, ...**2.1011**

Borehole Geophysics

CONSERVATION OF FRESH-WATER RESOURCES BY DEEP-WELL DISPOSAL OF LIQUID WASTES ...Core Analysis, Lithology, Permeability, Pollution Abatement, Underground Waste Disposal, ...5.0025

EXPERIMENTAL INVESTIGATION OF HYDROLOGICAL PARAMETERS OF AQUIFERS THROUGH ELECTRICAL RESISTIVITY MEASUREMENTS ...Aquifers-general, Electric Logging, Hydrology-general, Other Models, Porosity-permeability, ...7.0028

EXPLORATION AND MAPPING OF THE SALISBURY PALEOCHANNEL ...Atlases-maps, Channels, Geophysical Analysis, Maryland, Valley, Buried, ...2.0566

BOREHOLE GEOPHYSICS AS APPLIED TO GEOHYDROLOGY ...Aquifers-general, Geophysical Analysis, Groundwater Movement, Instrumentation-general, Technique Development, ...7.0018

DESIGN OF UNDERGROUND POWERPLANTS ...Digital Computers, Electric Power Plants, Mechanics of Structures-other, Power Plant, Rock Mechanics, ...8.0031

DRILL PERFORMANCE MONITOR ...Drilling Operation, Foundations-general, Pressure, Soil Exploration, Temperature, ...8.0097

ENGINEERING GEOLOGIC PROPERTIES OF ROCK ...Aerial, Foundations-general, Geology - Engineering, Microstructure, Technique Development, ...8.0098

DEVELOPMENT OF NX BOREHOLE INSTRUMENT FOR DEFORMATION MODULUS ...Deformation, Drilling and Coring, ...8.0047

RADIOISOTOPE GROUND WATER MEASUREMENTS IN SMALL DIAMETER DRILL HOLES ...Drilling and Coring, Groundwater, Instrumentation-general, Radioisotopes, Technique Development, ...8.0066

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DEVELOPMENT OF ECONOMICAL METHODS OF BORON REMOVAL FROM IRRIGATION RETURN WATERS ...Desalination, Reverse Osmosis, Use of Impaired Water, Waste Treatment-economics, Waste Water Pre-treatment, ...5.0093

EFFECT OF BORON IN BIOLOGICAL WASTE TREATMENT ...Activated, Aerobic, Industrial Wastes, Sewage - Domestic, Surfactants, ...5.0223

THE PROCESSES AND CONDITIONS CONTRIBUTING TO THE ACCUMULATION OF NUTRIENTS IN DRAINAGE WATER FROM IRRIGATED AREA AND SOIL RECLAMATION ...Nitrogen, ...4.0027

CHEMISTRY OF BORON IN CALIFORNIA SOILS ...Absorption, Fixation, Exchange, Phytotoxic, Soil Amendments, Soil and Rock Leaching, Soil Management -non-specific, Soil Morphology, Profiles, ...5.0080

TOLERANCE OF CITRUS TO SALINITY AND BORON IN THE SOIL AND IRRIGATION WATER ...Citrus, Saline Soils, ...3.0186

Bottom Sampling

THE FEASIBILITY OF COLD WATER FISHES FOR LAKE SHARPE, SOUTH DAKOTA ...Fish -non-specific, Low Temp. - but Above 32f, Reservoirs and Impoundments, South Dakota, Temperature, ...7.0041

ANALYSIS OF WATER CHEMISTRY ...Aeration, Chemical Analysis (water), Destratification, Physical-general, ...4.0035

TROUT STREAM - SURVEY OF STREAMS AND THEIR WATERSHEDS ...Biological-general, Erosion-general, Georgia, Physical-general, Population Dynamics, ...2.0361

BOTTOM FAUNA STUDIES ...Benthic Fauna, Depth,water Level, Fluctuation, Lakes, Number Or Density, Water Level Fluctuation, ...4.0126

CHEMICAL AND PHYSICAL ANALYSES OF WATER AND SOILS ...Chemical-general, Lakes, Physical-general, Soil Chemical Properties, Water Level Fluctuation, ...2.0548

THE EFFECTS OF EXTREME FLOODS AND PLACER MINING ON THE BASIC PRODUCTIVITY OF SUBARCTIC STREAMS ...Alaska, Benthic Fauna, Floods, Meteorological Extremes, Placer, Productivity - Food Chain, ...2.0022

DISTRIBUTION AND ECOLOGY OF AQUATIC INSECTS OF IDAHO ...Aquatic Ecology, Chemical-general, Idaho, Insects - non-specific, Physical-general, ...2.0393

FARMINGTON RIVER SHAD STUDIES ...Alewife,menhaden,shad,herring, Migration, Plankton Sampling, Water Properties-general, Water Sampling, ...6.0117

RESEARCH IN SEDIMENT SAMPLING EQUIPMENT ...Bed Load, Instrumentation-general, Suspension, Turbidity, Ultrasonics, ...7.0059

SAN PABLO BAY STUDY ...Bays, Benthic Fauna, Excavation, Spoil Banks, Water Sampling, ...6.0038

ROUTINE SAMPLING AT SEVEN INDEX STATIONS ...Data Acquisition-general, Fish -non-specific, Lake Erie, Plankton Sampling, Water Sampling, ...6.0438

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DEVELOPMENT OF THE VACUUM FREEZING VAPOR COMPRESSION PROCESS FOR USE WITH BRACKISH WATERS ...Desalination, Freezing, Mobile, North Carolina, Pilot Plants, ...3.0487

DEVELOPMENT OF ADVANCED TRANSPORT DEPLETION PROCESSES ...Desalination, Electrodialysis, Ion Selective, Pilot Plant, ...3.0002

HIDDEN COSTS OF USING SUBSTANDARD QUALITY WATER, AS EXPERIENCED BY WATER USERS IN WEBSTER, SOUTH DAKOTA ...Desalination, Economic Impact, Potable Water, South Dakota, Water Costs, ...6.0495

SYNTHESIS AND EVALUATION OF NEW POLYMER MEMBRANE CANDIDATES FOR APPLICATION IN REVERSE OSMOSIS ...Brines, Desalination, Membranes-other, Organic, Reverse Osmosis, ...3.0174

THE EFFECTS OF VELOCITY ON THE PASSIVATION OF ALLOYS IN BRACKISH WATER ...Desalination, Electrolytes, Metallic Alloys, Passivation, Velocity -water, ...3.0136

DEVELOPMENT OF A 50,000 GALLON PER DAY NELLEN STACK ELECTRODIALYSIS MODULE ...Cost Analysis, Desalination, Electrodialysis, Membranes-other, Waste Treatment-economics, ...3.0150

EVALUATION OF AN ELECTROCHEMICAL DESALINATION PROCESS FOR BRACKISH WATER ...Desalination, Electrochemistry-other, ...3.0396

ELECTROLYTIC REGENERATION OF ION EXCHANGE RESINS ...Desalination, Ion Exchange-other, Pilot Plant, Regeneration-other, ...3.0327

A COST-EFFECTIVENESS STUDY OF PRETREATMENT METHODS SUITABLE FOR INTEGRATION TO MEMBRANE DESALTING PLANTS ...Desalination, Economic Efficiency, Use of Impaired Water, Waste Treatment-economics, Waste Water Pre-treatment, ...5.0746

STUDIES IN THE THERMOECONOMICS OF SEA AND BRACKISH WATER DEMINERALIZATION ...Demineralization, Desalination, Optimization, Sea Water-general, ...3.0319

RESEARCH AND DEVELOPMENT OF ULTRATHIN FILM MEMBRANES FOR REVERSE OSMOSIS DESALINATION ...Cellulosics, Desalination, Dimensions, Expansion, Membranes-other, Reverse Osmosis, ...3.0298

ION SELECTIVE ELECTROCHEMICAL SENSORS ...Brines, Detectors and Sensors, Electroanalyses-other, Electrode, Technique Development, ...5.1166

FIELD EVALUATION OF THE SUL-BISUL ION EXCHANGE PROCESS FOR DESALTING BRACKISH WATERS ...Desalination, Ion Exchange-other, Mobile, Salinity, ...3.0214

DEEP WELL DISPOSAL OF DESALINATION BRINE WASTES ...Artificial Recharge, Desalination, Desalination Wastes, Economics-general, Water Law-general, ...3.0296

PROCESS AND CONFIGURATION DEVELOPMENT FOR TUBULAR REVERSE OSMOSIS UNITS ...Desalination, Other, Pilot Plant, Reverse Osmosis, ...3.0057

BRACKISH WATER FIELD TEST EVALUATION OF MEMBRANE PROCESSES ...Desalination, Economic Efficiency, Membranes-other, Pilot Plant, ...3.0072

DESIGN AND CONSTRUCTION OF A LOW PRESSURE HOUSEHOLD REVERSE OSMOSIS UNIT ...Cost Analysis, Desalination, Mobile, Potable Water, Reverse Osmosis, ...3.0320

PARAMETRIC ECONOMIC AND ENGINEERING EVALUATION STUDY OF THE ELECTRODIALYSIS PROCESS ...Cost Analysis, Desalination, Electrodialysis, Other, Pilot Plant, ...3.0270

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PHYSIOLOGICAL CHANGES IN PLANTS PRODUCED BY SALINE SOLUTIONS ...Beans (garden), Humidity, Repression, Transpiration and Evap, Water Movement, ...**2.0061**

TAXONOMY AND BIOLOGY OF SLUDGE WORMS ...Animal Taxonomy, Bioindicators, Earthworms, Fresh Water, Pollution Effects, ...**5.0167**

GRAND VALLEY SALINITY CONTROL DEMONSTRATION PROJECT ...Canals, Colorado River, Linings-pavings, Mineralization, Natural Recharge, ...**5.0203**

AGRICULTURAL UTILIZATION OF SOILS AFFECTED BY SALINITY ...Absorption, Fixation, Exchange, Mineral Nutrition, Movement, Availability, Saline Soils, Yield, ...**3.0237**

MANAGEMENT OF SALINE WATER FOR CROP PRODUCTION ...Arizona, Management, Saline and Alkaline Soils, Use of Impaired Water, Water Quality-general, ...**3.0014**

EXTENT OF BRACKISH WATER IN TIDAL RIVERS ...Maryland, Saline Water Intrusion, Salinity, Tidal Streams, Tides, ...**2.0562**

EXPERIMENTAL REARING OF SALMON AND STEELHEAD IN BRACKISH WATER IMPOUNDMENTS ...Captive Rearing, Environmental Response, Mortality Rates, Rainbow Trout, Steelhead Trout, Stocking of Fish & Shellfish, ...**6.0461**

LIGHTWEIGHT WATER PURIFICATION UNIT ...Density, Desalination, Distillation-other, Distilling Units, Mobile, Plastic Matrix, Technique Development, Waste Water Treatment-general, ...**3.0250**

RELICT COPEPODS FROM LAKE TUBORG, ELLESMERE ISLAND ...Canada, Carbon-14, Copepods, Lakes, Plankton Sampling, ...**2.0257**

DISTRIBUTION OF ELEMENTS IN FLUVIAL AND BRACKISH ENVIRONMENTS ...Adsorption Capacity, Adsorption-general, Chemical Reactions, Element Ratios, Exchange Capacity, Solution, ...**2.0282**

EXTENT OF BRACKISH WATER IN TIDAL RIVERS, MARYLAND ...Runoff, Tides, Water Utilization -general, ...**2.0569**

SELECTION OF SITES FOR FIELD TESTING BRACKISH WATER CONVERSION UNITS ...Desalination, Other, ...**3.0123**

PROGRAM FOR FIELD EVALUATION OF REVERSE OSMOSIS PILOT PLANTS ON BRACKISH WATERS ...Cost Analysis, Membranes-other, Other, Pilot Plant, Reverse Osmosis, ...**3.0115**

AQUIFERS AND DRAINAGE ...Aquifers-other, Drainage, Groundwater Movement, Irrigation-general, Model Studies, ...**2.0166**

VALUE OF DESALTED WATER FOR IRRIGATION ...Desalination, Electrodialysis, Irrigation-general, Saline Soils, Water Costs, ...**3.0128**

THE EFFECT OF OCEAN WATER INTRUSION INTO BACK BAY, VIRGINIA, AND CURRITUCK SOUND, NORTH CAROLINA, ON THE WATERFOWL AND FISH HABITAT ...Aquatic Ecology, Fish -non-specific, Habitat Studies, Saline Water Intrusion, Water Fowl, N.s. , Water Salinity, ...**2.0585**

EFFECTS OF USING SALINE AND INDUSTRIAL WASTE WATERS ON YIELD AND QUALITY OF PLANTS ...Industrial Wastes, Irrigation, Irrigation-general, Saline and Alkaline Soils, Soil and Rock Leaching, Soil-water-plant Relationships, ...**3.0258**

THE EFFECT OF BRACKISH WATER ON PLANTS AND SOIL IN THE SOUTH ...Irrigation, Saline and Alkaline Soils, Soil-water-plant Relationships, Southern, ...**3.0192**

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SOLUBILITY OF NATURAL GASES IN CONNATE WATER AND OF WATER IN NATURAL GASES ...High Pressure - 1-1000 Atm, Interstitial - Connate Water, Ions and Gases, Natural Gas, Solubility, Solution Chemistry, ...**1.0080**

FUNDAMENTAL STUDIES OF DESALINATION BY FREEZING ...Desalination, Freezing, Heat Transfer, Removal--organics, ...**3.0281**

STUDIES OF FUNDAMENTAL MECHANISMS IN THE DEPOSITION OF CALCIUM SULFATE SCALE ...Dilatometry, Electron, Nucleation, Phase Relationship, Scale Formation, ...**3.0293**

THE EFFECTS OF NONELECTROLYTES AND SELECTED SALTS ON STRUCTURING IN WATER ...Heat Capacity-other, Solubility, Thermal Relation-other, Water, ...**1.0104**

RECOVERY OF SALTS FROM SALINE WATERS VIA SOLVENT EXTRACTION ...Desalination, Distribution Coefficient, Extraction, Magnesium, Material Recovery, ...**5.0162**

PROTECTIVE FILMS FORMED BY PLASMA ANODIZATION ...Aluminum, Anodic, Desalination, Iron, Passivation, ...**3.0263**

SYNTHESIS AND EVALUATION OF NEW POLYMER MEMBRANE CANDIDATES FOR APPLICATION IN REVERSE OSMOSIS ...Brackish Water, Desalination, Membranes-other, Organic, Reverse Osmosis, ...**3.0174**

MINERAL RECOVERY FROM CONCENTRATED BRINES ...Chloride, Desalination, Great Salt Lake, Magnesium, Potassium, Regeneration-other, ...**5.1198**

DIFFUSION IN TERNARY AQUEOUS SALINE SOLUTIONS ...Diffusion, Thermodynamic Non Equilibrium, ...**1.0042**

NUCLEATION AND GROWTH OF ICE CRYSTALS ...Crystal Growth, Desalination, Freezing, Hydration, Nucleation, ...**3.0041**

ION SELECTIVE ELECTROCHEMICAL SENSORS ...Brackish Water, Detectors and Sensors, Electroanalyses-other, Electrode, Technique Development, ...**5.1166**

WATER RESEARCH PROGRAM III CORROSION ...Composition Parameters-other, Nickel Alloys, Pitting, Titanium, ...**3.0438**

REACTIONS AND TRANSPORT PHENOMENA AT SURFACES ...Analysis and Detection, Electrode, Pitting, Separation-general, Transport, ...**3.0440**

DEVELOPMENT OF DIRECT CONTACT CONDENSATION MULTISTAGE FLASH (DCC-MSF) DISTILLATION PROCESS ...Condensation, Desalination, Film, Flash Distillation, Heat Transfer, Plastics - General, ...**3.0040**

STUDIES ON THE HYDRATE PROCESS FOR DEMINERALIZING SEA WATER ...Crystal Growth, Demineralization, Hydration, Removal--inorganics, ...**3.0366**

DESALINATION AND REDUCTION OF CONCENTRATION POLARIZATION EFFECTS IN REVERSE OSMOSIS SYSTEMS USING POROUS WALL SECTIONS ...Fluid Flow-other, Membranes-other, Other, Porosity, Reverse Osmosis, ...**3.0359**

LIME MAGNESIUM CARBONATE PROCESS - SEA WATER SOFTENING PLANT ...Evaporation, High Temperature - 1000-3000 , Precipitation , Removal--inorganics, Waste Water Pretreatment, ...**3.0105**

EFFECT OF ELECTROCHEMICAL AND METALLURGICAL FACTORS ON CORROSION OF METALSAND ALLOYS ...Desalination, Pitting, Stainless Steels-other, ...**3.0283**

EVALUATION OF HIGH PRESSURE PUMPS FOR REVERSE OSMOSIS PROCESS ...Axial Flow, Pumping, Reverse Osmosis, Sea Water-general, ...**3.0410**

TEST OPERATION OF A 2,500 GPD TWO-STAGE SEA WATER REVERSE OSMOSIS PILOT PLANT ...Cost Analysis, Desalination, Membranes-other, Optimization, Pilot Plant, Reverse Osmosis, ...**3.0079**

DEVELOPMENT OF NEW AND IMPROVED CELLULOSE ESTER REVERSE OSMOSIS MEMBRANES ...Desalination, Homopolymers, Membranes-other, Natural Occurring, Reverse Osmosis, ...**3.0060**

THERMOPHYSICAL PROPERTIES OF SEA WATER AND AQUEOUS ELECTROLYTE SOLUTIONS CONTAINING NACL, KCL, NA2SO4, AND MGSO4 ...Boiling Point, Conductivity, Density, Tables, Compilations, Catalogs, Vapor Pressure, Viscosity, ...**3.0286**

PROBABLE EFFECTS ON MARINE ENVIRONMENTS OF DISPERSING BRINE EFFLUENTS FROM LARGE DESALINATION PLANTS IN THE GULF OF CALIFORNIA ...Atomic Plants, Desalination, Gulf of California, Marine Environments-general, Pollution - Effects of , ...**3.0020**

REMOVAL OF INORGANIC MATERIAL FROM SALINE WATER BY PRECIPITATION PROCESSES ...Crystal Growth, Demineralization, Nucleation, Precipitation, Removal--inorganics, ...**5.0420**

A COMPREHENSIVE ANALYSIS OF THE TULAROSA BASIN SALINE WATER RESOURCES - THEIR AVAILABILITY AND POTENTIAL ECONOMIC DEVELOPMENT ...Atomic Plants, Desalination, Electric Power Plants, Impact, New Mexico, ...**7.0076**

RECONDITIONING AND REUSE OF FOOD PROCESSING BRINES ...Canning Wastes, Filtration, Lagoon, Waste Treatment-economics, Water Reuse, ...**5.0234**

NORTH FORK ALLUVIAL DECONTAMINATION PROJECT ...Artificial Recharge, Petroleum Industry, Seepage, Surface Water, Texas, ...**5.1145**

UTILIZATION OF OIL FIELD BRINES AS A POSSIBLE FERTILIZER SOURCE ...Atomic Absorption, Emission, Geochemical Analysis, Material Recovery Wastes, X-ray, ...**1.0056**

CHEMICAL QUALITY OF BRINES ASSOCIATED WITH DEEP SEDIMENTS BENEATH GREAT SALT LAKE ...Chemical Analysis (water), Great Salt Lake, Salt, Water Sampling, Water Wells, ...**5.1200**

HYDROLOGY OF THE SUB-LAKE SEDIMENTS BENEATH GREAT SALT LAKE ...Artificial Recharge, Geology - Engineering, Great Salt Lake, Interstitial - Connate Water, Permeability, ...**2.1082**

CHEMISTRY OF BRINE STRATIFICATION AND RELATED EVAPORATION STUDIES ...Analysis and Detection, Chemical-general, Evaporation, Ions and Gases, Water Sampling, ...**1.0119**

PERMIAN BASIN - ORIGIN OF SALINE WATER DISCHARGE ...Groundwater Movement, Permian Period, Saline Water Intrusion, Subsurface Flow, Texas, ...**2.1004**

BINDERS OF CONCRETE RESISTANT TO SALINE WATER AT ELEVATED TEMPERATURES ...Aggregates, Extenders, Fillers, Binders, Cement, Concrete, D.t.a. , X-ray, ...**8.0086**

SOLUBILITIES OF SILICATES IN SALINE WATERS ...Analysis and Detection, Desalination, Scale Formation, Silicate. Solubility, ...**4.0198**

CHEMISTRY OF SUBSURFACE OILFIELD BRINES ...Chemical-general, Fresh Water, Primary Recovery, ...**2.0873**

ANALYTICAL METHODS - OILFIELD WATER CHEMISTRY ...Chemical Analysis (water), Fluid Properties, General, Technique Development, ...**2.0874**

SOLUBILITIES OF THE SULFATES OF BARIUM AND STRONTIUM IN OILFIELD WATERS ...Barium, Fluid Properties, Radioisotopes, Solution Chemistry, Strontium, Thermal Properties-other, ...**1.0097**

MINING-POLLUTION CONTROL TECHNOLOGY - OIL PRODUCTION GROUND-WATER RECLAMATION BY SELECTIVE PUMPING ...Groundwater, Mine Drainage Control, Petroleum Industry, Pumping, Saline Water Intrusion, Secondary Recovery, ...**5.0913**

British Isles

RESEARCH ON DECISION MAKING AND RELATED MANAGERIAL ASPECTS OF BRITISH WATER RESOURCES PROGRAMS ...Administrative Structures, Management, Operations Research, Water Law-general, ...**6.0381**

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DEVELOPMENT OF FIELD TEST FOR FREE CHLORINE ...Chlorine, Colorimetric, Membranes-other, Sterilants, Technique Development, ...**5.0808**

(U) DETERMINATION OF FREE BROMINE IN WATER (US 14) ...Amines, Analysis and Detection, Chlorine, Colorimetric, ...**5.0372**

DISINFECTION OF SEWAGE EFFLUENTS ...Bacteria, Chemical-general, Chlorination, Chlorine, Disinfection, Sewage, ...**5.0380**

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PREPARE AN OPERATIONAL PLAN, CONCEPTUAL DESIGN AND PLANS AND SPECIFICATIONS FOR A SEAWATER CORROSION TEST FACILITY ...Construction-general, Desalination, Research Facilities, Test Methods, Water, ...**3.0297**

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A STUDY OF THE ECONOMIC IMPACT OF DROUGHT ON WATER SUPPLY SYSTEMS IN THE PASSAIC RIVER BASIN, NEW JERSEY ...Economic Impact, Meteorological Extremes, New Jersey, River Basins, Water Quality-general, ...**2.0761**

THE LOCAL WATER DISTRICT AS AN URBAN WATER-POLICY DETERMINING ENTITY ...California, Management, State-local Government, Urban Environments, ...**6.0060**

QUANTITATIVE ANALYSIS OF WATER USE PATTERNS IN PUERTO RICO ...Consumptive Use, Projections and Estimations, Puerto Rico, Water Utilization -general, ...**6.0484**

EFFECTS OF LIMNOLOGICAL FACTORS ON WATER TREATMENT ...Iowa, Other, Reservoirs, Reservoirs and Impoundments, Water Quality-general, ...**5.0415**

A MATHEMATICAL MODEL FOR REGIONAL TREATMENT OF WATER POLLUTION SYSTEMS ...Estuaries, Mathematical Analysis, Public Works, Regional Areas, Sewerage Systems-other, Value Analysis, ...**5.0114**

REVIEW OF ALGALCIDES ...Algacides -non-specific, Algal Pollutant Sources, Residential, Survey Studies, Water Distribution Systems, ...**5.0358**

DEMAND FOR WATER UNDER DYNAMIC CONDITIONS ...Colorado, Social Aspects, Water Costs, Water Demand, ...**6.0087**

INORGANIC ADDITIONS RESULTING FROM WATER USE ...Composition, Hardness-minerals, Mineralization, Water Reuse, ...**5.0350**

REGIONAL COMPREHENSIVE MULTI-PURPOSE WATER RESOURCES PLANNING STUDIES ...Augmentation-general, Multiple-purpose Projects, New York, Planning, Water Resources Development, ...**6.0370**

UTILITIES IN PERMAFROST AREAS ...Codes and Standards, Cold - Climates, Permafrost-frozen, Sewage Treatment Plant, ...**2.0756**

POWER TRANSMISSION STRUCTURES, NEW TYPES ...Electric Power Plants, Electrical Engineering-general, Power Transmission, Structural, Transmission Lines, ...**8.0120**

EMPIRICAL PREDICTION OF SAND FILTER PERFORMANCE ...Public Works, Sand, Urban Environments, Waste Water Treatment-general, ...**5.0403**

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REVIEW OF ALGALCIDES ...Algacides -non-specific, Algal Pollutant Sources, Public Utilities, Survey Studies, Water Distribution Systems, ...**5.0358**

Components and Equipment

Roofs

NEW ROOFING SYSTEMS ...Domestic Structural, Elastomers Rubber, Standards, Specifications, Weathering, ...**8.0078**

Construction

Codes and Standards

UTILITIES IN PERMAFROST AREAS ...Cold - Climates, Permafrost-frozen, Public Utilities, Sewage Treatment Plant, ...**2.0756**

Construction-general

PREPARE AN OPERATIONAL PLAN, CONCEPTUAL DESIGN AND PLANS AND SPECIFICATIONS FOR A SEAWATER CORROSION TEST FACILITY ...Desalination, Manufacturing, Research Facilities, Test Methods, Water, ...**3.0297**

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EPOXY RESINS FOR CIVIL WORKS PROJECTS ...Concrete-other, Epoxies, Fracture Mechanics, Maintenance, Repairing, ...**8.0248**

Equipment

INVESTIGATIONS OF PLACEABILITY OF CONCRETE ...Cement, Concrete, Methods, Plasticity, ...**8.0258**

PERFORMANCE OF CONSTRUCTION PLANT AND EQUIPMENT ...Concrete-general, Construction, Machines, ...**8.0251**

Excavation

RESEARCH TO DETERMINE THE FEASIBILITY OF NUCLEAR EXCAVATION ...Geology - Engineering, Nuclear Excavation, Nuclear Explosion, ...**2.0102**

RAPID SOILS EXCAVATION ...Construction, Machines, Nuclear Excavation, Technique Development, ...**8.0082**

EXPLOSIVE EXCAVATION IN THE DEVELOPMENT OF WATER RESOURCES ...Earth & Rockfill Dams, Nuclear Power, Open Channel, Reservoirs, Water Resources Development, ...**8.0041**

SAN PABLO BAY STUDY ...Bays, Benthic Fauna, Bottom Sampling, Spoil Banks, Water Sampling, ...**6.0038**

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INVESTIGATIONS OF PLACEABILITY OF CONCRETE ...Cement, Concrete, Equipment, Plasticity, ...**8.0258**

IMPROVEMENTS IN CONCRETE CONSTRUCTION PRACTICES ...Aggregates, Extenders, Fillers, Construction, Moisture, ...**8.0259**

DURABILITY AND BEHAVIOR OF PRESTRESSED CONCRETE BEAMS ...Beams - Bars, Construction Materials-other, Prestressed, Weathering, ...**8.0253**

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UTILITIES IN PERMAFROST AREAS ...Cold - Climates, Permafrost-frozen, Public Utilities, Sewage Treatment Plant, ...**2.0756**

ULTIMATE STRENGTH DESIGN ...Electric Power Plants, Power Development, Reinforced, Structural, ...**8.0030**

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INVESTIGATION OF THE USE OF LOW-COST PLASTIC FILMS FOR SOLAR STILL CONSTRUCTION ...Costs, Distilling Units, Film, Glass, Plastics - General, Weathering, ...**3.0391**

ULTIMATE STRENGTH DESIGN ...Codes and Standards, Electric Power Plants, Power Development, Reinforced, ...**8.0030**

POWER TRANSMISSION STRUCTURES, NEW TYPES ...Electric Power Plants, Electrical Engineering-general, Power Transmission, Public Utilities, Transmission Lines, ...**8.0120**

Land Use

Planning

URBAN AND METROPOLITAN STUDIES ...Aerial, Geography-physical, Remote Sensing-general, Urban, Urban Environments, ...**6.0139**

Redevelopment of Land

INTERRELATIONS BETWEEN RIVER BASIN DEVELOPMENTS AND DEVELOPMENT OF METROPOLITAN AREAS ...Planning, River Basins, Urban Research, Water Resources Development, ...**6.0165**

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INFLUENCE ON LAND VALUES OF IMPROVED UTILIZATION THROUGH FLOOD PROTECTION ...Economic Impact, Floodproofing, Land Use, Rural Areas, Urban Environments, ...**6.0129**

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FLOODS IN PUNALUU-HAUULA AREA, OAHU, HAWAII ...Floodproofing, Floods, Hawaii, Peak Flow, ...**4.0086**

Landscape

ANALYSIS OF DRAINAGE BASINS AND LANDSCAPES ...River Basins, Watersheds-general, ...**2.0633**

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DISTRIBUTION OF LIQUIDS IN POLAR CAMPS ...Flow, Permafrost-frozen, Pipes, Polar, Sewage, ...**5.0134**

EPOXY RESINS FOR CIVIL WORKS PROJECTS ...Concrete-other, Construction-other, Epoxies, Fracture Mechanics, Repairing, ...**8.0248**

Public Works

A MATHEMATICAL MODEL FOR REGIONAL TREATMENT OF WATER POLLUTION SYSTEMS ...Estuaries, Mathematical Analysis, Public Utilities, Regional Areas, Sewerage Systems-other, Value Analysis, ...**5.0114**

EMPIRICAL PREDICTION OF SAND FILTER PERFORMANCE ...Public Utilities, Sand, Urban Environments, Waste Water Treatment-general, ...**5.0403**

ORGANIC MATTER AND ITS ROLE IN WATER QUALITY ...Management, Organic Matter, Reservoirs and Impoundments, Urban Environments, Waste Water Treatment-general, ...**5.0122**

EXTRACTION OF ALGAE BY FLOCCULATIVE TECHNIQUES ...Additives, Algal Pollutant Sources, Extraction, Flocculation, ...**5.0398**

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BIOLOGY AND CHEMISTRY OF MARINE PLANKTON POPULATIONS ...Chlorophyll, Food Chains, Nutrients, Phytoplankton, Vertical Distribution, Zooplankton, ...**6.0289**

VERTICAL CURRENT STRUCTURE IN THE GREAT LAKES ...Currents -water, Forecasting-prediction, Great Lakes-general, Model Studies, Wind-water Interaction, ...**2.0632**

Cadmium

HEMATOLOGICAL CHANGES IN F. HETEROCLITUS UPON EXPOSURE TO TOXIC METALS ...Blood Cells, Blood Plasma and Serum, Killifishs - Cyprinodon, Lead, Mineral Origin, ...**5.1092**

Calcium

NEW SELECTIVE MEMBRANES ...Desalination, Ion Selective, Natural Occurring, Reverse Osmosis, ...**5.0763**

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Temperature-other

AN INVESTIGATION OF THE EFFECT OF CONTROLLED RELEASES ON THE PHYSICAL, CHEMICAL AND BACTERIOLOGICAL CHARACTERISTICS OF FORT LOUDOUN RESERVOIR ...Nitrogen, Phosphate, Phosphite, Stratified Flow, Suspension, Tennessee, ...**5.1128**

HIGH RESOLUTION NUCLEAR MAGNETIC RESONANCE SPECTRA OF ORGANIC PESTICIDES ...Carbamates -non-specific, Chlorinated Hydrocarbons, Concentration, Decomposition-general, Isotopic, Nuclear Magnetic Resonance, Organophosphorous Cpds. , ...**5.0283**

Chemistry - Instrumentation

Application Or Purpose

Analyzing

INSTALLATION OF INSTRUMENTATION FOR CLAIR ENGLE PLANT ...Computers-general, Desalination, Flash Distillation, Gaging, ...**3.0457**

DEVELOPMENT OF A CALIBRATION MODULE FOR TRACE OXYGEN ANALYZERS ...Calibration Devices, Chemical Analysis (water), Inorganic, Oxygen, Technique Development, ...**3.0055**

DEVELOPMENT OF INSTRUMENTAL TECHNIQUES FOR THE ANALYSIS OF TRACE ORGANIC CONSTITUENTS IN WATER ...Chromatography-other, Infrared, Odor, Organic, Organic Wastes, ...**5.0211**

A CONTINUOUS MULTIPARAMETER WATER QUALITY MONITOR ...Instrumental Services, Mobile, Recording Systems, Transducers, Water Quality-general, ...**7.0006**

ANALYTICAL INSTRUMENTATION FOR DETERMINING LOW LEVELS OF TOTAL ORGANIC CARBON IN WATER ...Chemical Analysis, Organic-general, Total Organic Carbon, ...**5.0094**

THE DETERMINATION OF THE STRUCTURES OF ORGANIC CONTAMINANTS IN WATER ...Chem Str Determ-other, Chemical Identification, Chromatography-other, Distillation-other, Spectroscopy-other, ...**5.0278**

Property Measurement

THERMAL PROPERTIES OF SALT SOLUTIONS ...Conductivity, Salts, Solution, ...**1.0057**

Mobile

DEVELOPMENT OF THE VACUUM FREEZING VAPOR COMPRESSION PROCESS FOR USE WITH BRACKISH WATERS ...Brackish Water, Desalination, Freezing, North Carolina, Pilot Plants, ...**3.0487**

TRAINING, TECHNICAL SUPERVISION, AND ASSISTANCE REGARDING THE OPERATION OF A SKID-MOUNTED MSF UNIT ...Aeration, Distillation-other, Foam, Other, Pilot Plant, ...**3.0491**

FIELD EVALUATION OF THE SUL-BISUL ION EXCHANGE PROCESS FOR DESALTING BRACKISH WATERS ...Brackish Water, Desalination, Ion Exchange-other, Salinity, ...**3.0214**

DESIGN, CONSTRUCTION AND OPERATION OF A SKID-MOUNTED ION EXCHANGE PILOT PLANT ...Cost Analysis, Desalination, Economics-general, Ion Exchange-other, Pilot Plants, ...**3.0329**

OPERATION OF A 50,000 GPD PORTABLE PILOT PLANT ...Membranes-other, Pilot Plant, Reverse Osmosis, Scale Formation, Zeolite, ...**3.0029**

DESIGN AND CONSTRUCTION OF A LOW PRESSURE HOUSEHOLD REVERSE OSMOSIS UNIT ...Brackish Water, Cost Analysis, Desalination, Potable Water, Reverse Osmosis, ...**3.0320**

BIOLOGICAL NITROGEN FIXATION IN LAKES ...Acetylene, Ethylene, Gas, Lakes, Nitrogen, Nitrogen Fixation, ...**5.1299**

A CONTINUOUS MULTIPARAMETER WATER QUALITY MONITOR ...Analyzing, Instrumental Services, Recording Systems, Transducers, Water Quality-general, ...**7.0006**

DEVELOP DESIGN DATA FOR LIGHT WEIGHT WATER PURIFICATION UNIT ...Filtration, Potable, Potable Water, Technique Development, Waste Water Treatment-other, ...**8.0297**

LIGHTWEIGHT WATER PURIFICATION UNIT ...Brackish Water, Density, Desalination, Distillation-other, Distilling Units, Plastic Matrix, Technique Development, Waste Water Treatment-general, ...**3.0250**

REVERSE OSMOSIS WATER PURIFICATION ...Cellulose Acetate, Military Aspects, Other, Potable Water, Reverse Osmosis, ...**3.0251**

ION EXCHANGE UNIT, 3000 GPH ...Demineralization, Ion Exchange-other, Other, Potable Water, Radioactivity-general, ...**5.1215**

TECHNIQUES AND INSTRUMENTATION ...Chemical Analysis (water), Physical Parameters, Technique Development, Temperature, Water Sampling, ...**5.0187**

Type

FLUOROMETRIC QUALITATION AND QUANITATION OF LIGNIN SULFONATES IN WATER ...Fluorometry, Natural Occurring, Pulp and Paper, Pulp and Paper Wastes, Sulfate, Sulfite, Sulfonates (rso3na), ...**5.0286**

Automatic

ASSEMBLY AND EVALUATION OF AN IMPROVED PPB OXYGEN ANALYZER FOR SEA WATER ...Calibration Devices, Gases, Inorganic, Oxygen, Technique Development, ...**3.0453**

PROCESS CONTROL MODEL FOR OXYGEN REGENERATION OF POLLUTED RIVERS ...Aeration, Chemical Oxygen Demand, Detectors and Sensors, Model Studies, Oxygen, Streams, ...**5.0727**

Calibration Devices

DEVELOPMENT OF A CALIBRATION MODULE FOR TRACE OXYGEN ANALYZERS ...Analyzing, Chemical Analysis (water), Inorganic, Oxygen, Technique Development, ...**3.0055**

ASSEMBLY AND EVALUATION OF AN IMPROVED PPB OXYGEN ANALYZER FOR SEA WATER ...Automatic, Gases, Inorganic, Oxygen, Technique Development, ...**3.0453**

Detectors and Sensors

ION SELECTIVE ELECTROCHEMICAL SENSORS ...Brackish Water, Brines, Electroanalyses-other, Electrode, Technique Development, ...**5.1166**

PROCESS CONTROL MODEL FOR OXYGEN REGENERATION OF POLLUTED RIVERS ...Aeration, Automatic, Chemical Oxygen Demand, Model Studies, Oxygen, Streams, ...**5.0727**

DETECTION AND IDENTIFICATION OF MOLECULAR WATER POLLUTANTS BY LASER RAMAN SPECTROSCOPY ...Chemical Analysis, Industrial Wastes, Lasers and Masers, Pesticides -non-specific, Physical Parameters, Raman, Surfactants, ...**5.0441**

ANALYSIS OF SOLUTIONS FOR SURFACE-ACTIVE CONSTITUENTS ...Absorption-other, Electrochemical-other, Electrode, Electrolytes, Surfactants, ...**5.0439**

TURBULENCE IN LIQUIDS ...Quartz, Turbulence, Turbulent, ...**8.0187**

QUANTITATIVE DETECTION OF SMALL AMOUNTS OF VIRUSES IN LARGE VOLUMES OF WATER ...Analysis and Detection, Concentration, Filtration, Membranes-other, Virus, ...**5.0842**

Testing Devices

FISHER AND PORTER INSTALLATION METHODS ...Evaporation, Gages, Technique Development, ...**7.0049**

Ultrasonics

A STUDY OF HYPERSONIC WAVES IN WATER AND IN AQUEOUS SOLUTIONS ...Dissociation, Hypersonic Waves, Inorganic, Relaxation, Ultrasonic, Water, ...**1.0030**

ION HYDRATION AND ION INTERACTION ...Assoc & Dissoc, Attenuation, Calcium, Hydration, Magnesium, Salt, Ultrasonic, ...**1.0059**

EFFECT OF SURFACTANT MICELLES ON METAL ION REMOVAL BY FLOTATION FROM METALLURGICAL WASTEWATER ...Copper, Foam, Metal Pickling Wastes, Micelle, Surfactants, Zinc, ...**5.0691**

FABRICATION AND EVALUATION OF AN ULTRASONIC FILTRATION SYSTEM FOR TREATING COMBINED SEWER OVERFLOWS ...Biochemical Oxygen Demand, Combined Sewer, Filter-other, Overflow, Waste Treatment-economics, ...**5.0105**

A STUDY OF THE EFFECT OF ULTRASONIC ENERGY ON WASTE WATER ...Ammonia, Disinfection, Organics, ...**5.0104**

Chemistry - Mechanisms

Kinetics

Kinetic-general

TRANSPORT PROPERTIES OF CONCENTRATED SALT SOLUTIONS ...Bond Type-general, Conductivity, Desalination, Diffusion-other, ...**1.0087**

THE KINETICS OF COMPRESSIBILITY EFFECTS IN TWO PHASE SINGLE COMPONENT FLOW ...Bubble, Rate Determination, Spectroscopy-other, Two-phase-other, ...**3.0292**

KINETIC STUDIES OF THE OXIDATIVE DEGRADATION OF DETERGENT, AND RELATED CHEMICAL SPECIES IN AQUEOUS SOLUTION ...Biodegradation, Biological, Chemical Degradation, Physical Degradation, Surfactants, Waste Water Treatment-general, ...**5.0495**

PREPARATION OF MONODISPERSE EMULSIONS ...Distribution, Emulsion, Nucleation, Precipitation, ...**5.0064**

Kinetics-other

THE EFFECT OF ORGANIC INHIBITORS ON THE DISSOLUTION KINETICS OF IRON ...Corrosion General, Electrochemical-other, Electrode, Inhibitors, Iron, ...**3.0065**

AIR OXIDATION OF ORGANIC COMPOUNDS IN AQUEOUS SYSTEMS ...Chemical Treatment, Mass Transfer, Organic Wastes, Solution, Wet Oxidation, ...**5.0215**

KINETICS AND MECHANISM IN ACTIVATED SLUDGE PROCESSES ...Activated, Process Design, ...**5.0927**

A STUDY OF THE KINETICS OF THE ACTIVATED SLUDGE PROCESS ...Activated, Aeration, Flow Regulations, Pump, Storage-retention-facilities, ...**5.0862**

Order

OXYGENATION KINETICS OF REDUCED SULFUR SPECIES ...Other, Oxidation-general, Oxygen, ...**5.0496**

Rate of Reaction

BEHAVIOR OF LIQUID SURFACES DURING EVAPORATION AND CONDENSATION ...Evaporation, ...**1.0083**

DIFFUSION PHENOMENA IN ICE - RECRYSTALLIZATION PHENOMENA IN ICE ...Concentration, Crystal Growth, Desalination, Diffusion-other, Electrolytes, ...**3.0361**

MAXIMUM RATE OF VAPORIZATION AND CONDENSATION OF WATER WITH DISSOLVED SALTS AND SURFACE CONTAMINATION ...Condensation, Electrolytes, Evaporation, Gas/gas, Vapor Pressure, ...**3.0413**

ENGINEERING FEASIBILITY STUDY OF THE HORIZONTAL TUBE MULTIPLE EFFECT DISTILLATION PROCESS ...Desalination, Distilling Units, Economic Efficiency, Heat Transfer, North Carolina, ...**3.0352**

REMOVAL OF COLLOIDAL MATTER FROM WASTE WATER ...Microbial-bacterial, Organic Wastes, Pollutant-other, Sediments, Waste Water Treatment-general, ...**5.0599**

THE MOLECULAR NATURE OF ORGANIC WASTE REMOVAL PATTERNS ...Activated, Analysis and Detection, Gas, Organics, Structural Effect-other, ...**5.1155**

MECHANISMS AND RATES OF HEAVY METAL SORPTION AND DESORPTION ...Adsorption-desorption, Concentration, Mechanisms, Other, Oxidation Reduction, ...**2.0181**

Relaxation

ION-SOLVENT AND ION-ION INTERACTIONS IN AQUEOUS ELECTROLYTES ...Activity, Assoc & Dissoc, Electrolytes, Temperature Jump Method, Ultrasonic, ...**1.0095**

A STUDY OF HYPERSONIC WAVES IN WATER AND IN AQUEOUS SOLUTIONS ...Dissociation, Hypersonic Waves, Inorganic, Ultrasonic, Ultrasonics, Water, ...**1.0030**

A NUCLEAR MAGNETIC RELAXATION INVESTIGATION OF WATER-MEMBRANE INTERACTIONS ...Inorganic, Interface, Isotope-other, Membranes-other, Nuclear Magnetic Resonance, ...**3.0349**

Mechanism Determination

Mechanisms

REMOVAL OF PHOSPHATE FROM WATER BY ALUMINUM AND IRON ...Aluminum, Complexes, Iron, Phosphate, Phosphite, Waste Water Treatment-general, ...**5.0732**

BEHAVIOR OF TRACE ELEMENTS IN WATER RECLAMATION TREATMENT PROCESSES ...Chemical Treatment-general, Pollutant-other, Radioisotopes, Trace Elements, ...**5.0177**

THE ECOLOGY OF THE MICROBIAL POPULATION OF ACTIVATED SLUDGE ...Activated, Degradation, Industrial Processes-other, Plant Succession, Toxic Substances -non-specific, ...**5.0168**

MECHANISMS AND RATES OF HEAVY METAL SORPTION AND DESORPTION ...Adsorption-desorption, Concentration, Other, Oxidation Reduction, Rate of Reaction, ...**2.0181**

PHOSPHATE REMOVAL BY ACTIVATED SLUDGE PROCESS APPLICATION - PLANT SCALE DEMONSTRATION ...Activated, Location, Phosphate, Phosphite, Pollutant-other, Sewage Treatment Plant, ...**5.0912**

STUDY OF MICROBIOLOGICAL-BIOCHEMICAL PHOSPHATE SORPTION MECHANISM BY ACTIVATED SLUDGE ...Absorption-other, Activated, Other, Phosphate, Phosphite, Sewage Bacteria, ...**5.0907**

Transition State

THE ROLE OF WATER IN ORGANIC REACTIONS ...Deuterium, Inorganic, Ketonic, Solvolyses, Structure - Activity, Water, ...**1.0062**

Reaction Media

Gaseous

SPECTROSCOPIC AND DIELECTRIC STUDIES OF NEW HYDROGEN BONDED SPECIES ...Dielectric Properties, Hydrogen, Infrared, Far, Phase Relationship, Water, ...**1.0061**

ENGINEERING SERVICES - 50-150 MM GALLON PER DAY MULTISTAGE, MULTIFLASH DESALINATION PROCESS ...Desalination, Distilling Units, Flash Distillation, Fluid Flow-other, Removal--inorganics, ...**3.0064**

HIGH-PRESSURE VAPOR EXTRACTION OF SOLUBLE ORGANIC SOLUTES FROM AQUEOUS INDUSTRIAL WASTE STREAMS ...Extraction, Flow of Gas in Liquid, High Pressure - 1-1000 Atm, Industrial Processes-other, Two-phase-other, ...**5.0070**

Liquid

INTERMOLECULAR FORCES AND THE LIQUID STATE ...Atomic & Molecular Beam, Bond Energy, Forces, Desalination, Hydrogen, Inorganic, ...**1.0051**

Solid State

STUDIES OF CONCENTRATED AQUEOUS ELECTROLYTES AND OF MOLTEN ELECTROLYTES BY INFRARED SPECTROSCOPY ...Electrolytes, Infrared, Raman, Solution, Variable Temperature, ...**1.0118**

STUDY OF METHODS TO RETARD COMPACTION OF CELLULOSE ACETATE MEMBRANES IN REVERSE OSMOSIS DESALINATION ...Cellulose Acetate, Desalination, Membranes-other, Natural Occurring, Reverse Osmosis, ...**3.0149**

Solution

INVESTIGATIONS OF AQUEOUS SALT SOLUTIONS BY RAMAN SPECTROSCOPY ...Complexes, Complexing, Raman, Solvent-other, Thermal Relation-other, ...**1.0079**

SOLUTE PROPERTIES OF WATER ...Hydration, Hydrogen, Polarization, Water, ...**1.0098**

AN INVESTIGATION OF ION MOBILITY IN AQUEOUS SOLUTIONS ...Conductivity, State Variables - Pvt, Transport, Variable Temperature, Variational Pressure, ...**1.0064**

STUDIES BEARING ON THE RELATION OF STRUCTURE TO PROPERTIES IN LIQUID SOLUTIONS ...Activity, Electrolytes, Water, ...**1.0105**

STUDIES OF CONCENTRATED AQUEOUS ELECTROLYTES AND OF MOLTEN ELECTROLYTES BY INFRARED SPECTROSCOPY ...Electrolytes, Infrared, Raman, Solid State, Variable Temperature, ...**1.0118**

THERMODYNAMICS OF MIXING OF SALT SOLUTIONS ...Alkali Metals-general, Salt, ...**1.0090**

STATISTICAL MECHANICAL THEORIES OF FLUIDS ...Interface, Quantum Analysis, Statistical, Tension, Van Der Waals Forces, ...**1.0084**

ENERGETICS AND STRUCTURE OF THE HYDROGEN BOND ...Alcohols, Hydrogen, Infrared, Polarization, Telemerization, ...**1.0036**

THE INVESTIGATION OF TRANSPORT PROCESSES IN AQUEOUS ELECTROLYTE SOLUTIONS ...Conductivity, Diffusion-other, Electrolytes, Ionic, Water, ...**1.0093**

HETEROGENEOUS NUCLEATION AND CONDENSATION OF VAPORS ...Argon, Liquid, Nucleation, Water, 4 Ring System, ...**1.0094**

THERMAL PROPERTIES OF SALT SOLUTIONS ...Conductivity, Property Measurement, Salts, ...**1.0057**

FREEZING POTENTIAL STUDY ...Desalination, Electrolytes, Freezing, Polarization, Relaxation, ...**3.0183**

DISSOLVED GASES AND WATER CLUSTERING IN AQUEOUS SOLUTION ...Chlorine, Dioxide, Ions and Gases, Salt, Thermal Properties-other, Water, ...**1.0052**

ION DISCRIMINATION BY HYDROPHOBIC MEMBRANES ...Diffusion-other, Equilibrium-other, Hydrophobic, Membranes-other, ...**3.0234**

ION - ION AND ION - MOLECULE INTERACTIONS IN AQUEOUS SALT SOLUTIONS ...Activity, Conductivity, Ionic, Osmotic Pressure, Polarization, ...**1.0020**

A STUDY OF THE INTERACTIONS PRESENT IN AQUEOUS SALT SOLUTIONS BY NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY ...Conservation-general, Ionic, Nuclear Magnetic, Transition Metal-general, Water Resources Development, ...**1.0074**

ROTATIONAL STABILITY OF DILUTE POLYMER SOLUTIONS ...Fluid Flow-other, Mass Transfer, Organic, Polymer Type-other, Transport, ...**1.0027**

AIR OXIDATION OF ORGANIC COMPOUNDS IN AQUEOUS SYSTEMS ...Chemical Treatment, Kinetics-other, Mass Transfer, Organic Wastes, Wet Oxidation, ...**5.0215**

DIFFUSIVITY OF OXYGEN AND SULFIDE SPECIES IN AQUEOUS SOLUTIONS ...Chemical Treatment, Gas/liquid, Oxygen, Sulfide, Surfactants, ...**1.0003**

ROTATIONAL STABILITY IN DILUTE POLYMER SOLUTIONS ...Polymer Type-other, Rheological-general, States of Flow, Waste Water Treatment-other, ...**1.0028**

ADSORPTION OF ORGANIC COMPOUNDS ONTO SOLIDS FROM AQUEOUS SOLUTIONS ...Adsorption-general, Area, Organic Matter, Organics-general, Surface Energy, Surface-other, ...**1.0122**

ISOTOPE EFFECT ON THE THERMODYNAMIC ACTIVITY OF WATER ...Activity, Chemical-general, Deuterium, Vapor Pressure, Water, ...**1.0112**

NMR AND X-RAY STUDIES OF STRUCTURE IN AQUEOUS ELECTROLYTE SOLUTIONS ...Adsorption-other, Electrolytes, Nuclear Magnetic, Nuclear Magnetic Resonance, Reaction-general, X-ray, ...**1.0073**

ATOMIZATION AND DROP SIZE OF NON-NEWTONIAN FLUID ...Atomization, Distribution, Non - Newtonian, Nozzles, Spray Devices, ...**5.0796**

STUDIES OF LOW MOLECULAR WEIGHT LIGNIN SULFONATES ...Column, Molecular Weight Distribution, Natural Occurring, Sulfonates (rso3na), ...**5.1262**

OXYGENATION OF AQUEOUS BODIES USING LIQUID OXYGEN ...Aeration, Diffusion-other, Oxygen, Waste Treatment-economics, ...**5.0685**

THERMODYNAMICS OF WATER AND WATER SOLUTIONS ...Entropy, Water, ...**1.0043**

Vapor

WATER RESEARCH PROGRAM - SECTION I, PROPERTIES OF SOLUTIONS ...Colloidal Phenomena, Distribution Coefficient, Membranes-other, Potentiometry, Salts, Transport, ...**1.0115**

INVESTIGATION OF ANOMALOUS WATER ...Condensation, Density, Phy and Chem Properties, Vapor Pressure, Viscosity, Water, ...**3.0288**

EFFECT OF THE WARM CLOUD BASE UPON CLOUDSEEDING FROM THE GROUND ...Clouds-precipitation, Iodine, Nucleation, Nucleation Physics, Silver, ...**2.0156**

Chemistry - Organic Compounds

Aliphatics

Acids

DEVELOPMENT OF REVERSE OSMOSIS MEMBRANES ...Casting of Materials, Cellulose Acetate, Desalination, Nitrogen, Technique Development, ...**3.0050**

THE BIOCHEMISTRY OF ANAEROBIC DIGESTION ...Anaerobic, Anaerobic Bacteria, Biodegradation, Other, Respiration, ...**5.0762**

STUDIES ON THE METHANOGENIC BACTERIA IN SLUDGE ...Culture Collections, Digestion, Isolation From Nat. environ. , Methane Bacteria (non-specif.), ...**5.0259**

NEW-TYPE GLYCOL MONO ALKYL ETHERS FOR THE CONTROL OF WATER EVAPORATION, TO EXTEND THE USE OF COTTONSEED OIL ...Agronomic, Condensation, Evaporation, Water Loss Control, ...**2.0451**

EFFECT OF NITRILOTRIACETIC ACID (NTA) UPON THE TOXICITY OF METALS TO SELECTED SPECIES OF ESTUARINE PHYTOPLANKTON ...Carbon, Chemicals (incl. algacides), Estuaries, Phytoplankton, Radioisotopes, ...**5.1085**

INVESTIGATION OF SOAP-DETERGENT COMBINATIONS BASED ON INEDIBLE ANIMAL FA ...Biodegradation, Hydrolysis, Organic, Stability, Surfactants, ...**5.0991**

Alcohols

SILVEX PERSISTENCE IN WATER AND HYDROSOIL ...Chemical Analysis (water), Clay, Esters, Sand, ...**8.0162**

DIELECTRIC PROPERTIES OF HYDROGEN-BONDED LIQUIDS ...Desalination, Dielectric Properties, Hydrogen, Isomerism, Thermal Relation-other, ...**1.0078**

ENERGETICS AND STRUCTURE OF THE HYDROGEN BOND ...Hydrogen, Infrared, Polarization, Solution, Telemerization, ...**1.0036**

VISCOSITY STUDIES OF AQUEOUS SOLUTIONS ...Activation Energy, Desalination, Mixed Solvents, Viscosity, Water, ...**1.0033**

INTERFACIAL STRUCTURE AND TRANSPORT IN WATER ...Evaporation, Flow Characteristics -water, Surface-other, Viscosity, Water Loss Control, ...**3.0152**

INTERMEDIATE PRODUCTS IN THE BACTERIAL DECOMPOSITION OF HEXADECANOL AND OCTADECANOL ...Biodegradation, Gas, ...**5.1158**

SOIL MOISTURE EVAPORATION AND ITS CONTROL ...Antitranspirants, Evaporation, Organometallic, Soil Environment, Soil Physical Properties, Tillage, Cropping Systems, Water Loss Control, ...**2.0969**

EVAPORATION REDUCTION INVESTIGATIONS STUDY OF THE EFFECTS OF FATTY ALCOHOLS ON THE ECOLOGY OF LAKE HEFNER ...Antitranspirants, Lakes, Physiological Ecology, Plankton (non-specific), Texas, ...**3.0130**

Aldehydes

AEROBIC SECONDARY TREATMENT OF PLYWOOD GLUE WASTES ...Activated, Aeration, Aerobic, Lagoon, Process Design, Secondary Treatment, ...**5.0984**

Aldose and Ketose

THE HYDROLOGIC SIGNIFICANCE OF CHEMICALLY DERIVED MEAN BASIN TEMPERATURES ...Air Temperature Instruments, Evaporation, Forecasting-prediction, Heat Measurement, Pennsylvania, ...**2.0924**

AN EVALUATION OF THE SUGAR-INVERSION METHOD OF MEASURING MEAN TEMPERATURE IN A CLIMATOLOGICAL NETWORK ...Inversion, Microclimate-general, Physical Climatology, Temperature, ...**2.0925**

Amines

(U) DETERMINATION OF FREE BROMINE IN WATER (US 14) ...Analysis and Detection, Bromine, Chlorine, Colorimetric, ...**5.0372**

Esters

SILVEX PERSISTENCE IN WATER AND HYDROSOIL ...Alcohols, Chemical Analysis (water), Clay, Sand, ...**8.0162**

DEVELOPMENT OF ULTRATHIN SKIN MEMBRANES - HEMA POLYMERS ...Desalination, Films, Membranes-other, Polymerization-general, Reverse Osmosis, ...**3.0278**

BIODEGRADABLE DETERGENTS FROM ANIMAL FATS ...Biodegradation, Septic Tanks, Sulfonates (rso3na), Surfactants, ...**5.0992**

Olefins

STUDIES OF MEMBRANE PHENOMENA - PREPARATION OF NEW ELECTRODIALYSIS MEMBRANES ...Electrodialysis, Ion Selective, Organic, Polarization, ...**3.0350**

Phosphorous

NMR AND IR STUDIES OF HYDROGEN BONDING IN N-ALKYLPHOSPHORAMIDATES ...Hydrogen, Infrared, Nuclear Magnetic Resonance, Salt, Steric Effects, ...**5.0279**

Salt

THERMODYNAMICS OF MIXING OF SALT SOLUTIONS ...Alkali Metals-general, Solution, ...**1.0090**

THE HEATS OF MIXING OF STRONG ELECTROLYTES ...Alkaline Earth-general, Electrolytes, Solution, Water, ...**1.0029**

DISSOLVED GASES AND WATER CLUSTERING IN AQUEOUS SOLUTION ...Chlorine, Dioxide, Ions and Gases, Solution, Thermal Properties-other, Water, ...**1.0052**

ION HYDRATION AND ION INTERACTION ...Assoc & Dissoc, Attenuation, Calcium, Hydration, Magnesium, Ultrasonic, Ultrasonics, ...**1.0059**

TRANSPORT PHENOMENA IN FUSED ORGANIC SALTS ...Desalination, Diffusion-other, Reverse Osmosis, Thermal Properties-other, Viscosity, ...**3.0075**

Saturated Hydrocarbons

DISSOLVED ORGANIC PHOSPHORUS IN NATURAL WATERS ...Analysis and Detection, Organic-general, Precipitation, Radiochemical Techniques, Removal--inorganics, ...**1.0088**

CONSTANT TOTAL PRESSURE EVAPORATION WITH HEART REUSE BY A BULIT-IN ENGINE ...Additives, Boiling Point, Condensation, Desalination, Heat Recovery, ...**3.0135**

ORGANIC DECOMPOSITION AT POISED O-R POTENTIAL LEVELS ...Anaerobic, Digestion, Electrodialysis, Membranes-other, ...**5.0550**

MICROBIAL INTERACTIONS IN WASTE TREATMENT SYSTEMS ...Anaerobic, Digestion, Filter-other, Ion Selective, Microbial-bacterial, ...**5.0395**

CONTROLLING FACTORS IN METHANE FERMENTATION ...Bacterial Culture, Cell. env.(non-specific & Ot.), Fermentation, Methane Bacteria (non-specif.), Respiration, ...**5.0754**

MICROBIOLOGY OF ANAEROBIC SLUDGE ...Anaerobic, Biological, Digestion, Fermentation, Microbial-bacterial, ...**5.0809**

Condensed Alicyclics

4 Ring System

HETEROGENEOUS NUCLEATION AND CONDENSATION OF VAPORS ...Argon, Liquid, Nucleation, Solution, Water, ...**1.0094**

Condensed Aromatics

Nitroso Compounds

REAGENTS FOR DETERMINATIONS OF TRACE IMPURITIES IN WATER ...Analysis and Detection, Cobalt, Inorganic, Nitrate, Nitrite, Spectroscopy-general, ...**5.0330**

Quinones

COMPOSITION OF RESIDUES FROM PULP BLEACHING TREATMENTS ...Chlorination, Extraction, Natural Occurring, Pulp and Paper Wastes, ...**5.0760**

METHOD FOR QUANTITATIVE ANALYSIS OF PHENOLS IN FUEL CELL PRODUCT WATER ...Alcohols, Fuel Cell-other, Steam Distillation, Ultraviolet, Water, ...**1.0041**

Dyes and Coloring

BIOLOGICAL TREATMENT OF SPENT VEGETABLE TANNINS ...Biological, Chemical Treatment, Industrial Wastes, Tannery Wastes, Waste Water Treatment-general, ...**5.1283**

CHEMICAL CHARACTERISTICS OF ORGANIC COLOR IN WATER ...Chemical Analysis, Coagulation, Depolymerization, Hydrolysis, Other, ...**5.1259**

LIGAND EXCHANGE REAGENTS ...Colorimetric, Complexes, Compound, Ion Exchange-other, Spectroscopy-other, ...**5.0431**

WATER MEASUREMENT ...Discharge-general, Fluids, Measurement, Technique Development, Water Quantity-general, ...**8.0128**

SOLAR REFLECTANCE OF MONOLAYER-COVERED WATER SURFACES AS RELATED TO EVAPORATION SUPPRESSION ...Antitranspirants, Evaporation, Monolayers, Polymer-other, Sunshine, ...**3.0110**

Heterocyclics (1 Hetero)

Nitrogen

DEVELOPMENT OF REVERSE OSMOSIS MEMBRANES ...Acids, Casting of Materials, Cellulose Acetate, Desalination, Technique Development, ...**3.0050**

DESIGN AND CONSTRUCTION OF A REVERSE OSMOSIS PILOT PLANT FOR THE DESALINATION OF SEA WATER ...Desalination, Membranes-other, Pilot Plant, Reverse Osmosis, Sea Water-general, ...**3.0051**

Heterocyclics (2 Hetero)

Heterocyclics-other

ENHANCEMENT OF WATER QUALITY USING FOREST DERIVED COAGULATING SYSTEMS ...Alcohols, Aldehydes, Coagulation, Condensation, Industrial Processes-other, Pulp, Paper , and Logging, ...**5.1255**

Noncondensed Aromatics

Alcohols

ENZYMES FOR ANALYSIS AND PURIFICATION OF SALINE WATER SYSTEMS ...Biodegradation, Bioindicators, Degradation, Fluorometry, Heavy Elements, Pesticides, ...**5.0456**

ENHANCEMENT OF WATER QUALITY USING FOREST DERIVED COAGULATING SYSTEMS ...Aldehydes, Coagulation, Condensation, Heterocyclics-other, Industrial Processes-other, Pulp, Paper , and Logging, ...**5.1255**

METAL ION-CATALYZED OXIDATION OF PHENOLS AND AROMATIC AMINES ...Catalytic, Metal Ion, Organic Wastes, Radioisotopes, ...**5.1159**

EXPERIMENTAL CLOSED WATER SYSTEM TO ELIMINATE WASTE WATER DISCHARGE FROM JOHNS MANVILLE PLANT 03, DEFIANCE, OHIO ...Industrial Processes-other, Screening, Solubility, Waste Water Treatment-general, ...**5.0724**

DEMONSTRATION OF A FACILITYFOR THE BIOLOGICAL TREATMENT OF COMPL EX CHLOROPHENOLIC WASTE ...Aerobic, Organics, Pesticides, Pond, Removal of Residues, ...**5.0055**

METHOD FOR QUANTITATIVE ANALYSIS OF PHENOLS IN FUEL CELL PRODUCT WATER ...Fuel Cell-other, Quinones, Steam Distillation, Ultraviolet, Water, ...**1.0041**

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Cloud Formation and Evolution

NUMERICAL SIMULATION OF THE MACROPHYSICAL AND MICROPHYSICAL PROCESSES OF MOIST CONVECTION ...Clouds-precipitation, Convection, Formation, Model Studies, Thermodynamics, ...2.0239

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ELECTRONIC ANALOG SIMULATION OF THE SALINITY FLOW SYSTEM WITHIN THE UPPER COLORADO RIVER BASIN ...Analog Computers, Management, Salinity, ...7.0105

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CALIFORNIA-ARIZONA ECONOMIC INTERDEPENDENCE AND THE COLORADO RIVER CONFLICT WITH PARTICULAR REFERENCE TO AGRICULTURE ...Agriculture, Agriculture Industry, Economic Impact, Income, Input - Output Analysis, Water Allocation, ...6.0050

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MCNARY ARTIFICIAL SPAWNING CHANNEL STUDIES ...Channels, Construction Land Use Effects, Salmon -coho,chinook,sockeye.., Spawn Or Nesting Sites, Temperature, ...8.0302

COLLECTION OF JUVENILE SALMON IN TURBINE INTAKES ...Control Gate, Electric Power Plants, Mortality Rates, Salmon & Trout - Non-specific, Turbine-other, ...8.0299

PROBLEMS AND OPPORTUNITIES OF WATER RESOURCE UTILIZATION IN THE UPPER COLUMBIA AND MISSOURI

RIVER BASINS ...Economics-general, Missouri River, Water - Alternative Uses, Water Resources Development, Water Utilization -domestic, ...**6.0328**

A COMPARATIVE ANALYSIS OF AMERICAN AND CANADIAN GOVERNMENTAL DEVELOPMENT OF REGIONAL WATER POLICY IN THE COLUMBIA RIVER BASIN ...Administrative Structures, Intergovernmental Relations, International, Water Resources Development, ...**6.0632**

FORMULATION OF A GENERAL MATHEMATICAL MODEL FOR THE PREDICTION OF THERMAL ENERGY CHANGES IN IMPOUNDMENTS ...Forecasting-prediction, Mathematical Analysis, Model Studies, Reservoirs and Impoundments, Thermal Pollution, ...**5.0163**

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A RUN TIMING STUDY IN THE LOWER COLUMBIA RIVER BY MEANS OF A TESTFISHING PROGRAM ...Migration, Nets, Number Or Density, Salmon -coho,chinook,sockeye.., Streams, ...**2.0884**

COLUMBIA RIVER CHINOOK SALMON ...Construction Land Use Effects, Habitat Studies, Population Dynamics, Salmon - coho,chinook,sockeye.., Spawn Or Nesting Sites, ...**2.1129**

PLANKTON-PERIPHYTON STUDIES IN THE COLUMBIA RIVER ...Food Webs, Periphyton, Phytoplankton, Radioactivity-general, Radioecology, ...**2.1127**

TRANSLOCATION OF RADIONUCLIDES BY FISH ...Fish -non-specific, Migration, Phosphorus, Radioactivity-general, Zinc, ...**2.1130**

COLUMBIA RIVER ECOLOGY ...Chromium, Phosphorus, Pollutants - Path of , Radioisotopes, Zinc, ...**6.0613**

EFFECT OF REACTOR EFFLUENT ON QUALITY OF COLUMBIA RIVER WATER ...Atomic Plants, Digital Computers, Filtration, Pollution - Effects of , Radioactivity-general, ...**5.1246**

MECHANISMS OF ENVIRONMENTAL EXPOSURE ...Radioactive Isotopes, Radioactivity-general, Radiologic Health, Regulation and Selection, Toxicological and Allergy, ...**5.1244**

MOVEMENT OF RADIONUCLIDES IN THE LOWER COLUMBIA RIVER ...Absorbed Load, Adsorption Capacity, Pollutants - Path of , Radioactivity-general, ...**2.0902**

THE MOVEMENT OF RADIONUCLIDES IN THE COLUMBIA RIVER ESTUARY ...Absorbed Load, Estuaries, Pollutants - Path of , Radioactivity-general, ...**2.0903**

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SALMON PRODUCTION IN AREAS MADE INACCESSIBLE BY DAMS ...Aquatic Ecology, Engineering Structures-general, Environmental Ecology, Salmon & Trout - Non-specific, Spawn Or Nesting Sites, ...**8.0309**

ADULT SALMON BEHAVIOR STUDIES IN RIVERS AND AT DAMS (SONIC TRACKING) ...Aquatic Ecology, Behavioral Ecology, Migration, Salmon & Trout - Non-specific, Tags, ...**8.0305**

PREDICTION OF ENVIRONMENT ...Biological-general, Environmental Ecology, Low Temp. -but Above 32f, Physical-general, Reservoirs and Impoundments, Salmon & Trout - Non-specific, Snake River, Temperature, Thermal Pollution, ...**6.0617**

EFFECTS OF INDUSTRIAL EXPANSION ON THE AQUATIC ENVIRONMENT OF ESTUARINE AREAS ...Estuaries, Salmon & Trout - Non-specific, ...**2.1131**

Column Leaching & Diffusing

MOVEMENT AND ADSORPTION OF PESTICIDES IN STERILIZED SOIL COLUMNS ...Absorption Rates, Absorption, Fixation, Exchange, Internal Water Movement, Movement, Leaching, Pesticides -non-specific, Soil Tests, ...**5.0256**

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TIDAL FLOWS IN RIVERS AND HARBORS ...Harbors, Hydraulics-general, Streams, Tides, ...**2.0688**

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Vegetables

PILOT PLANT DEVELOPMENT OF THE ION-EXCHANGE PROCESS FOR RECOVERY OF AMINO COMPOUNDS FROM POTATO STARCH FACTORY EFFLUENTS ...Agricultural Chemicals-other, Air Pollution -other, Amino Acids -non-specific, Food Processing Industry, Plant Waste Removal, Treatment, ...**5.0990**

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Mass Communication

MEASUREMENT OF COMMUNITY OPINION RELATING TO PUBLIC WATER SUPPLIES ...Attitudes & Attitude Change, Citizen's Participation, Social Aspects, Water Quality-general, Water Supply-general, Water Utilization -domestic, ...**6.0167**

Communication Systems

Radio

AUTOMATIC VHF RADIO HYDROLOGIC DATA REPORTING SYSTEM ...Automatic Data Aquisition, Data Transmission Systems, General Synoptic Observations, Hydrology-general, Very High Frequency, ...**7.0096**

Communication Theory

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A SYNTHETIC COMPUTER LANGUAGE FOR SANITARY ENGINEERING ...Computation Techniques, Solid Waste-general, ...**5.1014**

Composite Materials

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MECHANICAL PROPERTIES OF ULTRA-THIN LIPID MEMBRANE ...Creep, Elasticity - General, Fracture - General, Natural Occuring, Permeability, ...**3.0342**

FREE DROP WATER CONTAINER ...Airborne-operation, Equipment, Logistics, Pipe, Tube, Urethanes, ...**8.0209**

Reinforced Systems

Ceramic Matrix

PLASTIC PIPE AND TUBING ...Corrosion General, Engineering Structures-general, Pipe, Tube, Plastic Matrix, Plastics - General, ...**8.0132**

THE DEVELOPMENT OF CONCRETE-POLYMER MATERIALS ...Cement, Concrete, Durability, Deterioration, In-situ, Plastics - General, Radiation Induced, Strength, Cohesion, ...**8.0045**

Filament Winding

SELF-ADJUSTING AND SELF-CLEANING FILTER FEASIBILITY STUDY ...Chlorination, Combined Sewer, Filter-other, Pollutant-other, Pressure-other, ...**5.0227**

Plastic Matrix

DEVELOPMENT OF WATER PURIFICATION SYSTEMS BASED ON REVERSE OSMOSIS ...Desalination, Membranes-other, Natural Occurring, Reinforcing Materials, Reverse Osmosis, ...**3.0147**

LIGHTWEIGHT WATER PURIFICATION UNIT ...Brackish Water, Density, Desalination, Distillation-other, Distilling Units, Mobile, Technique Development, Waste Water Treatment-general, ...**3.0250**

PLASTIC PIPE AND TUBING ...Ceramic Matrix, Corrosion General, Engineering Structures-general, Pipe, Tube, Plastics - General, ...**8.0132**

GLASS FIBER REINFORCED PLASTIC MORTAR PIPE FOR PRESSURE IRRIGATION DISTRIBUTION SYSTEM ...Fiber, Filament, Whisker, Glass, Irrigation Engineering, Pipe, Tube, Pipelines, ...**8.0027**

Reinforcing Materials

DEVELOPMENT OF WATER PURIFICATION SYSTEMS BASED ON REVERSE OSMOSIS ...Desalination, Membranes-other, Natural Occurring, Plastic Matrix, Reverse Osmosis, ...**3.0147**

Computer Electronics

Analog

GEOHYDROLOGIC SYSTEM ANALYSIS WITH AN ELECTRIC ANALOG COMPUTER ...Analog Computers, Aquifers-general, Digital Computers, Groundwater, Induced Infiltration, Network Synthesis, Systems Analysis, ...**2.0417**

Data Acquisition Systems

RADAR DATA ACQUISITION OVER OCEANOGRAPHIC TEST SITES ...Electronics - Applied, Icebergs, Optical, Radar, Surface Environments, Waves, ...**6.0274**

EVALUATION OF HYDROLOGIC INSTRUMENTATION ON MAYNARD CREEK WATERSHED ...Data Processing Services, Evaluation Other, Montana, ...**7.0073**

IMPROVE COMPONENTS OF THE DATA ACQUISITION SYSTEM - SATELLITE COMMUNICATIONS EQUIPMENT ...Automatic Data Aquisition, Instrumental Services, Rain-general, Satellites & Deep Space Probes, Streams, ...**7.0050**

IMPROVE PRECIPITATION MEASURING EQUIPMENT - HYDROLOGIC EQUIPMENT IMPROVEMENT ...Atmospheric Pressure, Gages, Instrumental Services, Technique Development, Transducers, ...**7.0051**

Data Transmission Systems

TELEMETERING OF HYDROLOGIC DATA FROM REMOTE AREAS ...Automatic Data Aquisition, Mountains-alpine, Other Telemetry, Remote Areas, Technique Development, ...**7.0026**

AUTOMATIC VHF RADIO HYDROLOGIC DATA REPORTING SYSTEM ...Automatic Data Aquisition, General Synoptic Observations, Hydrology-general, Radio, Very High Frequency, ...**7.0096**

Digital Computers

DIGITAL INSTRUMENTATION AND TELEMETRY FOR WATER RESOURCES RESEARCH ...Automatic Data Aquisition, Electronics - Applied, ...**7.0072**

DIGITAL SYSTEMS FOR ON-SITE DATA COLLECTION FOR WATER QUALITY ANALYSIS ...Automatic Data Aquisition, Data Networks, Technique Development, Water Quality-general, ...**7.0005**

HIGH-VOLTAGE D-C TRANSMISSION INVESTIGATIONS ...Ac-dc, Dc-ac, Electrical Engineering-general, Power Regulator, Power Transmission, Silicon-controlled-rectifiers, ...**8.0054**

Recording Systems

A CONTINUOUS MULTIPARAMETER WATER QUALITY MONITOR ...Analyzing, Instrumental Services, Mobile, Transducers, Water Quality-general, ...**7.0006**

INSTRUMENTATION FOR RESEARCH ...Doppler, Fluid Dynamics, Instrumental Services, Turbulence, Velocity, ...**7.0109**

Computer Methods -general

Computer Methods -other

LIVESTOCK WASTE MANAGEMENT AND SANITATION ...Aerobic, Animal Waste Removal-treatment, General Sanitation Methods, Manure, ...**5.0360**

Computers

Analog Computers

APPLICATION OF MAGNETOHYDRODYNAMICS TO MEASUREMENT OF LIQUID VELOCITY AND TURBULENCE ...Analog Computers Math, Technique Development, Turbulent, Turbulent Flow, Velocity, Velocity -water, ...**2.1166**

SIMULATION OF WATER RESOURCE REGIMES ...Estuaries, Groundwater, Model Studies, Surface Water, ...**7.0047**

SEDIMENTATION AND IN-PLACE FILTRATION DURING FLOW THROUGH EARTH FRACTURES ...Filtration, Joints-fractures, Mathematical Analysis, Model Studies, Sedimentology-general, ...**4.0018**

APPLICATION OF AN ELECTRONIC ANALOG COMPUTER TO THE SIMULATION OF THE TOTAL HYDROLOGIC-ECONOMIC FLOW SYSTEM ...Economics-general, Hydrology-general, Model Studies, River Basins, ...**6.0585**

TIDAL EFFECTS ON GROUND WATER HYDRAULICS IN HAWAII ...Groundwater, Hawaii, Hydraulics-general, Model Studies, Tides, ...**2.0378**

THE DEVELOPMENT OF A SIMULATION MODEL FOR THE BEAR RIVER BASIN ...Development of Models, Model Studies, Planning, River Basins, Utah, ...**6.0586**

EFFECTS OF FOREST COVER MANIPULATION ON WATER YIELD AS STUDIED BY AN ELECTRIC ANALOG ...Development of Models, Forest Watersheds, Soils and Fertilizer, Washington, Water Yield, ...**3.0484**

COMPUTER SIMULATION OF URBAN HYDROLOGIC SYSTEMS ...Hydrographs, Runoff, Texas, Urban Environments, Watersheds-other, ...**4.0258**

COMPUTER SIMULATION OF AQUIFERS OF COASTAL PLAIN OF NORTH CAROLINA ...Carbonate Aquifers, Development of Models, Digital Computers, Model Studies, North Carolina, ...**2.0822**

ANALOG MODELING TO DETERMINE FRESH WATER AVAILABILITY ON THE OUTER BANKS OF NORTH CAROLINA ...Groundwater, Groundwater Movement, Model Studies, North Carolina, Water Yield, ...**3.0375**

ELECTRONIC ANALOG SIMULATION OF THE SALINITY FLOW SYSTEM WITHIN THE UPPER COLORADO RIVER BASIN ...Colorado River, Management, Salinity, ...**7.0105**

STUDIES OF THE SOIL-MOISTURE-PLANT REGIME FOR THE CONDITIONS OF WESTERN OKLAHOMA ...Climate-general, Consumptive Use, Evapotranspiration, Oklahoma, Soil-water-plant Relationships, ...**2.0880**

HYDRAULICS OF FLOOD MOVEMENTS ...Floods, Mathematical Analysis, Open Channel Flow, Partial, Routing, Unsteady Flow, ...**2.0348**

HYDROLOGIC ANALYSIS BY ANALOG COMPUTERS ...Groundwater, Hydrographs, Hydrology-general, Reservoirs and Impoundments, Routing, Surface Water, ...**2.0429**

SACRAMENTO-SAN JOAQUIN DELTA ANALOG MODEL STUDIES ...Deltas, Electronics - Applied, Instrumental Services, Model Studies, Sacramento River, ...**7.0008**

GEOHYDROLOGIC SYSTEM ANALYSIS WITH AN ELECTRIC ANALOG COMPUTER ...Analog, Aquifers-general, Digital Computers, Groundwater, Induced Infiltration, Network Synthesis, Systems Analysis, ...**2.0417**

APPLICATION OF OPTIMIZATION TECHNIQUES TO PROBLEMS TO AGRICULTURE ...Animal Waste Removal-treatment, Digital Computers, Model Studies, Optimization, Solid Waste, Waste Water Treatment-general, ...**5.0427**

ELECTRONIC ANALOG MODEL STUDIES OF RIVER BASINS ...Groundwater, Management, Model Studies, Precipitation-general, River Basins, Runoff, Water Cycle, Water Resources Development, ...**2.1059**

A STUDY OF THE INTEGRATION OF THE WATER RESOURCES OF THE BEAR, WEBER, AND JORDAN RIVERS IN NORTHERN UTAH ...Analog Computers Math, Model Studies, Planning, Utah, Water Transfer, ...**6.0587**

DENVER MULTIPHASE FLOW ...Infiltration, Instrumental Services, Internal Water Movement, Transducers, Unsaturated Flow, ...**2.0192**

ELECTRICAL ANALOG MODELS OF HYDROLOGIC SYSTEMS ...Flow Characteristics -water, Groundwater, Groundwater Movement, Model Studies, Surface Water, ...**2.0037**

MILL CREEK VALLEY ANALOG MODEL STUDY, OHIO ...Aquifers-general, Artificial Recharge, Model Studies, Ohio, Recharge Pits - Wells, ...**4.0195**

ELECTRICAL-ANALOG ANALYSIS OF HYDROLOGIC DATA, ARVA VALLEY, ARIZ ...Arizona, Groundwater, Model Studies, Pumping, Water Table Fluctuation, ...**2.0044**

HYDROGEOLOGY OF GLACIAL OUTWASH NEAR SIOUX FALLS, SOUTH DAKOTA ...Available Water, Outwash Plains, Prediction Models, Projections and Estimations, South Dakota, ...**2.0975**

IRRIGABLE LAND SUITABILITY STUDY ...Irrigation-general, Percolation, Saline and Alkaline Soils, Water Quality-general, ...**6.0092**

INSTRUMENTATION, DATA ACQUISITION, AND COMPUTER TECHNIQUES ...Automatic Data Aquisition, Data Analysis Applications, Digital Computers, Hydraulics-general, ...**7.0019**

HIGH-VOLTAGE A-C TRANSMISSION ...Development of Models, Digital Computers, Electrical Engineering-general, Power Transmission, Switching, ...**8.0056**

APPLICATIONS OF ANALOG COMPUTER SIMULATION TECHNIQUES FOR RUNOFF PREDICTIONS WITHIN THE REYNOLDS CREEK WATERSHED ...Forecasting-prediction, Idaho, Model Studies, Runoff, Simulation Theory, ...**7.0106**

THE SIMULATION OF HYDROLOGIC EVENTS IN ARID REGIONS ...Arid and Desert, Hydrology-general, Management, Model Studies, Surface Water, ...**2.1075**

DRAINAGE SYSTEMS FOR THE IMPERIAL VALLEY ...Digital Computers, Drainage, Groundwater Movement, ...**4.0026**

Analog Computers Math

APPLICATION OF MAGNETOHYDRODYNAMICS TO MEASUREMENT OF LIQUID VELOCITY AND TURBULENCE ...Analog Computers, Technique Development, Turbulent, Turbulent Flow, Velocity, Velocity -water, ...**2.1166**

A STUDY OF THE INTEGRATION OF THE WATER RESOURCES OF THE BEAR, WEBER, AND JORDAN RIVERS IN NORTHERN UTAH ...Analog Computers, Model Studies, Planning, Utah, Water Transfer, ...**6.0587**

Computers-general

COMPUTER SIMULATION OF ESTUARINE DISPERSION ...Dispersion -water, Estuaries, Model Studies, Seasonal, Tides, ...**5.0935**

INSTALLATION OF INSTRUMENTATION FOR CLAIR ENGLE PLANT ...Analyzing, Desalination, Flash Distillation, Gaging, ...**3.0457**

A METHOD FOR SYSTEM EVALUATION AND COST-EFFECTIVENESS OF LARGE MULTISTAGE FLASH DESALTING PLANTS ...Cost Analysis, Desalination, Flash Distillation, Research - Development, Systems Analysis, ...**3.0166**

AN ANALYSIS OF PHOSPHORUS AND NITROGEN COMPOUNDS IN TIDAL MARSHLAND DRAINAGE - LABORATORY PROCEDURES ...Colorimetric, Conductrometry, Management, Nitrogen, Phosphate, Phosphite, Swamps-marshes, ...**1.0024**

EVAPORATION FROM SOIL SURFACES AS AFFECTED BY SALT, STRUCTURE AND TEXTURE ...Boundary Process (moisture), Development of Models, Evaporation, Saline Properties, Soil Morphology, Profiles, Water Movement-general, ...**2.0216**

MATHEMATICAL SIMULATION OF RAINFALL RUNOFF PROCESSES ...Hydrographs, Model Studies, Optimization, Other Computers, Runoff, Storms-general, ...**2.1015**

A CONTINUATION OF THE STUDY TO DETERMINE THE COSTS OF WATER IN INDUSTRIAL USES ...Benefit-cost Analysis, Industrial-general, Model Studies, Water Costs, Water Demand, ...**6.0468**

UTILIZATION OF PHYSICAL AND MATHEMATICAL MODELS IN ESTUARINE WATER RESOURCES RESEARCH AND MANAGEMENT ...Estuaries, Management, Model Studies, Shoreline - Coastline, Tides, ...**6.0607**

PROGRAMMED SELECTION OF OPTIMUM USES OF A SMALL WATER RESOURCE SUBJECTED TO COMPLEX SIMULTANEOUS DEMAND STRESSES ...Model Studies, Optimization, Water - Alternative Uses, Water Demand, Water Supply-general, ...**6.0281**

COMPUTER SIMULATION OF AQUIFERS OF COASTAL PLAIN OF NORTH CAROLINA ...Carbonate Aquifers, Mining Industry, North Carolina, Saline Water Intrusion, Water Table Fluctuation, ...**2.0821**

MEASUREMENT AND ANALYSIS OF NATURAL-TYPE SURFACES AFFECTING FLUID FLOW ...Channel Roughness, Fluid Flow-other, Frictional, Hydraulic Gradient, ...**2.0247**

STOCHASTIC ANALYSIS OF HYDROLOGIC SYSTEMS ...Mathematical Analysis, Model Studies, River Basins, Stochastic Models, Systems Analysis, ...**6.0203**

ANOMALOUS FLOOD RESPONSE IN REGIONS OF SIMILAR GEOMORPHIC CHARACTERISTICS ...Floods, Flow Characteristics -water, Morphology-general, Pennsylvania, ...**2.0927**

NUMERICAL SIMULATION OF GROUNDWATER FLOW SYSTEMS ...Groundwater Movement, Management, Research - Development, Simulation Theory, ...**2.0918**

A WATER QUALITY COMPUTER MODEL OF COOK INLET (PHASE ONE - THE HYDRAULIC MODEL) ...Alaska, Estuaries, Hydraulics-general, Model Studies, Water Quality-general, ...**7.0002**

ECONOMIC EVALUATION OF WATER QUALITY ...Benefit-cost Analysis, Management, Model Studies, Systems Analysis, Waste Water Treatment-general, ...**6.0046**

TO EVALUATE THE UTILITY OF EXISTING AUTOMATIC CHEMICAL ANALYSIS EQUIPMENT FOR WATER QUALITY SURVEILLANCE UNDER COMPUTER CONTROL ...Atomic Absorption, Automatic Data Aquisition, Chemical Analysis (water), Information Retrieval Methods, Information Storage and File, System Development, Water Properties-general, ...**7.0078**

COMPLEMENTARY - COMPETITIVE ASPECTS OF WATER STORAGE ...Benefit-cost Analysis, Model Studies, Reservoirs and Impoundments, Storage of Water, Water - Alternative Uses, ...**5.0144**

MATHEMATICAL AND COMPUTER SERVICES FOR THE ANALYSIS OF DATA AND DESIGN OF EXPERIMENTS FOR CERTAIN FWPCA PROGRAMS ...Data Analysis - General, Facilities, Instrumental Services, Oregon, ...**5.0934**

DEVELOPMENT OF MATHEMATICAL MODEL OF SEWAGE SLUDGE FLUIDIZED BED INCINERATORS ...Disposal, Fluidized Bed, Mathematical Analysis, Model Studies, ...**5.0344**

A MATHEMATICAL MODEL FOR THE FINAL CLARIFIER OF AN ACTIVATED SLUDGE PROCESS ...Activated, Effluents-waste Water, Forecasting-prediction, Thickening, Zeta Potential, ...**5.1322**

MODEL STUDIES FOR DEVELOPMENT AND CALIBRATION OF STREAMFLOW CONTROL DEVICES IN THE SOUTHERN BRANCH ...Channel Regulation-general, Discharge-general, Gaging, Models, Synthetic Hydrology-general, ...**3.0189**

ECONOMIC EVALUATION OF IRRIGATION IN NORTH DAKOTA ...Economics-general, Irrigation-general, North Dakota, Optimization, ...**3.0379**

SOIL CHARACTERISTICS AFFECTING SUBSURFACE DRAINAGE ...Model Studies-general, Permeability, Void Ratio and Porosity, ...**4.0194**

DATA REDUCTION METHODS FOR STREAMFLOW FROM SMALL, WILDLAND WATERSHEDS ...Data Analysis - General, Discharge-general, Gaging, Integration, Quadrature, Small Watersheds, Utah, ...**2.1068**

COMPUTER SIMULATION AND EVALUATION OF CLIMATOLOGICAL MODELS ...Model Studies, Patterns, Statistics-general, ...**7.0044**

ANALYSIS AND SYNTHESIS OF HYDROLOGIC SYSTEMS ...Flow Characteristics -water, Hydrology-general, Open Channel Flow, Patterns, Technique Development, ...2.0615

NUMERICAL MODELING OF GENERAL CIRCULATION OF EARTHS ATMOSPHERE ...Air Motion-general, Heat Exchange, Humidity, Latent Heats, Weather Modification-general, ...7.0014

AUTOMATION OF GROUND-WATER RECORDS ...Automatic Data Aquisition, Groundwater, Information Retrieval Methods, Other Storage, ...7.0046

PROBABILITIES OF SEQUENCES OF DRY DAYS IN TEXAS ...Forecasting, Irrigation-general, Planning, Tables, Compilations, Catalogs, Water Supply-general, ...3.0442

OPTIMIZATION IN THE USE OF VARIABLE QUALITY DESALTED WATER AND AN ARTIFICAL UNDERGROUND RESERVOIR TO SUPPLY PEAK MUNICIPAL WATER DEMANDS ...Conjunctive Use, Desalination, Optimization, Other Computers, Urban Environments, Use of Impaired Water, ...3.0470

WEATHER RADAR - PRECIPITATION RELATIONSHIP ...Automatic Stations, Forecasting, Patterns, Radar, ...2.0876

NATIONWIDE PRECIPITATION - NMC FORECAST TECHNIQUES ...Clouds-general, Forecasting, Forecasting-prediction, General Synoptic Observations, Regression Analysis, ...2.0589

NUMERICAL PRECIPITATION MODEL ...Forecasting, Model Studies, Simulation Theory, Western, ...2.0588

DEVELOPMENT OF HYDROLOGIC ANALYSIS TECHNIQUES ...Data Analysis - General, Hydrology-general, Land Use, Model Studies, Technique Development, ...2.0988

COMPUTER-ORIENTED MATHEMATICAL MODEL FOR CONTINUOUS STREAMFLOW PREDICTION ...Amount, Development of Models, Discharge-general, Prediction Models, ...2.0985

HYDROLOGY TRAINING AND METHODOLOGY ...Education and Training, Hydraulic Engineering-other, Hydrology-general, Meetings, ...9.0001

RESERVOIR SYSTEM ANALYSIS FOR LOW-FLOW REGULATION ...Low Flow, Management, Optimization, Reservoirs and Impoundments, Systems Analysis, ...2.0151

PLAN FORMULATION AND EVALUATION STUDIES - RECREATION DESIGN CRITERIA AND DEMAND ...Costs, Frequency of Use, Planning, Projected Demand, Survey, ...6.0078

ARTIFICIAL FLOODS ...Dam, Dams-other, Floods, Flow Characteristics -water, ...6.0076

REMOTE SENSING, EVERGLADES AREA, FLORIDA ...Florida, Remote Areas, Swamps-marshes, Visible Light, Water Properties-general, ...2.0329

STRUCTURAL RESPONSE, DYNAMIC LOADS ...Dynamic-other, Earthquakes, Electric Power Plants, Industrial Structures, Other Computers, Rock Mechanics, ...8.0032

EXPERIMENTAL DESIGN & STATISTICAL EVALUATION OF WEATHER MODIFICATION EXPERIMENTS ...Data Analysis - General, Data Analysis Applications, Statistics-general, Technique Development, Weather Modification-general, ...2.0198

EFFECTS OF CRACKING IN ARCH DAMS ...Analysis Structural, Arch Dams, Engineering Structures-general, Fracture Mechanics, Tensile, ...8.0092

SMALL IMPOUNDMENTS ...Destratification, Flow Augmentation, Reservoirs and Impoundments, Water Quality-general, ...5.0189

PREDICTING NITRATE CONTENT OF AGRICULTURAL DRAIN WATER ...Agricultural Watersheds, Drainage, Model Studies-general, Moisture Content, Nitrate, Nitrite, Nitrogen, ...5.0181

DISTRIBUTION AND ABUNDANCE OF ZOOPLANKTON IN LAKE ERIE ...Aquatic Ecology, Environmental Ecology, Interbiotic Relat.(non-specif), Lake Erie, Other Computers, Population Dynamics, ...6.0294

SOIL WATER MOVEMENT IN RELATION TO THE CONSERVATION OF WATER SUPPLIES ...Conservation-general, Evaporation, Groundwater Movement, Infiltration, Internal Water Movement, Water Loss Control, ...2.0033

METHODS FOR WATER QUALITY IMPROVEMENT AND ITS STORAGE UNDERGROUND ...Denitrification, Groundwater Basins, Management, Natural Recharge, Percolation, Underground Waste Disposal, Waste Water Treatment-general, ...4.0005

SOIL HEAT TRANSFER - PERMAFROST AND FROST PENETRATION ...Heat Flow, Math. model, Permafrost-frozen, Thermal Properties-other, ...2.0024

Digital Computers

URBAN HYDROLOGIC STUDIES ...Drainage, Forecasting-prediction, Louisiana, Peak Flow, Urban Environments, ...2.0551

SIMULATION MODELING OF THERMAL EFFECTS ON SELECTED RIVER SYSTEMS ...Atomic Plants, Forecasting-prediction, Model Studies, Self-purification, Thermal Pollution, ...4.0270

A STUDY OF THE HYDROLOGIC EFFECTS OF RAINFALL AUGMENTATION ...Amount, Augmentation-general, Clouds-precipitation, Model Studies, Watersheds-general, ...3.0076

REVERSE OSMOSIS TUBULAR MODULE OPTIMIZATION ...Desalination, Membranes-other, Pilot Plant, Reverse Osmosis, ...3.0070

SIMULATION OF MULTISTAGE FLASH TEST MODULI (9-STAGE SAN DIEGO PLANT) ...Desalination, Development of Models, Flash Distillation, Hybrid Computers, Ordinary, ...3.0328

ANALYSIS OF DESALTING PLANTS AS A SOURCE OF SUPPLEMENTAL SAFE YIELD ...Desalination, Optimization Technique, Other, Process Development-other, ...3.0469

GENERAL STUDIES RELATED TO CODING GROUND-WATER APPROPRIATIONS & BASIC DATA FOR INFORMATION, STORAGE & PROCESSING SYSTEMS ...Data & Statistics Info Storage, Data and Statistics Centers, General Design, Water Law-general, ...7.0074

DIGITAL INSTRUMENTATION AND TELEMETRY FOR WATER RESOURCES RESEARCH ...Automatic Data Aquisition, Electronics - Applied, ...7.0072

MATHEMATICAL SIMULATION OF HYDROLOGIC EVENTS ON UNGAGED WATERSHEDS ...Hydrographs, Runoff, Sensitivity Problems, Testing of Models, Watersheds-general, ...2.0461

DIGITAL SYSTEMS FOR ON-SITE DATA COLLECTION FOR WATER QUALITY ANALYSIS ...Automatic Data Aquisition, Data Networks, Technique Development, Water Quality-general, ...7.0005

PRECIPITATION INTENSITY-FREQUENCY RELATIONSHIPS FOR WEST VIRGINIA ...Amount, Patterns, West Virginia, ...2.1141

SIMULATION OF THE HYDROLOGIC CYCLE ON SMALL AGRICULTURAL WATERSHEDS BY DIGITAL TECHNIQUES ...Agricultural Watersheds, Algorithms, Other Models, Virginia, Water Cycle, ...2.1109

DEVELOPMENT OF COMPUTER MODELS & METHODOLOGY FOR FORECASTING & EVALUATING MUNICIPAL & INDUSTRIAL WATER REQUIREMENTS ...Maryland, Model Studies, Projections and Estimations, Urban Environments, Water Demand, ...6.0252

COMPUTER SIMULATION OF THE HYDROLOGIC SYSTEM OF A MOUNTAIN WATERSHED ...Groundwater, Hydrology-general, Model Studies, Mountains-alpine, Surface Water, Watersheds-other, ...2.0707

THE DETERMINATION OF ZONES OF INTENSE CONTRIBUTION TO STREAM FLOW AS RELATED TO THE CONCEPT OF PARTIAL AREA CONTRIBUTIONS ...Development of Models, Model Studies, Runoff, Synthetic Hydrology-general, Watersheds-general, ...2.0580

SIMULATION MODEL FOR EVALUATION OF INTERCEPTION FROM FOREST TREES ...Environment, Forests, Interception, Model Studies, Snow-general, ...2.0390

PARTIAL AREA CONTRIBUTION TO STREAM FLOW ...Flow Characteristics -water, Model Studies, Runoff, Water Yield, Watersheds-general, ...2.0581

DEVELOPMENT OF A REFINED PREDICTIVE SYSTEM FOR USE IN FORECASTING MUNICIPAL WATER NEEDS ...Forecasting-prediction, Testing of Models, Urban Environments, Water Utilization -domestic, ...6.0253

DEVELOP A COMPUTERIZED METHODOLOGY FOR EVALUATION OF MUNICIPAL WATER CONSERVATION RESEARCH PROGRAMS ...Conservation-general, Cost Analysis, Development of Models, Urban Environments, ...3.0253

A GENERALIZED COMPUTER LANGUAGE FOR HYDROLOGIC AND HYDRAULIC ANALYSIS ...Data Analysis - General, Facilities, Hydraulic Engineering-other, Problem Oriented Languages, ...8.0213

STOCHASTIC BASIS FOR COMPREHENSIVE RIVER BASIN PLANNING ...Development of Models, Monte Carlo Methods, New York, Planning, Stochastic Processes, Systems Analysis, ...6.0374

HYDROLOGIC ANALYSIS OF GROUNDWATER BASINS BY DIGITAL COMPUTER SIMULATION ...Aquifers-general, Groundwater Basins, Groundwater Movement, Mathematical Analysis, Model Studies, ...4.0043

COMPUTER SIMULATION OF AQUIFERS OF COASTAL PLAIN OF NORTH CAROLINA ...Analog Computers, Carbonate Aquifers, Development of Models, Model Studies, North Carolina, ...**2.0822**

WATER-QUALITY REGIMEN OF TAHOE-TRUCKEE SYSTEM ...California, Lakes, Model Studies, Nevada, Water Quality-general, ...**5.0706**

OPTIMAL DESIGN OF SEWER AND DRAINAGE SYSTEMS ...Open Channel, Process Design, Sewerage Systems-other, Unsteady, ...**5.0530**

HYDRAULICS OF SURFACE IRRIGATION ...Differential Equations, Irrigation, Steady, Surface Irrigation -general, Unsteady, ...**2.0098**

STATISTICAL ANALYSIS OF FLOOD PEAKS OF GEORGIA RIVERS ...Data Analysis Applications, Discharge-general, Floods, Georgia, Peak Flow, ...**2.0357**

TURBULENT FLOW THROUGH POROUS MEDIA ...Digital Computers, Finite Differences, Porous Media - Flow Through, Prediction Models, Turbulent, Turbulent Flow, ...**2.0354**

SYSTEM ANALYSIS OF RAINFALL-RUNOFF RELATIONSHIP ...Amount, Digital Computers, Ordinary, Runoff, Systems Analysis, ...**2.0427**

INVESTIGATION OF THE TURBULENT TRANSPORT MECHANISMS FOR HEAT AND MOMENTUM TRANSFER IN PIPE FLOW ...Heat-transfer-other, Statistics-general, Turbulent, Velocity, ...**5.0371**

PLANNING ALGORITHMS FOR REGIONAL WATER RESOURCE SYSTEMS ...Algorithms, Economic Efficiency, Planning, Systems Analysis, Water Resources Development, ...**7.0012**

GEOHYDROLOGIC SYSTEM ANALYSIS WITH AN ELECTRIC ANALOG COMPUTER ...Analog, Analog Computers, Aquifers-general, Groundwater, Induced Infiltration, Network Synthesis, Systems Analysis, ...**2.0417**

APPLICATION OF OPTIMIZATION TECHNIQUES TO PROBLEMS TO AGRICULTURE ...Analog Computers, Animal Waste Removal-treatment, Model Studies, Optimization, Solid Waste, Waste Water Treatment-general, ...**5.0427**

EFFECT OF THE CLIMATE AND MICROCLIMATE ON AGRICULTURE IN SOUTH DAKOTA ...Applied Climatology, Automatic Stations, Microclimate-general, South Dakota, Statistics-general, ...**2.0973**

EFFECT OF REACTOR EFFLUENT ON QUALITY OF COLUMBIA RIVER WATER ...Atomic Plants, Columbia River, Filtration, Pollution - Effects of , Radioactivity-general, ...**5.1246**

INSTRUMENTATION, DATA ACQUISITION, AND COMPUTER TECHNIQUES ...Analog Computers, Automatic Data Aquisition, Data Analysis Applications, Hydraulics-general, ...**7.0019**

DESIGN OF UNDERGROUND POWERPLANTS ...Borehole Geophysics, Electric Power Plants, Mechanics of Structures-other, Power Plant, Rock Mechanics, ...**8.0031**

HIGH-VOLTAGE A-C TRANSMISSION ...Analog Computers, Development of Models, Electrical Engineering-general, Power Transmission, Switching, ...**8.0056**

SLAB ANALYSIS ...Beams - Bars, Engineering Structures-general, ...**8.0117**

GROUNDWATER ANALYSIS BY DIGITAL COMPUTER APPLICATION DEVELOPMENT ...Aquifers-general, Forecasting-prediction, Water Table Fluctuation, ...**4.0059**

ENGINEERING ANALYSIS OF WASTE TREATMENT ...Activated Carbon, Development of Models, Electrodialysis, Optimization, Sewerage Systems-other, ...**5.0861**

COMPUTERIZED DESIGN AND SYSTEMS ANALYSIS OF WASTEWATER TREATMENT PLANTS ...Application, Development of Models, Forecasting-prediction, Systems Analysis, Waste Water Treatment-general, ...**6.0421**

DRAINAGE SYSTEMS FOR THE IMPERIAL VALLEY ...Analog Computers, Drainage, Groundwater Movement, ...**4.0026**

Digital Computers

TURBULENT FLOW THROUGH POROUS MEDIA ...Digital Computers, Finite Differences, Porous Media - Flow Through, Prediction Models, Turbulent, Turbulent Flow, ...**2.0354**

SYSTEM ANALYSIS OF RAINFALL-RUNOFF RELATIONSHIP ...Amount, Digital Computers, Ordinary, Runoff, Systems Analysis, ...**2.0427**

Hybrid Computers

SIMULATION OF MULTISTAGE FLASH TEST MODULI (9-STAGE SAN DIEGO PLANT) ...Desalination, Development of Models, Digital Computers, Flash Distillation, Ordinary, ...**3.0328**

EFFICIENCY OF DATA COLLECTION SYSTEMS IN HYDROLOGY AND WATER RESOURCES FOR PREDICTION AND CONTROL ...Control and Protection, Economic Efficiency, Hydrology-general, Systems Analysis, ...**7.0004**

DYNAMIC SYSTEM MODELING AND SIMULATION OF A RIVER BASIN ...Dynamic, Michigan, Model Studies, River Basins, Stochastic Models, ...**6.0301**

HYBRID COMPUTER SIMULATION OF GROUND-WATER BASINS ...Development of Models, Groundwater, Groundwater Basins, Model Studies, Water Quality Control-general, ...**2.0106**

DEVELOPMENT AND CALIBRATION OF A PITOT SPHERE ...Gaging, Hybrid Computers, Mass, ...**8.0193**

Hybrid Computers

DEVELOPMENT AND CALIBRATION OF A PITOT SPHERE ...Gaging, Hybrid Computers, Mass, ...**8.0193**

Other Computers

MATHEMATICAL SIMULATION OF RAINFALL RUNOFF PROCESSES ...Computers-general, Hydrographs, Model Studies, Optimization, Runoff, Storms-general, ...**2.1015**

OPTIMIZATION IN THE USE OF VARIABLE QUALITY DESALTED WATER AND AN ARTIFICAL UNDERGROUND RESERVOIR TO SUPPLY PEAK MUNICIPAL WATER DEMANDS ...Computers-general, Conjunctive Use, Desalination, Optimization, Urban Environments, Use of Impaired Water, ...**3.0470**

STRUCTURAL ANALYSIS ...Analysis Structural, Beams - Bars, Concrete-other, Finite Differences, Frame, Arch,truss, ...**8.0020**

STRUCTURAL RESPONSE, DYNAMIC LOADS ...Computers-general, Dynamic-other, Earthquakes, Electric Power Plants, Industrial Structures, Rock Mechanics, ...**8.0032**

Other Computers

DISTRIBUTION AND ABUNDANCE OF ZOOPLANKTON IN LAKE ERIE ...Aquatic Ecology, Computers-general, Environmental Ecology, Interbiotic Relat.(non-specif), Lake Erie, Population Dynamics, ...**6.0294**

Conifers

Conifers -non-specific

A STUDY OF SNOW INTERCEPTED BY CONIFEROUS TREE CROWNS AND ITS DISPOSITION UNDER THE CLIMATIC CONDITIONS OF CENTRAL NEW YORK ...Coniferous Forests, Interception, New York, Snow, Snow-other, ...**2.0787**

Douglas Fir

EFFECTS OF LOGGING ON SALMON POPULATIONS IN COASTAL STREAMS ...Forest Debris, Forest Watersheds, Logging, Transport, Equipment, Population Dynamics, Salmon - coho,chinook,sockeye.., ...**5.0947**

GENESIS AND MORPHOLOGY OF PYGMY FOREST-BLACKLOCK SOIL ECOSYSTEM ...California, Sequoia, Soil Ecology, Water Table Fluctuation, Wave-built Terrace, ...**6.0041**

TESTS OF DOUGLAS-FIR PLANTING STOCK FOR SURVIVAL UNDER DROUGHT STRESS ...Drought, Longevity, Mycorrhiza, Physiology, Plant Chemistry, Site Index and Site Quality, ...**2.0894**

Juniperus

EFFECTS OF PINYON-JUNIPER CONVERSION ON WATERSHED VALUES IN UTAH ...Cover Crops, Forest Watersheds, Moisture Budgets, Pines, Water Balance-budget, ...**2.1067**

Pines

FOREST TREE NUTRITION AND FOREST FERTILIZATION ...Irrigation-general, Physiology, Plant Chemistry, Potassium, Soil Fertility, Soils and Fertilizer, ...**2.0815**

EFFECTS OF PINYON-JUNIPER CONVERSION ON WATERSHED VALUES IN UTAH ...Cover Crops, Forest Watersheds, Juniperus, Moisture Budgets, Water Balance-budget, ...**2.1067**

TRANSPIRATION RATES OF CONIFERS ...Air Temperature - non-specific, Solar Light -non-specific, Spruces, ...**2.0712**

FOREST SITE AMELIORATION IN THE COASTAL FLATWOODS OF MISSISSIPPI - ECONOMIC AND BIOLOGICAL

CONSIDERATIONS ...Mississippi, Moisture Tension, Site Index and Site Quality, Water Table - Depth of , Water Table Fluctuation, ...**2.0682**

CONSERVING SOIL MOISTURE BENEATH RED PINE BY MEANS OF A FOLIAR SPRAY OF A STOMATA - CLOSING CHEMICAL ...Liquids Or Sprays, Moisture Content, PMA , Soil Environment, Soils and Fertilizer, Transpiration, ...**3.0151**

WATER CONTROL FOR FOREST PRODUCTION ...Available Water, Cultural Control, Palms, Timber Stand Improvement, Water Loss Control, ...**3.0175**

GROWTH AND DEVELOPMENT OF NATIVE HARDWOODS AND PINE ...Available Water, Growth, Soil Environment, Soil Types, Soils and Fertilizer, ...**2.0430**

EFFECTS OF SOIL MOISTURE STRESS ...Drought, Moisture Deficiency, Moisture Tension, Physiology, Plant Chemistry, Soil Environment, ...**2.0431**

EFFECT OF MOISTURE STRESS ON RATES OF PHOTOSYNTHESIS ...Drought, Growth Rate, Photosynthesis, Respiration, ...**2.0956**

THE MANAGEMENT OF PONDEROSA PINE - NEW METHODS OF THINNING DENSE STAGNATING SECOND GROWTH STANDS ...Fire Use for Silviculture, Soil Environment, Soils and Fertilizer, Timber Stand Improvement, ...**2.0065**

INTERRELATION OF MOISTURE REGIME & NUTRIENT LEVELS OF SELECTED MISSISSIPPI SOILS & THEIR RELATION TO THE SITE INDEX OF LOBLOLLY PINE ...Forest Watersheds, Mississippi, Moisture Tension, Site Index and Site Quality, Soils and Fertilizer, ...**2.0683**

SILVICULTURE OF COASTAL PLAIN TIMBER TYPES ...Environment, Forest Watersheds, Taxodioideae, Timber Stand Improvement, Wetlands, ...**4.0212**

Sequoia

SOIL MOISTURE DRYING CURVES-MANAGEMENT RELATIONS ...California, Management, Moisture Content, Soil Environment, ...**6.0036**

GENESIS AND MORPHOLOGY OF PYGMY FOREST-BLACKLOCK SOIL ECOSYSTEM ...California, Douglas Fir, Soil Ecology, Water Table Fluctuation, Wave-built Terrace, ...**6.0041**

Spruces

TRANSPIRATION RATES OF CONIFERS ...Air Temperature - non-specific, Pines, Solar Light -non-specific, ...**2.0712**

Taxodioideae

SILVICULTURE OF COASTAL PLAIN TIMBER TYPES ...Environment, Forest Watersheds, Pines, Timber Stand Improvement, Wetlands, ...**4.0212**

Conjunctive Use

WATER RESOURCE OPERATIONS STUDY ...Operations Research, Planning, Water Cycle, Weather Modification-general, Wyoming, ...**6.0652**

OPTIMIZATION OF WELLS AND RECHARGE FACILITIES IN CONJUNCTIVE USE OF GROUNDWATER RESERVOIRS ...Groundwater Basins, Optimization, Pumping, Recharge -general, Water Wells, ...**6.0054**

AN OPTIMAL WATER MANAGEMENT PLAN FOR THE MIAMI VALLEY ...Alternative Planning, Artificial Recharge, Augmentation-general, Floodproofing, Optimization Technique, Systems Analysis, ...**6.0467**

A SYSTEM APPROACH FOR INTEGRATING GROUNDWATER AND SURFACE-WATER USE ...California, Groundwater, Systems Analysis, Water Quality Control-general, Water Utilization -general, ...**6.0037**

SURFACE AND GROUND WATER POTENTIALITIES OF THE MULLICA RIVER BASIN ...Aqueducts, Economic Impact, Systems Analysis, Water Quality-general, Water Transfer, ...**4.0172**

A COMPENDIUM OF WATER LAW AND ECONOMICS IN NEW HAMPSHIRE ...Economic Impact, New Hampshire, Water Law-general, Water Quality-general, Water Rights-general, Water Utilization -domestic, ...**6.0283**

A COMPARATIVE STUDY OF THE USE TAX AS A MEANS OF ALLOCATION OF WATER RESOURCES IN A CONJUNCTIVE USE SYSTEM ...Benefit-cost Analysis, Fiscal, Groundwater, Water Allocation, Welfare Economics, ...**6.0056**

GROUNDWATER - SURFACE WATER INTEGRATION STUDY IN THE GRAND PRAIRIE REGION OF ARKANSAS ...Arkansas, Available Water, Groundwater, Recharge -general, Water Demand, ...**4.0020**

SYSTEMS SIMULATION FOR MANAGEMENT OF A TOTAL WATER RESOURCE ...Management, Optimization, Planning, River Basins, Water Transfer, ...**4.0230**

DRAINAGE DESIGN FOR IRRIGATION AGRICULTURE ...Aquifers-general, Artesian Flow, Groundwater Movement, Seepage, Water Wells, ...**4.0165**

ECONOMIC ANALYSIS OF ALTERNATIVE WATER USE TECHNIQUES IN PRODUCTION OF COTTON, GRAIN SORGHUM & RELATED CROPS - SOUTHERN HIGH PLAINS OF TEXAS ...Conservation-general, Economic Efficiency, Irrigation-general, Water - Alternative Uses, Water Costs, ...**6.0571**

OPTIMIZATION IN THE USE OF VARIABLE QUALITY DESALTED WATER AND AN ARTIFICAL UNDERGROUND RESERVOIR TO SUPPLY PEAK MUNICIPAL WATER DEMANDS ...Computers-general, Desalination, Optimization, Other Computers, Urban Environments, Use of Impaired Water, ...**3.0470**

OPTIMUM UTILIZATION OF SURFACE AND SUBSURFACE WATER FACILITIES ...Aquifers-general, Mathematical Analysis, Operations Research, Storage of Water, Survey Studies, ...**4.0110**

Connecticut

RATE AND DIRECTION OF GROUND WATER CIRCULATION IN CLOSE SPACED BEDROCK AND GRAVEL WELLS UNDER THE INFLUCENCE OF NON-SYNCHRONOUS PUMPING TIME ...Groundwater Movement, Land Use, Pumping, Subsurface Flow, ...**2.0244**

REVERSE FILTER EROSION PROTECTION ...Control and Protection, Engineering Structures-general, Erosion-general, Filters, Lining, ...**8.0147**

INTEGRATION OF CONNECTICUT WATER RIGHTS LAWS AND POLLUTION CONTROL LAWS ...Legal Review, State Government, Water Allocation, Water Quality Control-general, Water Rights-general, ...**6.0116**

STUDIES ON PHOSPHORUS TRANSFORMATIONS IN EUTROPHIC LAKES ...Bacterial Culture, Bacterial Pollutant Sources, Budgets -other, Eutrophication, Nutrition, Phosphorus, ...**5.0216**

ORGANIC DEBRIS ON CONNECTICUT BEACHES AND SHORES ...Catabolism and Degradation, Identification, Organic Matter, Physical-general, Shoreline - Coastline, ...**5.0204**

REGIONAL UTILITIES STUDY-WATER SUPPLY, SEWERAGE, DRAINAGE AND REFUSE DISPOSAL ...Municipal-waste-other, Operations Research, Planning, Sewage, Water Supply-general, ...**5.0207**

DISPOSAL OF LIQUID WASTES ...Disposal Wastes, Plants - Systems-general, ...**5.0206**

ECOLOGICAL FACTORS AFFECTING REPRODUCTION OF SHELLFISH (PHYSIOECOLOGY OF SHELLFISH PROGRAM) ...Environmental Ecology, Oysters, Reproductive System, Spawn Or Nesting Sites, Water Properties-general, ...**6.0114**

Connecticut River

DISTRIBUTION AND ABUDANCE OF JUVENILE AMERICAN SHAD, ALOSA SAPIDISSIMA (WILSON), IN THE CONNECTICUT RIVER ABOVE HOLYOKE DAM, MASSACHUSETTS ...Alewife,menhaden,shad,herring, Engineering Structures-general, Massachusetts, Migration, Number Or Density, ...**3.0271**

FOOD HABITS OF LARVAL AND JUVENILE SHAD IN THE CONNECTICUT RIVER ...Alewife,menhaden,shad,herring, Aquatic Ecology, Food Supply, Massachusetts, Recreation Sites, ...**3.0272**

STUDY OF THE RIVER PHASE OF THE LIFE HISTORIES OF ALOSA PSEUDOHARENGUS AND AESTIVALIS ...Alewife,menhaden,shad,herring, Aquatic Ecology, Environmental Ecology, Life History Studies, Spawn Or Nesting Sites, ...**6.0111**

POTENTIAL FISHERY FOR RIVER HERRINGS IN CONNECTICUT RIVER ...Alewife,menhaden,shad,herring, Environmental Ecology, Life History Studies, Nets, Spawn Or Nesting Sites, ...**4.0075**

OPTIMUM UTILIZATION AND MANAGEMENT OF WATER IN FORMATIONS HYDROLOGICALLY-CONNECTED TO A STRETCH OF THE CONNECTICUT RIVER ...Aquifers-general, Artificial Recharge, Baseflow, Massachusetts, Water Yield, ...**4.0134**

THE USE OF AERIAL PHOTOGRAPHS TO EVALUATE THE RECREATIONAL RESOURCES OF A RIVER ...Land Use, Methods, Photogrammetry, Recreation Sites, Streams, ...**6.0285**

FEASIBILITY OF USING ATMOSPHERIC WATER RESOURCES IN THE NORTHEASTERN UNITED STATES ...Applied Climatology, Benefit-cost Analysis, Clouds-precipitation, River Basins, Water Resources Development, ...2.0161

THE CONNECTICUT RIVER STUDY ...Projected Demand, Recreation Areas and Parks, Recreation Sites, Recreation Types - non-specific, Types of Resources, ...3.0168

Conservation

ECONOMICS OF SOIL CONSERVATION PRACTICES WITHIN WATERSHEDS ...Agricultural Watersheds, Economics-general, Kansas, Tillage, Cropping Systems, ...3.0243

Conservation-general

SAN LUIS WATERSHED STUDY ...Management, New Mexico, Sediment Yield, Small Watersheds, Water Yield, ...2.0234

MOUNTAIN MEADOW RESTORATION ...Agricultural Land Use Effects, Conservation, Management and Fertility, Mountains-alpine, Other Water Conditions, ...4.0166

HYDROLOGY OF SUBURAN AREAS ...Amount, Land, New Jersey, Runoff, Surburban Areas, ...4.0173

A STUDY OF THE INTERACTIONS PRESENT IN AQUEOUS SALT SOLUTIONS BY NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY ...Ionic, Nuclear Magnetic, Solution, Transition Metal-general, Water Resources Development, ...1.0074

WATER RESOURCES IN SOURDOUGH AND MIDDLE CREEK WATERSHEDS - A COMPARATIVE STUDY OF QUALITY AND HYDROLOGY ...Hydrology-general, Land Use, Montana, Water Quality Control-general, Watersheds-general, ...5.0695

LEGAL RESEARCH, WRITING AND DRAFTING TOWARD IMPROVING MONTANA WATER LAWS ...Legislation, Montana, State Government, Water Utilization -general, ...6.0333

DEVELOP A COMPUTERIZED METHODOLOGY FOR EVALUATION OF MUNICIPAL WATER CONSERVATION RESEARCH PROGRAMS ...Cost Analysis, Development of Models, Digital Computers, Urban Environments, ...3.0253

GROUND WATER RECHARGE AS AFFECTED BY SURFACE VEGETATION AND MANAGEMENT ...Antitranspirants, Groundwater, Infiltration, Natural Recharge, Soil-water-plant Relationships, ...4.0061

WATER CONSERVATION THROUGH EFFICIENT USE BY CROP PLANTS ...Metabolic-biochemical Genetics, Moisture Deficiency, Natural Variation of Water USE, Requirements for Water, Selection & Breeding, ...2.0057

CONSERVATION OF WATER RESOURCES THROUGH MODIFICATION OF THE PHYSICAL AND CHEMICAL PROPERTIES OF SOIL ...Persistence in Soils, Sand, Soil Environment, Storage of Water, Surfactants - Wetting Agents, ...2.0312

PHYSICAL AND ECONOMIC ANALYSIS OF WATERSHEDS AS RELATED TO SOIL AND WATER CONSERVATION ...Benefit-cost Analysis, Land, Land Use, Linear & Non-linear Program, Watersheds-general, ...6.0222

SOIL WATER MOVEMENT ...Groundwater Movement, Management, Moisture Meters, Moisture Tension, Movement, Availability, ...3.0245

SOIL AND WATER CONSERVATION MANAGEMENT ...Erosion-general, Soil Erosion -non-specific, Tillage, Cropping Systems, Yield, ...4.0150

CONSERVATION OF GROUNDWATER THROUGH REPLACEMENT OF PHREATOPHYTES WITH FORAGES ...Groundwater, Herbicides -non-specific, in Forages and Pasture, Soil Environment, Water Table - Depth of , ...3.0318

EVALUATION OF SOIL AND WATER CONSERVATION DESIGN ...Conservation, Conservation & Management Eng, Drainage Systems, Soil Preparation & Renovation, ...2.0800

SOIL SURFACE MANAGEMENT PROCEDURES FOR SOIL AND WATER CONSERVATION ...Conservation, Plant Residues, Humus, Compost, Tillage, Cropping Systems, Yield, ...2.0878

CONSERVATION AND RENOVATION OF WASTE WATER ...Effluents-waste Water, Natural Recharge, Pollution - Effects of , Soil Properties - General, Surface Irrigation -general, Waste Water Treatment-general, ...5.1035

CRITERIA FOR PUBLIC INVESTMENT IN NATURAL RESOURCES ...Cmc, Finance, Fiscal, Savings and Investment, ...2.0130

NATURAL RESOURCE MANAGEMENT AND CONSERVATION IN THE SOVIET UNION ...Multiple-purpose Projects, Russia, Survey Studies, Water Allocation, Water Quality-general, ...3.0485

SEDIMENTATION IN LAKES AND RESERVOIRS ...Land Use, Rate of Deposition, Reservoirs and Impoundments, Slopes, Soil Types-other, ...2.0422

PREDICTING RUNOFF AND GROSS EROSION FROM FARMLAND AND DISTURBED AREAS ...Agricultural Watersheds, Conservation, Erosion-general, Forecasting-prediction, Runoff, ...3.0224

INVESTIGATIONS OF EROSION CONTROL AND WATER CONSERVATION ...Amount, Erosion, Gullys - Arroyos, Land Use, Runoff, Sediment Yield, Stabilization-general, ...3.0226

SEASONAL WATER USE BY FOREST VEGETATION ...Environment, Forest Watersheds, Seasonal, Transpiration and Evap, Water Quality Control-general, ...2.0893

THE INFLUENCE OF GRAZING MANAGEMENT SYSTEMS ON VEGETATION COMPOSITION AND LIVESTOCK REACTION ...Agricultural Watersheds, Grazing, Management and Fertility, Water Loss-general, ...5.1160

ECONOMIC ANALYSIS OF ALTERNATIVE WATER USE TECHNIQUES IN PRODUCTION OF COTTON, GRAIN SORGHUM & RELATED CROPS - SOUTHERN HIGH PLAINS OF TEXAS ...Conjunctive Use, Economic Efficiency, Irrigation-general, Water - Alternative Uses, Water Costs, ...6.0571

GENERAL EVALUATION OF SOIL AND MOISTURE CONSERVATION TREATMENT PRACTICES ...Engineering Structures-general, Erosion-general, Runoff, Sedimentology-general, Soil Environment, ...2.0185

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THE EFFECTS OF VELOCITY ON THE PASSIVATION OF ALLOYS IN BRACKISH WATER ...Brackish Water, Desalination, Electrolytes, Metallic Alloys, Velocity -water, ...**3.0136**

Crustacea

Branchiopoda -other

DISTRIBUTION OF DIATOMS IN DESERT WATERS ...Algae-Diatoms, Deserts, Plant Prod. (non-specific), Playas, Respiratory System, ...**2.0138**

Copepods

IMPOUNDMENT EFFECTS ON WATER QUALITY AS REFLECTED IN PARASITISM OF RESERVOIR BASSES ...Pathology, Pre-impoundment Sites, Reservoirs and Impoundments, Water Level Fluctuation, Water Quality-general, ...**6.0024**

ANNUAL PHYTOPLANKTON PRODUCTION IN PUGET SOUND WATERS ...Invertebrate Cultures, Phytoplankton, Puget Sound, Standing Crops, Tides, ...**5.1256**

CHEMICAL ECOLOGY OF DIAPTOMID COPEPODS OF COLORADO ...Aquatic Ecology, Chemical Measurements -water, Colorado, Environmental Ecology, Fresh Water, ...**6.0088**

RELICT COPEPODS FROM LAKE TUBORG, ELLESMERE ISLAND ...Brackish Water, Canada, Carbon-14, Lakes, Plankton Sampling, ...**2.0257**

LIFE HISTORY OF CYCLOPS BICUSPIDATUS ...Aquatic Ecology, Life History Studies, Number Or Density, Reservoirs and Impoundments, South Dakota, ...**6.0527**

DEVELOPMENT OF CULTURE METHODS FOR ECOLOGICALLY IMPORTANT MARINE ZOOPLANKTON SPECIES ...Aquatic Ecology, Environmental Physiology, Invertebrate Cultures, Zooplankton, ...**5.1096**

DETERMINATION OF SELECTED ENVIRONMENTAL REQUIREMENTS OF IMPORTANT SPECIES OF MARINE ZOOPLANKTON ...Oxygen, Water Salinity, Water Temperature-non-specific, Zooplankton, ...**5.1097**

Crabs, All

SURVIVAL REQUIREMENTS OF JUVENILE AND ADULT BLUE CRABS ...Biological Rhythms, Environmental Physiology, Laboratory, Osmoregulation, Water Properties-general, ...**6.0401**

EFFECT OF ENVIRONMENTAL CHANGES ON BLUE CRAB ABUNDANCE ...Environmental Changes, Life History Studies, Migration, North Carolina, Population Dynamics, ...**6.0400**

REARING AND SENSITIVITY STUDIES OF VARIOUS LIFE STAGES OF MARINE MACROINVERTEBRATES ...Bioindicators, Shrimps - Common, Whole Body Culture & Rearing, ...**5.1079**

Crayfish, All

STUDY OF EXCRETORY PATTERNS IN CRAYFISHES ...Metabolism, Nitrogen, Osmoregulation, Stress, Urea, ...**6.0376**

Crustacea -non-specific

THERMAL EFFECTS ON MARINE AND ESTUARINE SHELLFISH ...Aquatic Ecology, Environmental Physiology, Mollusks - non-specific & Other, Pollution - Effects of , Water Temperature-non-specific, ...**5.1251**

MARINE BIOLOGICAL ASSESSMENT OF POLLUTIONAL FATE ...Contamination - Water, Fish -non-specific, Nets, Pollution - Effects of , ...**5.0975**

VIBRIO PARAHAEMOLYTICUS IN THE ESTUARINE ENVIRONMENT ...Estuaries, Isolation From Nat. environ. , Mollusks -non-specific & Other, Temporal Distribution, Vibrio N S, ...**2.1115**

BIOLOGICAL METHODS RESEARCH ...Chemical Identification, Enteroviruses of Humans, Isolation, Sewage, Viral Pollutant Sources, ...**5.0017**

EVALUATION OF METHODS FOR RECOVERY OF ENTEROBACTERIACEAE FROM MARINE SOURCES ...Bacterial Pollutant Sources, Estuaries, Intestinal Bacteria, Pollutants-general, ...**5.1225**

INVESTIGATIONS ON CIGUATERA-LIKE BIOTOXINS IN SHELLFISH ...Algal Culture, Algal Toxins, Bulk Culture -other, Gymnodinium, Mollusks -non-specific & Other, ...**5.0018**

COOPERATIVE STUDIES WITH FEDERAL AND STATE AGENCIES ...Bioassays, Mollusks -non-specific & Other, Public Health Ecology, Survey Studies, Water Quality-general, ...**7.0111**

GENERAL TECHNICAL ASSISTANCE ...Committee-support, Mollusks -non-specific & Other, Shellfish Depuration, Water Quality-general, ...**5.1075**

Diplostraca

Cladocera

NUCLIDE UPTAKE BY ALGAE AND ZOOPLANKTON ...Chlorella, Environment, Ionic Effect, Organic Matter Content - water, Radioisotopes -non-specific, ...**6.0048**

DIVERSITY AND ECOLOGICAL NICHES IN MULTI-SPECIES ASSOCIATIONS OF CHYORID CLADOCERA (CRUSTACEA) ...Environmental Ecology, Habitat Studies, Interbiotic Relat.(non-specif), Lakes, Microfossils, ...**2.0911**

AQUATIC ECOSYSTEM ...Acidity, Environment Resistance, Ph, Acidity -water, Pollution - Effects of , Productivity - Food Chain, ...**6.0084**

Isopods

FEEDING PATTERNS OF THE FRESHWATER ISOPOD LIRCEUS BRACHYURUS ...Aquatic Ecology, Behavioral Ecology, Food Supply, Nutrition - Invertebrate, Pennsylvania, Streams, ...**7.0093**

Shrimps - Brine Or Fairy

INFLUENCE OF SALINITY AND TEMPERATURE ON TOXICITY OF SOME PESTICIDES TO BRINE SHRIMP ...Environmental Effects, Salinity, Temperature, ...**5.0663**

Shrimps - Common

EXPERIMENTAL SEEDING (SHRIMP AQUACULTURE PROGRAM) ...Captive Rearing, Florida, Population Dynamics, Spawn Or Nesting Sites, Stocking of Fish & Shellfish, ...**6.0565**

REARING AND SENSITIVITY STUDIES OF VARIOUS LIFE STAGES OF MARINE MACROINVERTEBRATES ...Bioindicators, Crabs, All, Whole Body Culture & Rearing, ...**5.1079**

Shrimps - Seed Or Mussel

EFFECTS OF THE CHLORINATED HYDROCARBONS, ALDRIN AND DIELDRIN, ON FRESHWATER SEED SHRIMP (OSTRACODA) ...Aldrin, Contamination - Water, Dieldrin, Fresh Water, Laboratory Animals, Pollution - Effects of , ...**5.1117**

Crystallization

Crystal Growth

A STUDY OF THE NUCLEATION AND GROWTH CHARACTERISTICS OF SLURRIES OF ICE CRYSTALS ...Desalination, Fluid Dynamics, Freezing, Nucleation, Shear-flow, ...**3.0356**

DIFFUSION PHENOMENA IN ICE - RECRYSTALLIZATION PHENOMENA IN ICE ...Concentration, Desalination, Diffusion-other, Electrolytes, Rate of Reaction, ...**3.0361**

A STUDY OF THE EFFECTS OF SURFACE POTENTIAL ON SCALE FORMATION ...Desalination, Electrochemistry-other, Metals, Nucleation, Scale Formation, ...**3.0080**

NUCLEATION AND GROWTH OF ICE CRYSTALS ...Brines, Desalination, Freezing, Hydration, Nucleation, ...**3.0041**

STUDIES ON THE HYDRATE PROCESS FOR DEMINERALIZING SEA WATER ...Brines, Demineralization, Hydration, Removal--inorganics, ...**3.0366**

REMOVAL OF INORGANIC MATERIAL FROM SALINE WATER BY PRECIPITATION PROCESSES ...Brines, Demineralization, Nucleation, Precipitation, Removal--inorganics, ...**5.0420**

Crystallization-other

TREATMENT AND DISPOSAL OF CONDENSATE WASTES FROM HIGH LEVEL WASTE SOLIDIFICATION PROCESSES ...Disposal Wastes, Fractionation, Material Recovery Wastes, Nuclear, Precipitation, ...**5.1250**

DESALINATION BY HIGH PRESSURE SOLIDIFICATION OF WATER TO ICE ...Desalination, High Pressure - 1-1000 Atm, Other, ...**3.0360**

Nucleation

ICE FORMATION BY CONTACT NUCLEATION ...Formation, Growth and Preparation, Model Studies, Nucleation Physics, Temperature, ...**3.0339**

STUDIES OF FUNDAMENTAL MECHANISMS IN THE DEPOSITION OF CALCIUM SULFATE SCALE ...Brines, Dilatometry, Electron, Phase Relationship, Scale Formation, ...**3.0293**

A STUDY OF THE NUCLEATION AND GROWTH CHARACTERISTICS OF SLURRIES OF ICE CRYSTALS ...Crystal Growth, Desalination, Fluid Dynamics, Freezing, Shear-flow, ...**3.0356**

SALINE WATER BY FREEZING - A PROGRAM OF INVESTIGATION ...Desalination, Evaporation, Freezing, Microscopy-other, Washing, ...**3.0343**

HETEROGENEOUS NUCLEATION AND CONDENSATION OF VAPORS ...Argon, Liquid, Solution, Water, 4 Ring System, ...**1.0094**

A STUDY OF THE EFFECTS OF SURFACE POTENTIAL ON SCALE FORMATION ...Crystal Growth, Desalination, Electrochemistry-other, Metals, Scale Formation, ...**3.0080**

NUCLEATION AND GROWTH OF ICE CRYSTALS ...Brines, Crystal Growth, Desalination, Freezing, Hydration, ...**3.0041**

REMOVAL OF INORGANIC MATERIAL FROM SALINE WATER BY PRECIPITATION PROCESSES ...Brines, Crystal Growth, Demineralization, Precipitation, Removal--inorganics, ...**5.0420**

PREPARATION OF MONODISPERSE EMULSIONS ...Distribution, Emulsion, Kinetic-general, Precipitation, ...**5.0064**

SEEDING OF BRACKISH WATER ...Desalination Wastes, Evaporation, Material Recovery Wastes, Scale Formation, ...**5.1216**

EFFECT OF THE WARM CLOUD BASE UPON CLOUDSEEDING FROM THE GROUND ...Clouds-precipitation, Iodine, Nucleation Physics, Silver, Vapor, ...**2.0156**

Culture (methods & Techniques)

Algal Culture

VARIABILITY IN DIATOM MORPHOLOGY AND WATER POLLUTION ...Algae- Diatoms, Bioindicators, Environment, Pollution - Effects of , Water Quality-general, ...**5.0217**

ALGAL GROWTH AND DECOMPOSITION - EFFECTS ON WATER QUALITY ...Algal Pollutant Sources, Cell Injury and Autolysis, Growth and Differentiation, Mineral Composition, Model Systems, Water Quality-general, ...**5.0443**

A STUDY OF PHYTOPLANKTON DYNAMICS IN LAKE FAYETTEVILLE AS A MEANS OF ASSESSING WATER QUALITY ...Bioindicators, Eutrophication, Growth Rate, Phytoplankton, Primary Productivity, ...**6.0031**

THE AUTECOLOGY OF SOME BLUE-GREEN PLANKTON ALGAE ...Cyanophyta (non-specific & Ot), Eutrophication, Mixed Culture, Nutrition Studies, Phytoplankton, ...**5.0955**

ALGAE DEGRADATION IN WATERWAYS ...Algal Pollutant Sources, Cell Injury and Autolysis, Mixed Culture, Water Properties-general, ...**5.0126**

BACTERIDAL EFFECTS OF ALGAE ON ENTERIC ORGANISMS ...Algae- General, Bactericides -non-specific, Intestinal Bacteria, Sanitation, Sewage, ...**5.1151**

COLLECTION AND ESTABLISHMENT IN CULTURE OF SPECIES AND STRAINS OF MARINE PHYTOPLANKTON ORGANISMS ...Culture Collections, Marine Plants, Phytoplankton, Pollution-general, ...**5.1063**

USE OF PURE STRAINS OF ALGAE AND MIXED ALGAE-PROTOZOA, AND ALGAE-BACTERIA CULTURES IN SEWAGE TREATMENT ...Algae, Microbial-bacterial, Pilot Plant, Waste Water Treatment-general, ...**5.0382**

CULTURING AND PROPAGATION OF SELECTED INVERTEBRATES AND ASSOCIATED FOOD ORGANISMS ...Chlorophyceae (non-specif.&ot), Chrysophyceae (non-specif.&ot), Cyanophyta (non-specific & Ot), Food Supply, Invertebrate Cultures, ...**5.0591**

INTEGRATED FIELD AND LABORATORY SYSTEM FOR ASSAYING THE EFFECTS OF POLLUTANTS AND TOXICANTS UPON WATER QUALITY ...Axenic Culture, Environment, Phytoplankton, Pollution - Effects of , ...**5.1087**

DEVELOPMENT OF A METHOD FOR CHRONIC TOXICITY BIOASSAY USING MARINE PLANKTONIC ALGAE ...Bioassays, Marine Plants, Microbiological Analysis, Monitoring (long Term Studies), Phytoplankton, Technique Development, Toxicology, ...**5.1088**

MEASUREMENT OF THE RATE OF CARBON DIOXIDE (C14) FIXATION INTO SUBCELLULAR FRACTIONS OF ALGAE ...Algae- General, Bioindicators, Carbon, Carbon Dioxide Fixation, Growth Rate, Intracellular Localization, ...**5.1090**

LABORATORY STUDIES OF TOXIC DINOFLAGELLATES ...Algal Toxins, Gonyaulax, Gulf of Mexico, Gymnodinium, Vegetable Origin, ...**5.1161**

COMPARATIVE STUDIES OF DINOFLAGELLATE TOXINS ...Action- & Bioelectrical Pot. , Algal Toxins, Dinophyceae (non-specific &ot), Toxicology, ...**5.0716**

INVESTIGATIONS ON CIGUATERA-LIKE BIOTOXINS IN SHELLFISH ...Algal Toxins, Bulk Culture -other, Crustacea -non-specific, Gymnodinium, Mollusks -non-specific & Other, ...**5.0018**

Axenic Culture

INFLUENCE OF PROTOZOAN ACTIVITY ON HALOGENATED HYDROCARBON RESIDUES - INTERACTION BETWEEN MICROORGANISMS AND PESTICIDES ...Metabolism, Mode of Action -animal, Petroleum Cpds. -non-specific, Protozoa -other, ...**5.0642**

DETERMINATION OF SELECTED ENVIRONMENTAL REQUIREMENTS OF IMPORTANT MARINE PHYTOPLANKTON SPECIES ...Environment, Growth and Differentiation, Marine Biology, Marine Plants, Phytoplankton, ...**5.1094**

INTEGRATED FIELD AND LABORATORY SYSTEM FOR ASSAYING THE EFFECTS OF POLLUTANTS AND TOXICANTS UPON WATER QUALITY ...Algal Culture, Environment, Phytoplankton, Pollution - Effects of , ...**5.1087**

Bacterial Culture

STUDIES ON PHOSPHORUS TRANSFORMATIONS IN EUTROPHIC LAKES ...Bacterial Pollutant Sources, Budgets - other, Connecticut, Eutrophication, Nutrition, Phosphorus, ...**5.0216**

STUDIES ON AQUATIC STALKED BACTERIA ...Classification Or Taxonomy, Ecology, Growth (non-specific & Ot.), Stalks and Buds, Water Bacteria, ...**5.1280**

CONTROLLING FACTORS IN METHANE FERMENTATION ...Cell. env.(non-specific & Ot.), Fermentation, Methane Bacteria (non-specif.), Respiration, Saturated Hydrocarbons, ...**5.0754**

ROLE OF ENTERIC MICROORGANISMS IN DETOXIFICATION - INTERACTION BETWEEN MICROORGANISMS AND PESTICIDES ...Biodegradation, Fish -non-specific, Identification, Insecticides -non-specific, Intestinal Bacteria, ...**5.0641**

NITRIFICATION BY MARINE MICROORGANISMS ...Autotrophic, Bact. morphology (general), Isolation From Nat. environ. , Marine Bacteria (non-specific), Nitrification, Nitrogen Bacteria, Range Or Territorial Distr. , ...**1.0066**

Bulk Culture -other

INVESTIGATIONS ON CIGUATERA-LIKE BIOTOXINS IN SHELLFISH ...Algal Culture, Algal Toxins, Crustacea -non-specific, Gymnodinium, Mollusks -non-specific & Other, ...**5.0018**

Cell Cloning

EFFECT OF INDUST WASTES OF MEMPHIS & SHELBY COUNTY ON PRIMARY PLANKTONIC PRODUCERS ...Drainage, Industrial Wastes, Plankton (non-specific), Primary Productivity, Tennessee, ...**5.1134**

PLAQUING AND FLUORESCENT ANTIBODY METHODS FOR DETECTION AND IDENTIFICATION OF ENTEROVIRUSES ...Assay, Detection & Diagnosis, Enteroviruses of Animals, Pollutants-general, Waste Water Treatment-other, ...**5.0046**

Fungal Culture

COMPARATIVE BIOCHEMICAL AND MORPHOLOGICAL CHARACTERISTICS OF MARINE FUNGI FROM SHELLFISH ...Endoparasites -other, Histochemistry - Cytochem, Histology and Cytology, Marine Fungi (non-specific), Plant Taxonomy, ...6.0265

EFFECT OF ANTIBIOTICS ON FUNGUS PARASITES IN OYSTERS ...Antibiotics, Chemicals - Fungicides, Dermocystidium, Host Specificity, Oysters, ...5.1171

Invertebrate Cultures

ANNUAL PHYTOPLANKTON PRODUCTION IN PUGET SOUND WATERS ...Copepods, Phytoplankton, Puget Sound, Standing Crops, Tides, ...5.1256

ACUTE TOXICITY OF PESTICIDES TO FRESHWATER INVERTEBRATES - DEVELOPMENT OF A LABORATORY STREAM FOR REARING AND TESTING AQUATIC INVERTEBRATES ...Captive Rearing, Invertebrates -non-specific, Laboratory, Laboratory Animals, Pesticides -non-specific, ...6.0319

CULTURING AND PROPAGATION OF SELECTED INVERTEBRATES AND ASSOCIATED FOOD ORGANISMS ...Algal Culture, Chlorophyceae (non-specif.&ot), Chrysophyceae (non-specif.&ot), Cyanophyta (non-specific & Ot), Food Supply, ...5.0591

DEVELOPMENT OF CULTURE METHODS FOR ECOLOGICALLY IMPORTANT MARINE ZOOPLANKTON SPECIES ...Aquatic Ecology, Copepods, Environmental Physiology, Zooplankton, ...5.1096

Mixed Culture

BIOLOGICAL DEGRADATION OF WASTES UNDER PSYCHROPHILIC ENVIRONMENTS ...Bacterial Pollutant Sources, Biological, Low Temp. - But Above 32f, Polar, Water Bacteria, ...5.0036

OXYGEN TRANSFER IN CONCENTRATED MICROBIAL SYSTEMS ...Degradation, Microbial-bacterial, Model Studies, Oxygen, Physico - Chem - Metab, ...5.0801

THE AUTECOLOGY OF SOME BLUE-GREEN PLANKTON ALGAE ...Algal Culture, Cyanophyta (non-specific & Ot), Eutrophication, Nutrition Studies, Phytoplankton, ...5.0955

ALGAE DEGRADATION IN WATERWAYS ...Algal Culture, Algal Pollutant Sources, Cell Injury and Autolysis, Water Properties-general, ...5.0126

BIOLOGICAL ALGICIDES ...Algacides -non-specific, Algal Virus, Cell Injury and Autolysis, Endogenous Cpds -plants, ...5.0226

Culture Collections

STUDIES ON THE METHANOGENIC BACTERIA IN SLUDGE ...Acids, Digestion, Isolation From Nat. environ. , Methane Bacteria (non-specif.), ...5.0259

COLLECTION AND ESTABLISHMENT IN CULTURE OF SPECIES AND STRAINS OF MARINE PHYTOPLANKTON ORGANISMS ...Algal Culture, Marine Plants, Phytoplankton, Pollution-general, ...5.1063

Cumberland River

SIMULATED OPEN CHANNEL HYDRAULICS ...Mathematical Analysis, Model Studies, Numerical Analysis-other, Open Channel Flow, Tennessee, ...2.0983

Currents -water

THE RELATIONSHIP BETWEEN TURBIDITY CURRENTS AND FISH MOVEMENTS IN GARRISON RESERVOIR ...Nets, North Dakota, Reservoirs and Impoundments, Turbidity, Turbidity & Suspended Matter, ...5.0829

FACTORS AFFECTING THE MOVEMENTS OF WATER AND ORGANISMS WITHIN A REGULATED MULTIPURPOSE LAKE ...Bacterial Pollutant Sources, Boundary Layer Studies, Lakes, Sediments, Washington, ...2.1114

EUTROPHICATION OF SHELTERED BAYS IN A LARGE LAKE ...Bays, Chemical-general, Eutrophication, Freshwater Ecology, Utah, ...5.1188

A THREE DIMENSIONAL STUDY OF PARAMETERS RELATED TO THE CURRENT DISTRIBUTION IN LAKE ROOSEVELT ...Model Studies, Reservoirs and Impoundments, Stratification, Temperature, Water Quality-general, ...5.1245

A LIMNOLOGICAL STUDY OF LAKE PONTCHARTRAIN, LOUISIANA, IN THE SUMMER OF 1968 ...Chemical-general, Lakes, Louisiana, Physical-general, Water Sampling, ...5.0457

MIXING AND DISPERSION OF CONTAMINANTS IN RESERVOIRS ...Dispersion -water, Mixing, Reservoirs and Impoundments, Tracers-general, Velocity -water, ...5.1153

VERTICAL CURRENT STRUCTURE IN THE GREAT LAKES ...Buoys, Forecasting-prediction, Great Lakes-general, Model Studies, Wind-water Interaction, ...2.0632

FEASIBILITY OF RATING CURRENT METERS IN A VELOCITY FIELD ...Gaging, Mass, Model Studies, Velocity -water, ...7.0107

SALINITY INTRUSION AND RELATED PHENOMENA ...General Deposition, Mixing, Open Channel Flow, Saline Water Intrusion, Sediment Transport-general, ...2.0687

GREAT LAKES RESEARCH - CHARACTERISTICS OF LAKE WATER ...Chemical-general, Great Lakes-general, Ocean Meteorological Studies, Physical-general, Water Quality-general, ...2.0648

GREAT LAKES RESEARCH - HARBOR CURRENTS ...Great Lakes-general, Harbors, Model Studies, Pressure-density, Water Level Fluctuation, Wind-general, ...2.0642

LIMNOLOGICAL FEATURES LAKE SHARPE IN RELATION TO COLD-WATER FISHES ...Fish -non-specific, Low Temp. -but Above 32f, Reservoirs and Impoundments, South Dakota, Temperature, ...6.0517

PHYSICAL LIMNOLOGY OF THE GREAT LAKES ...Environmental Ecology, Fish -non-specific, Temperature, ...5.0541

ECOLOGY OF GREAT LAKES ESTUARIES ...Bays, Estuaries, ...2.0626

Cyclopropane

PHYTOCHEMISTRY OF NARCOTIC PRINCIPLES IN CAULERPA ...Biochemical, Biochemical Analysis, Caulerpa, Medicinal Plants, Phaeophyta (non-specific & Ot), ...6.0172

Dairy Husbandry

Management

WATER POLLUTION BY DAIRY FARM WASTES AS RELATED TO METHOD OF WASTE DISPOSAL ...Alabama, Animal Waste Removal-treatment, Bacterial Pollutant Sources, Chemical Oxygen Demand, Farm Wastes, Sewage Lagoons, Waste Disposal-general, ...5.0011

FEED AND WASTE HANDLING IN THE DAIRY OPERATION ...Animal Waste Removal-treatment, Animal Wastes - Feed Lots, Pennsylvania, Sprinkler Irrigation, ...5.1023

Dam Sites

EXTREME RAINFALL FOR THE MEKONG RIVER BASIN ...Floods, Management, Meteorological Extremes, Southeast Asia, Water Loss Control, ...2.0596

Data Acquisition

LAKE EFFECT SNOW SITUATIONS, EASTERN LAKE ONTARIO AREA ...Atmospheric Pressure, General Synoptic Observations, Lake Ontario, Topographic Influences, ...7.0084

OCEANOGRAPHIC DATA COLLECTION - MIDDLE PUGET SOUND ...Oysters, Puget Sound, Salinity, Temperature, Trace Elements, ...7.0112

Automatic Data Aquisition

GREAT LAKES RESEARCH - MONITORING OF WATER CHARACTERISTICS ...Forecasting-prediction, Geophysical Analysis, Great Lakes-general, Temperature, ...2.0647

TELEMETERING OF HYDROLOGIC DATA FROM REMOTE AREAS ...Data Transmission Systems, Mountains-alpine, Other Telemetry, Remote Areas, Technique Development, ...7.0026

A STUDY OF THE OPEN WATER DISTRIBUTION AND ABUNDANCE OF NET-PLANKTON AS AN INDEX OF EUTROPHICATION IN LAKE SUPERIOR ...Bioindicators, Lake Superior, Plankton Sampling, Water Quality-general, Zooplankton, ...5.0600

DIGITAL INSTRUMENTATION AND TELEMETRY FOR WATER RESOURCES RESEARCH ...Digital Computers, Electronics - Applied, ...7.0072

HYDROLOGIC ANALYSIS OF THE NORTH FORK OF ELK CREEK ...Discharge-general, Montana, Observation Wells, Water Table Fluctuation, ...2.0714

DIGITAL SYSTEMS FOR ON-SITE DATA COLLECTION FOR WATER QUALITY ANALYSIS ...Data Networks, Digital Computers, Technique Development, Water Quality-general, ...**7.0005**

THERMAL AND INDUSTRIAL POLLUTION - DELAWARE RIVER ...Delaware River, Electric Power Plants, Industrial Wastes, Physical Parameters, Pulp, Paper , and Logging, Thermal Pollution, ...**5.0989**

TO EVALUATE THE UTILITY OF EXISTING AUTOMATIC CHEMICAL ANALYSIS EQUIPMENT FOR WATER QUALITY SURVEILLANCE UNDER COMPUTER CONTROL ...Atomic Absorption, Chemical Analysis (water), Computers-general, Information Retrieval Methods, Information Storage and File, System Development, Water Properties-general, ...**7.0078**

WATER QUALITY TELEMETRY ...Benefit-cost Analysis, Instrumental Services, Other Telemetry, Water Quality-general, ...**5.1197**

SYSTEM MONITORING AND REMOTE CONTROL ...Effluents-waste Water, Gages, Instrumental Services, Other Telemetry, Physical Parameters, ...**5.0559**

AUTOMATION OF GROUND-WATER RECORDS ...Computers-general, Groundwater, Information Retrieval Methods, Other Storage, ...**7.0046**

SEDIMENTATION METER ...Gaging, Rate of Deposition, ...**7.0104**

IMPROVE COMPONENTS OF THE DATA ACQUISITION SYSTEM - SATELLITE COMMUNICATIONS EQUIPMENT ...Data Acquisition Systems, Instrumental Services, Rain-general, Satellites & Deep Space Probes, Streams, ...**7.0050**

DEVELOP PROTOTYPE PRECIPITATION OCCURRENCE SENSOR - DEVELOP AMOS III-70 (AUTOMATIC WEATHER STATION) ...Automatic Stations, Precipitation Instruments, Precipitation-other, Technique Development, ...**7.0053**

TEST AND EVALUATION OF TELEMETERING STORAGE PRECIPITATION GAGE ...Amount, Automatic Stations, Gages, Technique Development, ...**7.0048**

IMPROVE PRECIPITATION MEASURING EQUIPMENT - D-III PRECIPITATION EQUIPMENT ...Amount, Automatic Stations, Gages, Technique Development, ...**2.0591**

AUTOMATIC VHF RADIO HYDROLOGIC DATA REPORTING SYSTEM ...Data Transmission Systems, General Synoptic Observations, Hydrology-general, Radio, Very High Frequency, ...**7.0096**

GREAT LAKES RESEARCH - MONITORING OF WATER CHARACTERISTICS ...Forecasting-prediction, Geophysical Analysis, Great Lakes-general, Instrumentation-general, Temperature, ...**2.0649**

INSTRUMENTATION, DATA ACQUISITION, AND COMPUTER TECHNIQUES ...Analog Computers, Data Analysis Applications, Digital Computers, Hydraulics-general, ...**7.0019**

DEVELOPMENT OF AUTOMATED ANALYSES FOR THE SUPPORT OF ADVANCED WASTE TREATMENT RESEARCH PROJECTS ...Chemical Analysis (water), Instrumentation-general, Waste Water Treatment-general, ...**5.0863**

DESIGN CRITERIA FOR LIVESTOCK FARMSTEAD WATER SYSTEMS ...Design Criteria, Storage of Water, Water Demand, Water Transfer, Water Utilization -animal, ...**6.0257**

Data Acquisition-general

THERMAL POLLUTION AND ITS IMPLICATIONS FOR THE COAL INDUSTRY-A SURVEY OF THE STATE OF KNOWLEDGE ...Electric Power Plants, Pollution - Effects of , Survey Studies, Thermal Pollution, ...**5.0208**

RUNOFF STUDIES ON SMALL DRAINAGE AREAS ...Discharge-general, Drainage, Peak Flow, Small Watersheds, West Virginia, ...**2.0290**

HYDROLOGY RESEARCH PROJECT ...Data Analysis - General, Drainage, Hydrology-general, Small Watersheds, Structural, ...**2.0281**

COLLECTION OF HYDROLOGIC DATA OF SMALL DRAINAGE AREAS ...Drainage, Maryland, Runoff, Small Watersheds, Storm Water, ...**2.0560**

VERIFICATION OF HYDRAULIC DESIGN OF BRIDGES IN ALABAMA ...Alabama, Bridges & Culverts, Drainage, Engineering Structures-general, Floods, ...**8.0001**

HYDROLOGIC STUDIES ...Floods, Small Watersheds, Virginia, ...**2.0299**

COMPILATION OF WATER QUALITY DATA ...Aquatic Ecology, Basses -sea,white, White Perch, Data Analysis - General, Lakes, Water Quality-general, ...**5.0459**

RESTORATION AND REHABILITATION OF EARTHQUAKE DAMAGED PINK AND CHUM SALMON STUDIES IN PRINCE WILLIAM SOUND ...Alaska, Aquatic Ecology, Earthquakes, Flow Characteristics -water, Salmon -coho,chinook,sockeye.., Spawn Or Nesting Sites, Stream Rehabilitation, Tectonics-general, ...**2.0026**

VERMILION - CALCASIEU - SABINE SYSTEM ...Aquatic Ecology, Louisiana, Nets, Number Or Density, Plankton Sampling, ...**2.0546**

TIMBALIER - TERREBONNE BAYS SYSTEM ...Aquatic Ecology, Louisiana, Nets, Number Or Density, Plankton Sampling, ...**2.0547**

WATER RESOURCES PLANNING STUDIES - OKLAHOMA AND ARKANSAS ...Arkansas River, Federal Government, Planning, State-local Government, Storage of Water, ...**6.0445**

METHODOLOGY FOR INTEGRATING WATER QUALITY MANAGEMENT WITH THE MANAGEMENT OF THE TOTAL WATER RESOURCES IN MINNESOTA ...Management, Minnesota, Technique Development, Water Quality Control-general, ...**5.0605**

A CLASSIFICATION OF THE LAKES OF THE STATE OF OREGON ...Lakes, Oregon, Survey Studies, Water Properties-general, ...**2.0891**

SYSTEMATIC STUDY AND DEVELOPMENT OF LONG-RANGE PROGRAMS OF URBAN WATER RESOURCES RESEARCH ...Economics-general, Projections and Estimations, Social Aspects, Systems Analysis, Urban Environments, Water Law-general, ...**6.0392**

EVALUATION OF GROUNDWATER RESOURCES, LIVERMORE VALLEY, CALIFORNIA ...Groundwater Basins, Management, Model Studies, Subsurface Flow, Water Yield, ...**4.0025**

APPLICATION OF AERIAL PHOTOGRAPHS FOR THE INVESTIGATION OF THE DISCHARGE PROPERTIES OF DRAINAGE BASINS ...Aerial, Discharge-general, Photogrammetry, River Basins, Water Yield, ...**2.0792**

RESEARCH ON DATA AND ANALYTICAL SYSTEMS FOR PREPARING NATIONAL WATER ASSESSMENTS ...Data & Statistics Info Storage, Model Studies, Statistics-general, Water Quality-general, Water Quantity-general, ...**6.0397**

DATA COLLECTION ECONOMICS FOR WATER POLLUTION STUDIES ...Economic Efficiency, Operations Research, Water Quality Control-general, ...**7.0055**

EUTROPHICATION OF NATURAL WATERS ...Eutrophication, Forecasting-prediction, Lakes, Plant Succession, Water Quality Control-general, ...**5.1314**

A PILOT-SCALE STUDY OF ACID MINE DRAINAGE ...Acidity, Mining Industry, Pollution Abatement, Systems Analysis, ...**5.0881**

WATER POLLUTION STUDY OF THE WABASH RIVER ...Indiana, Low Flow, Model Studies, Oxygen, Water Quality-general, ...**5.0390**

ENVIRONMENTAL GEOLOGY STUDY OF DALLAS-FT. WORTH METROPOLITAN REGION ...Geology - Engineering, Groundwater, Shallow, Texas, Urban Environments, ...**7.0098**

AERIAL MEASUREMENT OF HYDROLOGIC PHENOMENA ...Aerial, Geophysical Analysis, Humidity Instruments, Hydrology-general, Infrared Radiation, ...**7.0003**

LOW-FLOW STUDY - WISCONSIN ...Baseflow, Flow Characteristics -water, Low Flow, Wisconsin, ...**2.1147**

TIDAL DISCHARGE RESEARCH, NEW JERSEY ...Discharge-general, Other Data Analysis, Sediments, Tides, Water Quality-general, ...**2.0769**

USE OF WATER ON FEDERAL IRRIGATION PROJECTS ...Irrigation-general, Moisture Content, Rio Grande River, Water Table Fluctuation, ...**6.0538**

SKYWATER ...Colorado, Gaging, Streams, ...**2.0190**

EFFECT OF RECLAMATION PROJECTS UPON THE QUALITY OF WATER OF THE MISSOURI RIVER ABOVE SIOUX CITY, IOWA ...Missouri River, River Basins, Water Quality-general, ...**5.0191**

INVENTORY OF THE GULF ESTUARY SYSTEM ...Bays, Estuaries, Fishing, Gulf of Mexico, Sedimentology-general, ...**2.0322**

ROUTINE SAMPLING AT SEVEN INDEX STATIONS ...Bottom Sampling, Fish -non-specific, Lake Erie, Plankton Sampling, Water Sampling, ...**6.0438**

Data Acquisition-other

HYDROLOGICAL DATA ACQUISITION THROUGH REMOTE RECONNAISSANCE SYSTEMS ...Aerial, Hydrology-general, Infrared Radiation, Mapping, Moisture Content, Reflectance, ...**7.0075**

Data Networks

UTAH ATMOSPHERIC WATER RESOURCES (THE WASATCH WEATHER MODIFICATION PROJECT) ...Automatic Stations, Clouds-precipitation, Gages, Patterns, Utah, ...**2.1074**

DIGITAL SYSTEMS FOR ON-SITE DATA COLLECTION FOR WATER QUALITY ANALYSIS ...Automatic Data Aquisition, Digital Computers, Technique Development, Water Quality-general, ...**7.0005**

CLIMATIC PATTERNS IN WASHINGTON STATE ...Climate, Data Analysis Applications, Evaporation, Forecasting, Patterns, ...**2.1122**

TEMPERATURE PREDICTION STUDIES RELATING TO THE DEVELOPMENT OF A POWER REACTOR SITE ON THE LOWER COLUMBIA RIVER ...Atomic Plants, Columbia River, Construction Sites, Dispersion -water, Thermal Pollution, ...**8.0303**

HYDROLOGIC MEASUREMENT SYSTEMS ...Amount, Error Analysis, Gages, Hydrology-general, Instrumentation-general, Rain-general, Technique Development, Urban Environments, ...**7.0056**

SOUTHERN ILLINOIS REGIONAL ECONOMIC DATA SYSTEM ...Economics-general, Illinois, Impact, Industrial-general, Regional Areas, ...**7.0030**

GROUND WATER TABLE FLUCTUATIONS ...Observation Wells, Other Data Analysis, Water Table Fluctuation, ...**4.0062**

DENSE RAINGAGE NETWORK PROJECTS ...Climatography, Gages, Modification, Storms-general, Weather Modification-general, ...**2.0424**

HYDROLOGIC RELATIONS IN HAWAII ...Amount, Floodproofing, Hawaii, Hydrology-general, Runoff, ...**2.0365**

VALUE OF STREAMFLOW DATA ...Benefit-cost Analysis, Gaging, Open Channel Flow, Unsteady Flow, Water Resources Development, ...**6.0077**

FLOOD INUNDATION MAPPING, NORTHEASTERN ILLINOIS ...Atlases-maps, Discharge-general, Floods, Gaging, Illinois, ...**4.0093**

Data Analysis - General

HYDROLOGY RESEARCH PROJECT ...Data Acquisition-general, Drainage, Hydrology-general, Small Watersheds, Structural, ...**2.0281**

SMALL STREAMS INVESTIGATIONS IN OREGON ...Discharge-general, Floods, Gaging, Hydrographs, Peak Flow, ...**2.0293**

DOUBTFUL HYDROGRAPHIC DATA ...Aircraft, Hydrology-general, Satellites, Technique Development, ...**6.0278**

DOCTORAL DISSERTATION RESEARCH IN GEOGRAPHY ...General Synoptic Observations, Geography-physical, Humidity, Ohio River, Water Balance-budget, ...**3.0392**

RAINFALL EVALUATION STUDIES ...Gages, Modification, Patterns, Sampling-general, Weather Modification-general, ...**3.0219**

GLACIOLOGY AND METEOROLOGY OF ANVERS ISLAND, ANTARCTICA ...Antarctica, Geologic Maps, Intensity, Movement, Thickness - Area, ...**2.0856**

PESTICIDE RESIDUE DATA PROCESSING ...Chemical Analysis, Document & Literature Info, Information Retrieval Methods, Persistance of Residues, Pesticides -non-specific, ...**5.0147**

CHEMICAL TREATMENT OF NEBISH LAKE ...Aquatic Ecology, Chemical Treatment-general, Control of Nuisance Species, Lakes, Stocking of Fish & Shellfish, ...**5.1293**

COMPILATION OF WATER QUALITY DATA ...Aquatic Ecology, Basses -sea,white, White Perch, Data Acquisition-general, Lakes, Water Quality-general, ...**5.0459**

AN EVALUATION OF RECENT APPROACHES FOR THE DESIGN OF BIOLOGICAL WASTES TREATMENT ...Biological Treatment-general, Pilot Plant, Process Design, Waste Water Treatment-general, ...**5.0928**

THE MANAGEMENT AND CONTROL OF WATER IN PUERTO RICO ...Control and Protection, Management, Puerto Rico, Types of Resources, Water Quality-general, Water Supply-general, ...**6.0480**

WATERSHED ANALYSIS RELATING TO EUTROPHICATION OF LAKE MICHIGAN ...Economics-general, Eutrophication, Great Lakes-general, Michigan, Social Aspects, ...**6.0302**

BIOLOGICAL PRODUCTIVITY OF THE COEUR D'ALENE RIVER AS RELATED TO WATER QUALITY ...Idaho, Primary Productivity, Productivity - Food Chain, Streams, Water Quality-general, ...**5.0326**

ASSEMBLY AND ANALYSIS OF HYDROLOGIC AND GEOMORPHOLOGIC DATA FOR SMALL WATERSHEDS IN INDIANA ...Geomorphology-general, Hydrographs, Indiana, Small Watersheds, Streams, ...**2.0459**

A GENERALIZED COMPUTER LANGUAGE FOR HYDROLOGIC AND HYDRAULIC ANALYSIS ...Digital Computers, Facilities, Hydraulic Engineering-other, Problem Oriented Languages, ...**8.0213**

COMPUTER ANALYSIS OF WATERSHED CHARACTERISTICS AFFECTING FLOOD HYDROLOGY ...Economic Efficiency, Floods, Research - Development, Small Watersheds, Water Loss Control, ...**2.0523**

PRECIPITATION AND RUNOFF DISTRIBUTIONS - ANALYSIS AND COMPARISONS ...Discharge-general, Forecasting-prediction, Other Probability, Patterns, Runoff, ...**2.0739**

DELAWARE ESTUARY AND BAY WATER QUALITY SAMPLING AND MATHEMATICAL MODELING PROJECT ...Delaware Bay, Mathematical Analysis, Model Studies, Pollution Abatement, Technique Development, ...**5.0749**

MATHEMATICAL AND COMPUTER SERVICES FOR THE ANALYSIS OF DATA AND DESIGN OF EXPERIMENTS FOR CERTAIN FWPCA PROGRAMS ...Computers-general, Facilities, Instrumental Services, Oregon, ...**5.0934**

CLIMATIC PATTERNS AND THEIR EFFECT ON CALIFORNIA AGRICULTURE ...Agriculture, Applied Climatology, California, Phenology, Production & Processing, Temperature, Weather, ...**2.0095**

EVALUATION OF CLIMATIC PATTERNS AFFECTING IDAHO AGRICULTURE ...Agricultural Watersheds, Applied Climatology, Evaporation, Forecasting, Idaho, Meteorological Averages, Patterns, ...**2.0396**

RAINFALL OVER MISSOURI ...Gages, Geography-physical, Modification, Patterns, Topographic Influences, ...**2.0694**

WEATHER INFORMATION FOR AGRICULTURE ...Climate-general, Evapotranspiration, General Synoptic Observations, Soil Physical Properties, ...**4.0190**

DATA REDUCTION METHODS FOR STREAMFLOW FROM SMALL, WILDLAND WATERSHEDS ...Computers-general, Discharge-general, Gaging, Integration, Quadrature, Small Watersheds, Utah, ...**2.1068**

RESEARCH ON CHARACTERISTICS OF CONVECTIVE CLOUDS IN TEXAS ...Aircraft, Cloud Physics, Cumulus, Model Studies, Texas, ...**2.1023**

REGIONAL CORRELATIONS IN HYDROLOGIC VARIABLES ...Annual, Correlation, Evaporation, Patterns, Runoff, ...**7.0097**

PILOT-STUDY OF SMALL WATERSHED HYDROLOGY ...Floods, Instrumentation-general, Mathematical Analysis, Rain-general, Runoff, Small Watersheds, ...**2.0379**

LAND FORMING FOR DRAINAGE AND FURROW IRRIGATION ...Drainage, Furrow Irrigation, Irrigation, Irrigation Engineering, Pumping, ...**5.1131**

CASCADES ATMOSPHERIC WATER RESOURCES PROGRAM ...Augmentation-general, Cascade Mountains, Clouds-precipitation, Formation, Washington, ...**2.1128**

STATE WATER PLANNING FOR WYOMING ...Planning, State-local Government, Water Supply-general, Wyoming, ...**6.0653**

DEVELOPMENT OF HYDROLOGIC ANALYSIS TECHNIQUES ...Computers-general, Hydrology-general, Land Use, Model Studies, Technique Development, ...**2.0988**

GREAT LAKES RESEARCH - ENERGY TRANSFER AT THE AIR-WATER INTERFACE ...Heat and Radiation Transfer, Heat-transfer-other, Lake Michigan, Mass Transfer, Towers, Wind-water Interaction, ...**2.0639**

STUDY OF TUNNEL LININGS AND REINFORCEMENT ...Channel Type-other, Lining, Linings-pavings, Reinforced, ...**8.0104**

EXPERIMENTAL DESIGN & STATISTICAL EVALUATION OF WEATHER MODIFICATION EXPERIMENTS ...Computers-general, Data Analysis Applications, Statistics-general, Technique Development, Weather Modification-general, ...**2.0198**

EVALUATION OF ESTUARINE DATA ...Current Research Projects Info, Estuaries, Gulf of Mexico, ...**2.1047**

Data Reduction and Analysis

Data Analysis Applications

STATISTICAL, METEOROLOGICAL AND DEPTH-AREA ANALYSIS OF RAINFALL ...Forecasting, Hydrology-general, Middle-east-general, Patterns, ...**2.0492**

STATISTICAL ANALYSES OF THE VARIATIONS OF PRECIPITATION-TEMPERATURE AND EVAPORATION IN TEXAS ...Evaporation, Patterns, Temperature, Texas, ...**2.1027**

CLIMATIC PATTERNS IN WASHINGTON STATE ...Climate, Data Networks, Evaporation, Forecasting, Patterns, ...**2.1122**

THE CHARACTERIZATION OF OVERLAND FLOW ON VERY ROUGH SURFACES ...Channel Roughness, Channels, Flow Characteristics uwater, Model Studies, Surface Flow, ...8.0192

STATISTICAL ANALYSIS OF FLOOD PEAKS OF GEORGIA RIVERS ...Digital Computers, Discharge-general, Floods, Georgia, Peak Flow, ...2.0357

STATISTICAL ANALYSIS OF WATER CONSUMPTION ...Consumptive Use, Illinois, Urban Environments, Water Sources - general, Water Utilization -general, ...7.0037

PERMEABILITY OF UNCONSOLIDATED AQUIFER MATERIALS ...Aquifers-general, Hydrology-general, Permeability, Unconsolidated Aquifers, Valleys and Canyons, ...7.0038

RAINFALL EVALUATION STUDIES ...Gages, General Synoptic Observations, Modification, Patterns, Storms-general, ...2.0416

SUBSYNOPTIC WEATHER SPECIFICATION ...Cloud Cover, Dew, Micrometeorology, Model Studies, Temperature, Weather Forecasting, ...2.0592

INSTRUMENTATION, DATA ACQUISITION, AND COMPUTER TECHNIQUES ...Analog Computers, Automatic Data Aquisition, Digital Computers, Hydraulics-general, ...7.0019

EXPERIMENTAL DESIGN & STATISTICAL EVALUATION OF WEATHER MODIFICATION EXPERIMENTS ...Computers-general, Data Analysis - General, Statistics-general, Technique Development, Weather Modification-general, ...2.0198

Other Data Analysis

OPERATIONAL HYDROMETEOROLOGICAL DATA MANAGEMENT SYSTEM ...Data Processing Services, Economics-business-management, Information Retrieval Methods, Management-general, Southern, Streams, System Development, ...7.0011

SEQUENTIAL USE WITHIN A HYDROLOGIC COMPLEX ...Hydrology-general, Management, Model Studies, Systems Analysis, Water Quality-general, ...5.1189

GROUND WATER TABLE FLUCTUATIONS ...Data Networks, Observation Wells, Water Table Fluctuation, ...4.0062

TIDAL DISCHARGE RESEARCH, NEW JERSEY ...Data Acquisition-general, Discharge-general, Sediments, Tides, Water Quality-general, ...2.0769

System Development

OPERATIONAL HYDROMETEOROLOGICAL DATA MANAGEMENT SYSTEM ...Data Processing Services, Economics-business-management, Information Retrieval Methods, Management-general, Other Data Analysis, Southern, Streams, ...7.0011

TO EVALUATE THE UTILITY OF EXISTING AUTOMATIC CHEMICAL ANALYSIS EQUIPMENT FOR WATER QUALITY SURVEILLANCE UNDER COMPUTER CONTROL ...Atomic Absorption, Automatic Data Aquisition, Chemical Analysis (water), Computers-general, Information Retrieval Methods, Information Storage and File, Water Properties-general, ...7.0078

WAVE RECORDING AND ANALYSIS ...Lasers-masers, Pressure, Radar, Sonar, Statistics-general, Water Motion Recorders, Waves, ...2.0262

Decision Making

THE DECISION SEQUENCE IN WATER RESOURCE PLANNING ...Decision Theory, Operations Research, Planning, ...6.0069

AN EXPLORATION OF THE INFLUENCE OF ATTITUDES FOR DECISION-MAKING IN WATER MANAGEMENT ...Attitudes & Attitude Change, Floods, Management, ...6.0187

Defects

Surface

FORMING, FINISHING, AND CURING CONCRETE ...Casting of Materials, Cement, Concrete, Setting, Curing, Surface Cleaning, Finishing, ...8.0257

Delaware

FLUSHING PATTERN OF CERTAIN TIDAL STREAMS IN DELAWARE ...Aquatic Ecology, Circulation -water, Discharge-general, Industrial-general, Tidal Streams, ...2.0250

THE GROUND-WATER FLOW SYSTEM IN THE DELMARVA PENINSULA ...Aquifers-general, Flow Characteristics -water, Groundwater, Model Studies, Water Balance-budget, ...2.0254

CLIMATE OF THE NORTHEAST - ANALYSES & RELATIONSHIP TO PLANT RESPONSE (NE-35 ...Aerial, Beans (garden), Climate-general, Envir. responses (non-specific, General Synoptic Observations, ...2.0251

ECOLOGICAL STUDIES OF WILDLIFE MANAGEMENT PRACTICES ...Depth,water Level, Fluctuation, Habitat Studies, Management, Swamps-marshes, Wildlife -non-specific, ...6.0119

REMOTE SENSING OF DELAWARE ESTUARY ...Aircraft, Estuaries, Pollutants-general, ...2.0909

Delaware Bay

DELAWARE ESTUARY AND BAY WATER QUALITY SAMPLING AND MATHEMATICAL MODELING PROJECT ...Data Analysis - General, Mathematical Analysis, Model Studies, Pollution Abatement, Technique Development, ...5.0749

ECONOMICS OF WATER QUALITY IN A REGIONAL SYSTEM ...Alternative Planning, Benefit-cost Analysis, Estuaries, Management, Water Quality-general, ...5.1011

Delaware River

THE ECONOMICS OF WATER SUPPLY AND QUALITY ...Benefit-cost Analysis, Flow Augmentation, Model Studies, Pollution Abatement, Urban Environments, Water Allocation, ...6.0286

ECONOMICS OF WATER QUALITY FOR A REGIONAL SYSTEM ...Economic Efficiency, Estuaries, Finance, Regional Areas, Water Demand, Water Quality-general, ...6.0465

THERMAL AND INDUSTRIAL POLLUTION - DELAWARE RIVER ...Automatic Data Aquisition, Electric Power Plants, Industrial Wastes, Physical Parameters, Pulp, Paper , and Logging, Thermal Pollution, ...5.0989

INTERSTATE REGIONAL PLANNING FOR WATER SUPPLY AND WASTE DISPOSAL ...Disposal-general, Interstate, Planning, Water Distribution Systems, Water Quality Control-general, Water Supply-general, ...5.0748

OXYGEN REGENERATION OF POLLUTED RIVERS ...Aeration, Economic Efficiency, Instrumentation-general, Oxygen, Pollution Abatement, Streams, ...5.0740

DELAWARE ESTUARY SEDIMENTATION STUDY ...Rate of Deposition, Sand Bars, Sediment Transport-general, Sediment Yield, Turbulent Flow, ...2.0908

Deltas

ENGINEERING PHASES OF SURFACE DRAINAGE ...Drainage, Drainage Engineering, Drainage Systems, ...4.0019

LAKE ERIE ENVIRONMENTAL STUDIES PROGRAM ...Biological, Biological-general, Chemical, Chemical-general, Eutrophication, Lake Erie, Meteorological Studies-general, Monitoring (long Term Studies), Physical-general, Sedimentology-general, ...2.0783

SACRAMENTO-SAN JOAQUIN DELTA ANALOG MODEL STUDIES ...Analog Computers, Electronics - Applied, Instrumental Services, Model Studies, Sacramento River, ...7.0008

Deposits - Non-metallic

Aggregrates - Crushed Rock

POROSITY AND PERMEABILITY OF VIRGINIA AGGREGATES ...Nitrogen, Permeability, Porosity, Virginia, ...2.1111

EVALUATION OF ROCK RIPRAP AND DEVELOPMENT OF SUBSTITUTES ...Engineering Structures-general, Erosion Control, Petrography, Slopes, Soil Cement, Wave Action, ...8.0081

Asphalt - Tar Sands

CHANGES IN PHYSICAL CHARACTERISTICS OF ASPHALT MATERIAL ...Aging, Bituminous, Cement, Concrete, Linings-pavings, Test Methods, ...8.0105

Brines - Saline Waters

SUBSURFACES BRINES CONTAINING VALUABLE AND STRATEGIC MINERALS ...Chemical-general, Geochemistry-general, Hardness-minerals, Potential of Deposit, ...7.0091

Coal

Bituminous

CHEMICAL CHARACTERISTICS OF WATERS IN FLOODED BITUMINOUS-COAL MINESHAFTS ...Acidity, Geochemical Analysis, Mine Drainage Control, Mine Hydrology, Pyrite Group, ...5.1279

Coal-general

COMBINED DESALINATION AND POWER-GENERATION BASED ON COAL ENERGY ...Cost Analysis, Desalination, Flash Distillation, Material Recovery, Reverse Osmosis, ...3.0325

SEWAGE TREATMENT, PILOT PLANT EVALUATION ...Ash-coal, Coal, Industrial Wastes, Pilot Plant, Waste Treatment-economics, ...5.0870

REMOVAL OF TRACE ORGANICS FROM WATER BY ADSORPTION ON COAL ...Activated Carbon, Adsorption, Isotherm, Organic, Waste Water Treatment-general, ...5.1209

HYDROLOGY AND WATER QUALITY OF SURFACE MINING FOR COAL IN PIKE COUNTY, INDIANA ...Hydrology-general, Indiana, Strip Mines, Water Quality-general, ...5.0384

PHYSICAL AND CHEMICAL CHANGES IN WEATHERING COAL SPOILS-EFFECT ON WATER SUPPLY AND PLANT GROWTH ...Growth Rate, Regeneration & Seed Production, Runoff, Soil and Rock Leaching, Spoil Banks, Spoil Banks, Strip Mine Soils, ...5.0903

ESTIMATING ACID MINE DRAINAGE POTENTIAL FROM COAL BEDS BY USE OF THE SOXHLET EXTRACTOR ...Acid Mine Wastes, Acidity, Extraction, Iron, Sulfate, Sulfite, ...5.0993

TREATMENT OF COAL MINE WATERS TO MEET CURRENT COMMONWEALTH WATER DISCHARGE REQUIREMENTS ...Lagoon, Mining Activities, Pennsylvania, Waste Treatment-economics, Waste Water Treatment-general, ...5.1038

COAL STRIP MINE WATERSHED STUDY ...Aquatic Ecology, Mining Activities, Pollution - Effects of , Soil Management -non-specific, Stream Rehabilitation, Strip Mines, ...2.0980

COAL STRIP MINE WATERSHED · DEMONSTRATION--JACKSON COUNTY, ALABAMA ...Alabama, Aquatic Ecology, Mining Industry, Pollution - Effects of , Water Quality-general, ...5.1124

HYDROLOGIC INFLUENCES OF STRIP MINING, BEAVER CREEK, KENTUCKY ...Appalachia, Hydrology-general, Mining Activities, Pollution - Effects of , Strip Mines, ...5.0890

WATER CONTROL - CONTROL TECHNIQUES FIELD TESTING AND EVALUATION ...Acidity, Chemical Analysis (water), Mine Drainage Control, Mining Activities, Pollution Abatement, ...5.1018

USE OF COAL AS ADSORBENT FOR TREATING WASTE WATER ...Adsorption-absorption-other, Anaerobic, Domestic, Material Recovery Wastes, Secondary Treatment, ...5.1017

REDUCTION IN DAMAGES TO FORESTS BY IMPROVING MINING AND REHABILITATION PROCEDURES ...Conservation & Management Eng, Forest Watersheds, Mining Industry, Site Index and Site Quality, Soils and Fertilizer, ...4.0120

Oil Shale

POLLUTANTS IN PRODUCT AND PROCESS WATERS FROM OIL-SHALE RETORTING OPERATIONS AND METHODS FOR THEIR REMOVAL ...Material Recovery Wastes, Mining Industry, Pollutants-general, Technique Development, Waste Water Treatment-general, ...5.1324

Water - Hot Water

GEOTHERMAL RESOURCES OF IDAHO ...Chemical-general, Hot Springs, Idaho, Survey Studies, Temperature, ...3.0206

Deserts

PRECIPITATION, STREAMFLOW AND SEDIMENT CONVEYANCE IN A SMALL ARID WATERSHED ...Climate, Flash Floods, Flow Characteristics -water, Patterns, Sediment Transport-other, ...2.0496

DISTRIBUTION OF DIATOMS IN DESERT WATERS ...Algae-Diatoms, Branchiopoda -other, Plant Prod. (non-specific), Playas, Respiratory System, ...2.0138

EVALUATION OF FIVE METHODS FOR SAMPLING DESERT AND WETLAND VEGETATION ...Arid and Desert, Colorado, Plant Ecology (non-specific), Utah, Wetlands, ...3.0471

ARID LAND ECOLOGY AND ENVIRONMENT STUDIES IV. WATER QUANTITY MANAGEMENT ...Arid and Desert, Big Horn, Deserts, Arid Lands, Moisture Content, Wyoming, ...4.0281

A UNIFIED APPROACH TO WATER, FOOD AND POWER IN A COASTAL DESERT COMMUNITY ...Arid and Desert, Desalination, Diesel, Distilling Units, Electric Power Plants, Greenhouse, Use of Impaired Water, ...3.0015

COOPERATIVE EVAPOTRANSPIRATION RESEARCH ...Climate, Evapotranspiration, Heat Exchange, Radiation-general, ...2.0136

RELATIONSHIP BETWEEN MOURNING DOVE PRODUCTION AND WATER DISTRIBUTION IN THE SONORAN DESERT ...Arizona, Dove, Habitat Studies, Productivity (agricultural), Water Utilization -animal, ...6.0262

Design Instrumentation

Design Instrumentation-other

DEVELOPMENT OF HYDROLOGIC EQUIPMENT ...Hydraulic Engineering-other, Hydrology-general, Instrumental Services, Instrumentation-general, Other Telemetry, ...7.0064

Dimension

Dimension-three

NUMERICAL ANALYSIS OF TIME-DEPENDENT FREE SURFACE FLOWS ...Capillarity, Finite Differences, Open Channel, Partial, Unsteady, ...2.0441

MODEL STUDIES OF MASS CONCRETE STRUCTURES ...Cement, Concrete, Mass, Model Studies, Stress Recorders, Technique Development, ...8.0227

Dimension-two

GROUND WATER DISPERSION DURING PUMPING AND RECHARGE OPERATIONS ...Approximations, Artificial Recharge, Dispersion -water, Finite Differences, Groundwater, Porous Media - Flow Through, Steady, ...5.0529

Math. model

SOIL HEAT TRANSFER - PERMAFROST AND FROST PENETRATION ...Computers-general, Heat Flow, Permafrost-frozen, Thermal Properties-other, ...2.0024

Measuring Devices

Fluids

RADIOISOTOPE WATER FLOW MEASUREMENT IN HIGH-HEAD TURBINES AND PUMPS ...Open Channel Flow, Pump-other, Radioisotopes, Technique Development, Turbine-other, ...4.0057

FLOW MEASUREMENT OF IRRIGATION WATER ...Canals, Flow Characteristics -water, Flume, Irrigation, Measurement, ...3.0144

HYDRAULIC INVESTIGATION OF TAINTER GATES AS FLOW MEASURING DEVICES ...Control Gate, Fluid Dynamics, Measurement, ...8.0167

WATER MEASUREMENT ...Discharge-general, Dyes and Coloring, Measurement, Technique Development, Water Quantity-general, ...8.0128

RADIOISOTOPE WATER FLOW MEASUREMENT IN HIGH-HEAD TURBINES AND PUMPS ...Open Channel Flow, Radioisotopes, Water, ...8.0065

Mass

DEVELOPMENT AND CALIBRATION OF A PITOT SPHERE ...Gaging, Hybrid Computers, Hybrid Computers, ...8.0193

FEASIBILITY OF RATING CURRENT METERS IN A VELOCITY FIELD ...Currents -water, Gaging, Model Studies, Velocity -water, ...7.0107

Moisture

DEVELOPMENT OF AUTOMATED SUBIRRIGATION SYSTEM ...Automated Equipment, Irrigation Engineering, Pipes, Plastics - General, Subsurface Irrigation, Water Distribution Systems, ...3.0024

PERFORMANCE OF CONSTRUCTION PLANT AND EQUIPMENT ...Concrete-general, Construction, Equipment, Machines, ...8.0251

Pressure

UNSTEADY FLOW PARAMETERS IN HYDRAULIC DESIGN ...Conduit, Incompressible, Reservoirs, Transition Sections, Unsteady, ...8.0200

PORE-PRESSURE MEASURING REFINEMENTS IN SOILS FOR SHEAR AND CONSOLIDATION ...Capillarity, Cohesive Soil-general, Pore Water, Technique Development, Triaxial, ...8.0080

DRILL PERFORMANCE MONITOR ...Borehole Geophysics, Drilling Operation, Foundations-general, Soil Exploration, Temperature, ...8.0097

Stress Recorders

MODEL STUDIES OF MASS CONCRETE STRUCTURES ...Cement, Concrete, Dimension-three, Mass, Model Studies, Technique Development, ...8.0227

DETERMINATION OF IN SITU STRESSES BY STRAIN-RELIEF METHOD ...Dams-other, Reinforced, ...8.0021

Temperature

SIMULTANEOUS RADIATION, CONVECTION AND CONDUCTION IN A TRANSPIRATION PROCESS ...Mixed Modes, Porous Media - Flow Through, Transpiration, ...2.1154

DRILL PERFORMANCE MONITOR ...Borehole Geophysics, Drilling Operation, Foundations-general, Pressure, Soil Exploration, ...8.0097

ELECTRICAL MACHINERY TEMPERATURE CONTROL ...Electric Power Plants, Motors and Appliances, Other Control Systems, Power Regulator, ...8.0125

Turbulence

TURBULENCE IN LIQUIDS ...Detectors and Sensors, Quartz, Turbulent, ...8.0187

INSTRUMENTATION FOR RESEARCH ...Doppler, Fluid Dynamics, Instrumental Services, Recording Systems, Velocity, ...7.0109

Velocity

INVESTIGATION OF THE TURBULENT TRANSPORT MECHANISMS FOR HEAT AND MOMENTUM TRANSFER IN PIPE FLOW ...Digital Computers, Heat-transfer-other, Statistics-general, Turbulent, ...5.0371

INSTRUMENTATION FOR RESEARCH ...Doppler, Fluid Dynamics, Instrumental Services, Recording Systems, Turbulence, ...7.0109

Requirement

SANITATION, WASTE DISPOSAL AND PEST AND VECTOR CONTROL ...Nuclear Explosion, Pollution - Effects of , Radioactive Fallout, Radiologic Warfare, Sewage, Urban Environments, ...5.0059

Simulators

DEVELOPMENT OF HYDRAULIC DESIGN CRITERIA ...Conduit, Design Criteria, Models, Spillways, Water Control Works-other, ...8.0226

HYDRAULIC PROTOTYPE TESTS ...Channel Regulation-other, Conduit, Models, Spillways, ...8.0228

Specifications

DURABILITY OF CONCRETE DRAIN TILE AND IRRIGATION PIPE ...Drainage, Pipes, Plain, Strength, Techniques, ...8.0221

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Techniques

COMPARISON OF EVAPORATION INSTRUMENTS ...Evaporation, Instrumentation-general, Tanks, ...2.0450

DURABILITY OF CONCRETE DRAIN TILE AND IRRIGATION PIPE ...Drainage, Pipes, Plain, Specifications, Strength, ...8.0221

Developmental Biology

Vertebrates

Basic Embryology

THE EFFECT OF DIELDRIN ON SURVIVAL AND DEVELOPMENT OF FISH EGGS ...Aldrin, Dieldrin, Mode of Action - animal, Ohio, Pollution - Effects of , ...5.0885

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WATERFOWL MANAGEMENT THROUGH WATER-LEVEL CONTROL ...Depth,water Level, Fluctuation, Management, Management -other, Water Fowl, N.s. , Wetlands, ...4.0133

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Drilling and Coring

EVALUATION BY TEST DRILLING OF GEOPHYSICAL PROSPECTING FOR GROUND WATER IN THE PIEDMONT AREA, ALABAMA ...Chemical Analysis (water), Geophysical Analysis, Groundwater, Pumping, Water Development, ...2.0006

GEOLOGY AND GROUND WATER RESOURCES OF TRAILL COUNTY ...Aquifers-general, Chemical-general, Groundwater, Permeability, Surficial Geology, ...2.0837

GEOLOGY AND GROUND WATER RESOURCES OF WELLS COUNTY ...Aquifers-general, Chemical-general, Groundwater, Permeability, Surficial Geology, ...2.0838

GEOLOGY AND GROUND WATER RESOURCES OF GRAND FORKS COUNTY ...Aquifers-general, Chemical-general, Groundwater, Permeability, Surficial Geology, ...2.0839

GEOLOGY AND GROUND WATER RESOURCES OF WILLIAMS COUNTY ...Aquifers-general, Chemical-general, Groundwater, Permeability, Surficial Geology, ...2.0840

GEOLOGY AND GROUND WATER RESOURCES OF BURKE COUNTY ...Aquifers-general, Chemical-general, Groundwater, Permeability, Surficial Geology, ...2.0842

WATER SUPPLY TECHNOLOGY - WATER QUALITY MANAGEMENT AND PROTECTION ...Demineralization, Groundwater, Reverse Osmosis, Water Reuse, ...5.1219

DEVELOPMENT OF NX BOREHOLE INSTRUMENT FOR DEFORMATION MODULUS ...Borehole Geophysics, Deformation, ...8.0047

RADIOISOTOPE GROUND WATER MEASUREMENTS IN SMALL DIAMETER DRILL HOLES ...Borehole Geophysics, Groundwater, Instrumentation-general, Radioisotopes, Technique Development, ...8.0066

Earth Electrical Properties

Applications

Porosity-permeability

FEASIBILITY STUDY OF ELECTRICAL GEOPHYSICAL METHODS IN THE DETERMINATION OF SUBSURFACE HYDROGEOLOGIC ENVIRONMENTS IN SOUTH CAROLINA ...Electric Logging, Electronics - Applied, Hydrology-general, Induction, Piedmont Province, Water Table Fluctuation, ...2.0950

EXPERIMENTAL INVESTIGATION OF HYDROLOGICAL PARAMETERS OF AQUIFERS THROUGH ELECTRICAL RESISTIVITY MEASUREMENTS ...Aquifers-general, Borehole Geophysics, Electric Logging, Hydrology-general, Other Models, ...7.0028

Exploration Methods

Electric Logging

DEVELOPMENT OF A PRACTICAL METHOD OF LOCATING AND TRACING SEEPAGE WATER IN UNSTABLE SLOPES ...Kentucky, Land and Rock Slides, Loss, Seepage, Slopes, ...2.0519

INDUCED ELECTRICAL POLARIZATION AND GROUND WATER ...Artificial Recharge, Geophysical Analysis, Groundwater, Groundwater Basins, Polarization, ...7.0007

GEOPHYSICAL INVESTIGATIONS IN ALLUVIAL BASINS IN SOUTHERN ARIZONA ...Arizona, Gravity Surveys, Hydrology-general, Seismic Refraction, ...**2.0062**

GEOPHYSICAL EXPLORATION FOR HAWAIIAN GROUND WATER - PHASE II ...Electromagnetic Probing, Geophysical Analysis, Groundwater, Hawaii, Seismic Surveys, ...**2.0371**

PHYSICAL CHARACTERISTICS OF BASALT AQUIFERS ...Flow Characteristics -water, Groundwater Movement, Local Structure, Porosity, Radioactivity Logging, ...**2.1117**

FEASIBILITY STUDY OF ELECTRICAL GEOPHYSICAL METHODS IN THE DETERMINATION OF SUBSURFACE HYDROGEOLOGIC ENVIRONMENTS IN SOUTH CAROLINA ...Electronics - Applied, Hydrology-general, Induction, Piedmont Province, Porosity-permeability, Water Table Fluctuation, ...**2.0950**

EVALUATION OF NEW TECHNIQUES IN ELECTRICAL RESISTIVITY SURVEYING IN THE PIEDMONT AREA, ALABAMA ...Alabama, Groundwater, Piedmont Province, Survey Studies, ...**2.0005**

GEOPHYSICAL EXPLORATION FOR HAWAIIAN GROUND WATER - PHASE III ...Geophysical Analysis, Groundwater, Hawaii, Seismic Surveys, Volcanoes, ...**2.0369**

INDUCTIVE ELECTROMAGNETIC METHODS FOR MAPPING AND EVALUATING AQUIFERS ...Aquifers-general, California, Geophysical Analysis, Groundwater, Mapping, ...**2.0083**

EXPERIMENTAL INVESTIGATION OF HYDROLOGICAL PARAMETERS OF AQUIFERS THROUGH ELECTRICAL RESISTIVITY MEASUREMENTS ...Aquifers-general, Borehole Geophysics, Hydrology-general, Other Models, Porosity-permeability, ...**7.0028**

ELECTRICAL EARTH RESISTIVITY SURVEYS ...Clastic Aquifers, Electrodes, Geophysical Analysis, Groundwater, Illinois, ...**7.0033**

Electromagnetic Probing

ADVANCE WARNING OF GROUND-WATER POLLUTION HAZARDS, WITH SPECIAL REFERENCE TO AQUIFERS IN GLACIAL OUTWASH ...Electrical, Groundwater, Outwash Plains, Physical Parameters, Unconsolidated Aquifers, ...**5.1235**

GEOPHYSICAL EXPLORATION FOR HAWAIIAN GROUND WATER - PHASE II ...Electric Logging, Geophysical Analysis, Groundwater, Hawaii, Seismic Surveys, ...**2.0371**

Field Characteristics

Induction

FEASIBILITY STUDY OF ELECTRICAL GEOPHYSICAL METHODS IN THE DETERMINATION OF SUBSURFACE HYDROGEOLOGIC ENVIRONMENTS IN SOUTH CAROLINA ...Electric Logging, Electronics - Applied, Hydrology-general, Piedmont Province, Porosity-permeability, Water Table Fluctuation, ...**2.0950**

Polarization

INDUCED ELECTRICAL POLARIZATION AND GROUND WATER ...Artificial Recharge, Electric Logging, Geophysical Analysis, Groundwater, Groundwater Basins, ...**7.0007**

Earth Magnetism

Exploration Methods

Aeromagnetic

COORDINATION AND LIAISON AT MANNED SPACECRAFT CENTER, HOUSTON ...Aircraft, Geography-physical, Hydrology-general, Infrared Radiation, Ultra - Violet Radiation, ...**6.0146**

Magnetic Surveys

GEOTHERMAL INVESTIGATIONS - YELLOWSTONE PARK ...Gravity Surveys, Hot Springs, Satellites, Seismic Surveys, Terrain Analysis, Yellowstone Plateau, ...**6.0147**

Earth Structures

Cuts

STABILIZATION OF SLOPES ...Bituminous, Clay, Embankments, Slopes, Soil Stabilization, ...**8.0069**

Dams

THE EFFECT OF HIGH CONFINING PRESSURE ON THE DEFORMATION OF SOIL ...Deformation, Earth & Rockfill Dams, Foundations-general, Pressure-other, Shear Strength, ...**8.0013**

LIQUEFACTION STUDIES OF UKAI DAM SAND ...Earthquakes, India, Sand, Soil Dynamics, Soil Liquefaction, ...**8.0186**

WATER QUALITY MONITORING STUDIES ...Aquatic Ecology, Chemical-general, Land Use, Monitoring Systems, Survey Studies, Water Quality-general, ...**6.0639**

INSTRUMENTATION IN EMBANKMENTS AND FOUNDATIONS ...Embankments, Foundations-general, Handbooks, Techniques & Instrumentation, ...**7.0062**

COMPILATION OF EARTH DAM CRITERIA FOR DESIGN USE ...Abstracts, Design Criteria, Earth & Rockfill Dams, Engineering Structures-general, ...**8.0254**

EARTH AND ROCKFILL DAM DESIGN PRACTICES ...Design Criteria, Earth & Rockfill Dams, Earthquakes, Engineering Structures-general, Soil Stability Analysis, ...**8.0137**

GENERAL ROCK MECHANICS INVESTIGATIONS ...Deep, Rock Mechanics, ...**8.0102**

STABILITY OF EARTH SLOPES ...Earthquakes, Open Channel, Pore Water, Slopes, Soil Stability Analysis, ...**8.0071**

VIBRATORY COMPACTION OF COHESIVE SOILS ...Cohesive Soil-general, Compaction, Embankments, Field Soils Compaction, Soil Dynamics, ...**8.0135**

Embankments

SHEAR CHARACTERISTICS OF UNDISTURBED WEAK CLAY ...Clay, Deformation, Disturbed/undisturbed, Pore Water, Shear Strength, ...**8.0006**

EMBANKMENT AND FOUNDATION MOVEMENTS ON THE INSTRUMENTED SECTIONS OF THE EAST ATCHAFALAYA BASIN PROTECTION LEVEE, ST. MARTIN PARISH, LOUISIANA ...Engineering Properties, Soil Settlements, Soil Stability Analysis, Soil Tests, ...**8.0212**

TEMPORARY LININGS FOR WATERWAYS AND EMBANKMENTS ...Cover Crops, Design Criteria, Erosion Control, Florida, Hydrology-general, Lining, ...**3.0178**

OBSERVATION AND EVALUATION OF INSTRUMENTATION IN THE FOUNDATION AND EMBANKMENT OF MORAINE STATE PARK DAM ...Foundations-general, Piezometers, Soil Settlements, Soil Stability Analysis, Uplift, ...**8.0170**

INSTRUMENTATION IN EMBANKMENTS AND FOUNDATIONS ...Dams, Foundations-general, Handbooks, Techniques & Instrumentation, ...**7.0062**

ASPHALT BINDING OF COBBLES FOR RIPRAP ...Aggregates, Extenders, Fillers, Binders, Bituminous, Conglomerates, Erosion-general, Slopes, ...**8.0106**

STABILIZATION OF SLOPES ...Bituminous, Clay, Cuts, Slopes, Soil Stabilization, ...**8.0069**

VIBRATORY COMPACTION OF COHESIVE SOILS ...Cohesive Soil-general, Compaction, Dams, Field Soils Compaction, Soil Dynamics, ...**8.0135**

Filters

REVERSE FILTER EROSION PROTECTION ...Connecticut, Control and Protection, Engineering Structures-general, Erosion-general, Lining, ...**8.0147**

FACTORS INFLUENCING THE FLOW OF SUBSOIL WATER IN THE IMMEDIATE PROXIMITY OF AND INTO DRAINAGE FACILITIES ...Design Criteria, Drainage Systems, Other, Permeability, Seepage, ...**4.0200**

DRAINAGE SYSTEMS - PIPE AND FILTERS ...Drainage Engineering, Drainage Systems, Hydraulic Gradient, Pipelines, Pipes, ...**8.0018**

FILTER CRITERIA FOR DRAINS AND WATER WELLS ...Drainage, Filtration, Infiltration, Linings-pavings, Water Wells, ...**8.0083**

Slopes

DEVELOPMENT OF A PRACTICAL METHOD OF LOCATING AND TRACING SEEPAGE WATER IN UNSTABLE SLOPES ...Electric Logging, Kentucky, Land and Rock Slides, Loss, Seepage, ...**2.0519**

FLUCTUATION OF RESERVOIR LEVELS AND THE RELATED CAUSE OF LANDSLIDES (THE OHIO RIVER VALLEY) ...Force, Land and Rock Slides, Reservoirs and Impoundments, Soil Stability Analysis, Water Level Fluctuation, ...**8.0191**

SPECIAL STUDIES FOR CIVIL WORKS SOILS PROBLEMS ...Design Criteria, Earth & Rockfill Dams, Erosion Control, Field Soils Compaction, Wave Action, ...**8.0255**

EVALUATION OF ROCK RIPRAP AND DEVELOPMENT OF SUBSTITUTES ...Aggregrates - Crushed Rock, Engineering Structures-general, Erosion Control, Petrography, Soil Cement, Wave Action, ...**8.0081**

STABILITY OF EARTH SLOPES ...Dams, Earthquakes, Open Channel, Pore Water, Soil Stability Analysis, ...**8.0071**

ASPHALT BINDING OF COBBLES FOR RIPRAP ...Aggregates, Extenders, Fillers, Binders, Bituminous, Conglomerates, Embankments, Erosion-general, ...**8.0106**

STABILIZATION OF SLOPES ...Bituminous, Clay, Cuts, Embankments, Soil Stabilization, ...**8.0069**

PREVENTING OR CONTROLLING ACCELERATED EROSION OF UNSTABLE FOREST SOILS ...Erosion-general, Mountains-alpine, Movement, Availability, Open Channel, Soil Science - other, Soil Stability Analysis, ...**5.0316**

Earth Thermal Properties

Exploration Methods

Survey Studies

GEOTHERMAL RESOURCES OF IDAHO ...Chemical-general, Hot Springs, Idaho, Temperature, Water - Hot Water, ...**3.0206**

Geothermal Gradient

THERMAL GRADIENTS IN SOUTH CAROLINA ...Groundwater Movement, Heat Flows, Permeability, South Carolina, Temperature, ...**2.0964**

DETECTION OF SUBSURFACE CAVITIES OR CONDUITS IN FOUNDATIONS OF PROPOSED RESERVOIRS AND ENGINEERING STRUCTURES ...Carbonates, Cave Studies, Engineering Structures-general, Geology - Engineering, Tritium, ...**8.0073**

Heat Flows

THERMAL GRADIENTS IN SOUTH CAROLINA ...Geothermal Gradient, Groundwater Movement, Permeability, South Carolina, Temperature, ...**2.0964**

Temperature Profiles

TEMPERATURE PROSPECTING FOR SHALLOW GLACIAL AND ALLUVIAL AQUIFERS ...Deposits, Geothermal, Temperature, Unconsolidated Aquifers, ...**4.0095**

Ecology (plant)

Applied Ecology

METHODS OF CONTROLLING CLUBMOSS (SELAGINELLA DENSA RYDB) AND REDEVELOPING THE PRODUCTIVE CAPACITY OF RANGES FOLLOWING CLUBMOSS CONTROL ...Lycopsida, Management and Fertility, Weeds -physiological Studies, ...**4.0160**

DEMONSTRATION OF THE CHANNEL AERATION PROCESS IN TREATMENT OF SEWAGE ...Aeration, Enteroviruses of Animals, Enteroviruses of Humans, Nutrients, Salmonella (non-specific & Ot), ...**5.0596**

EFFECTS OF POLLUTANTS ON SUBMARINE PLANT SYNECOLOGY ...Industrial Wastes, Nutrients, Plant Prod. (non-specific), Plant Succession, Sedimentation, Sediments, ...**5.1221**

PHOSPHATE MINING EFFLUENT IN ESTUARINE ECOLOGY ...Estuaries, Mining Activities, Mountmorillanite, Phosphate, Phosphite, Pollution - Effects of , ...**5.0821**

BIOCHEMICAL AND ECOLOGICAL RELATIONSHIPS OF PESTICIDES AND THE BIOLOGICAL CONSTITUENTS OF AQUATIC COMMUNITIES ...Bioenergetics, Cell Injury and Autolysis, Mortality Rates, Pesticides -non-specific, Sterility, ...**5.0566**

CRITERIA FOR FUNCTIONAL ANALYSIS OF SOIL-PLANT-WATER SYSTEMS ...Management, Quality -non-specific, Soil-water-plant Relationships, South Carolina, Yield, ...**2.0952**

INVESTIGATION OF AQUATIC WEED PROBLEMS AND MEANS OF CONTROL WITH EMPHASIS ON BRAZILIAN WATERWEED ...Herbicides -non-specific, of Aquatic Plants, Screening Potential Pesticides, Water Milfoil, Waterweed... , ...**5.0938**

STUDIES ON AQUATIC MYXOBACTERIA ...Bacterial Pollutant Sources, Fresh Water, Myxobacteria, Pollution Abatement, Range Or Territorial Distr. , ...**5.0954**

Aquatic Plant Group

Amphibious Plants

STUDIES ON THE PRODUCTIVITY OF VASCULAR HYDROPHYTES AND THEIR ROLE IN MINERAL CYCLING IN AQUATIC ECOSYSTEMS ...Budgets -other, Floating Plants, Freshwater Ecology, Primary Productivity, Submerged Plants, ...**6.0469**

INVASION OF THE AQUATIC HABITAT BY AMPHIBIOUS SPECIES OF POLYGONUM ...Clones, Habitat Studies, of Aquatic Plants, Plant Taxonomy, Polygonaceae, ...**2.1105**

ECOLOGICAL STUDIES OF MANIPULATED MARSHES AT DELTA, MANITOBA, CANADA ...Canada, Submerged Plants, Swamps-marshes, Water Depth, Water Levels, Water Fowl, N.s. , ...**4.0257**

STUDY OF THE DISTRIBUTION OF FOUR ASSOCIATIONS OF AQUATIC PLANTS IN THE VICINITY OF MONTREAL ...Canada, Depth, Freshwater Ecology, Range Or Territorial Distr. , St. lawrence River, ...**4.0047**

WEED CONTROL IN IRRIGATION AND DRAINAGE SYSTEMS ...Aquatic Soils, Herbicides -non-specific, of Aquatic Plants, Plant Pollutants, Submerged Plants, Timing -non-specific, ...**3.0094**

Aquatic Plants (non-specific)

CHANGES IN STREAM COMMUNITIES ASSOCIATED WITH EFFLUENT - INDUCED EUTROPHICATION ...Eutrophication, Invertebrates -non-specific, Number Or Density, Pennsylvania, Streams, ...**5.1029**

QUANTITATIVE AND QUALITATIVE MEASUREMENT OF AQUATIC VEGETATION-CURRITUCK SOUND ...Mapping, North Carolina, Pollution - Effects of , Saline Water Intrusion, Virginia, ...**5.0816**

THE AQUATIC PLANT RESOURCES OF WESTERN MONTANA ...Collections, Montana, Plant Taxonomy, Pubilications -other, ...**2.0717**

BROOD PRODUCTION AND POND PREFERENCE OF DIVING DUCKS IN THE TURTLE MOUNTAINS OF NORTH DAKOTA ...Chemical-general, Habitat Studies, Land Use, Water Fowl, N.s. , Water Utilization -animal, ...**6.0410**

INTERRELATIONS OF SEVERAL ABIOTIC FACTORS AND THE HIGHER AQUATIC PLANTS OF A STREAM ECOSYSTEM ...Plant Ecosystems(non-specific), Streams, ...**2.0656**

HYDROBIOLOGY OF THE MADISON RIVER AND ITS HEADWATERS ...Montana, Organic-general, Photosynthesis, Physiological Ecology, Respiration, ...**5.0697**

AQUATIC PLANTS OF POLLUTED WATERS IN S. W. UNITED STATES ...Habitat Studies, Plant Pollutants, Pollution Sources-general, Southwest, Tables, Compilations, Catalogs, ...**5.1184**

AQUATIC PLANT CHEMISTRY-ITS APPLICATION TO ECOLOGY ...Bacterial Pollutant Sources, Bactericides -non-specific, Endogenous Cpds -plants, Water Quality Control-general, ...**5.0793**

AQUATIC WEEDS ...Herbicides -non-specific, of Aquatic Plants, Physical-general, Plant Pollutants, Range Or Territorial Distr. , ...**5.0735**

FLORA OF THE GENESEE COUNTRY--AQUATIC VASCULAR PLANTS CONESUS LAKE COMMUNITY STUDIES ...Bacterial Pollutant Sources, Budgets -other, Floras, New York, Range Or Territorial Distr. , ...**6.0378**

ANTIBIOTIC EFFECTS OF ROOTED AQUATICS ON ZOOPLANKTON SPECIES ...Antibiotics, Environmental Physiology, Physiological Ecology, ...**2.0159**

A LIMNOLOGICAL INVENTORY OF IOWA LAKES AND STREAMS ...Aquatic Ecology, Iowa, Lakes, Streams, Survey Studies, Water Properties-general, ...**7.0042**

RESULTS OF APPLICATIONS OF KARMEX FOR CONTROL OF PLANTS IN PONDS AND LAK ...Diuron, Evaluation, Lakes, of Aquatic Plants, Water Quality-general, ...**6.0568**

MILWAUKEE RIVER WATERSHED LAKE VEGETATION SURVEY ...Lakes, Mapping, Range Or Territorial Distr. , Survey Studies, Wisconsin, ...**2.1144**

THE ROLE OF AQUATIC SOILS IN THE NUTRIENT DYNAMICS OF AQUATIC ECOSYSTEMS ...Floating Plants, Movement, Availability, Soil-water-plant Relationships, ...**6.0158**

Floating Plants

STUDIES ON THE PRODUCTIVITY OF VASCULAR HYDROPHYTES AND THEIR ROLE IN MINERAL CYCLING IN AQUATIC ECOSYSTEMS ...Amphibious Plants, Budgets -other, Freshwater Ecology, Primary Productivity, Submerged Plants, ...**6.0469**

EVALUATION OF HERBICIDES FOR CONTROL OF AQUATIC WEEDS ...Application Rates, Evaluation, Herbicides -non-specific, of Aquatic Plants, Submerged Plants, ...**5.0247**

THE ROLE OF AQUATIC SOILS IN THE NUTRIENT DYNAMICS OF AQUATIC ECOSYSTEMS ...Aquatic Plants (non-specific), Movement, Availability, Soil-water-plant Relationships, ...**6.0158**

Lower Plants

AMERICAN RIVER HYDROBIOLOGIC POTENTIAL STUDY ...Bioindicators, California, Phytoplankton, Primary Productivity, Water Quality-general, ...**5.0143**

Riparian Plants

WATER YIELD IMPROVEMENT FROM RIPARIAN AND UPLAND AREA OF RIVER BASINS ...Evapotranspiration, Management, Phreatophytes, River Basins, Sediment Yield, Southwest, ...**4.0006**

Submerged Plants

STUDIES ON THE PRODUCTIVITY OF VASCULAR HYDROPHYTES AND THEIR ROLE IN MINERAL CYCLING IN AQUATIC ECOSYSTEMS ...Amphibious Plants, Budgets -other, Floating Plants, Freshwater Ecology, Primary Productivity, ...**6.0469**

DISSOLVED ORGANIC MATTER AND PHOTOSYNTHESIS IN LAKES ...Autotrophic, Lakes, Nutrition, Secretions and Products, ...**5.0574**

EXPANDED AQUATIC PLANT CONTROL PROJECT ...Amaranthaceae -alligatorweed.., of Aquatic Plants, Translocation, 2,4-d, ...**6.0248**

AQUATIC VEGETATION STUDIES ...Lakes, Mapping, Water Level Fluctuation, ...**4.0127**

THE ECOLOGY OF SELECTED SUBMERSED AQUATIC WEEDS ...Depth, Ions and Gases, Nutrients, of Aquatic Plants, Range Or Territorial Distr. , ...**2.0620**

THE ECOLOGY OF SELECTED SUBMERSED AQUATIC WEEDS ...Elodea, Waterweed, Thalassia, Mineral Nutrition, of Aquatic Plants, Potamogeton, Ruppia, Zostera.., Water Milfoil, Waterweed... , ...**2.0764**

THE ECOLOGY OF SELECTED SUBMERSED AQUATIC WEEDS ...Elodea, Waterweed, Thalassia, of Aquatic Plants, Potamogeton, Ruppia, Zostera.., Water Properties-general, ...**2.0805**

ECOLOGICAL STUDIES OF MANIPULATED MARSHES AT DELTA, MANITOBA, CANADA ...Amphibious Plants, Canada, Swamps-marshes, Water Depth, Water Levels, Water Fowl, N.s. , ...**4.0257**

EVALUATION OF HERBICIDES FOR CONTROL OF AQUATIC WEEDS ...Application Rates, Evaluation, Floating Plants, Herbicides -non-specific, of Aquatic Plants, ...**5.0247**

GROWTH SUPPRESSION AND REDUCTION IN REGROWTH POTENTIAL OF AQUATIC WEEDS ...Acrolein, Biological Pollutants -other, Maturity Or Growth Stage of , of Aquatic Plants, Plant Resistance, ...**2.0191**

FIELD INVESTIGATION OF THE SUBMERSED AQUATIC ENVIRONMENT ...Aquatic Ecology, Canals, Irrigation-general, Plant Pollutants, Reservoirs and Impoundments, Weeds -phenological Studies, ...**3.0125**

WEED CONTROL IN IRRIGATION AND DRAINAGE SYSTEMS ...Amphibious Plants, Aquatic Soils, Herbicides -non-specific, of Aquatic Plants, Plant Pollutants, Timing -non-specific, ...**3.0094**

DISTRIBUTION, LIFE HISTORY, AND ECOLOGY OF EURASIAN WATERMILFOIL ...Chesapeake Bay, Range Or Territorial Distr. , Water Milfoil, Waterweed... , Weeds -other, ...**6.0263**

Biomes

Biomes (non-specific)

ANALYSIS OF VEGETATIVE CHANGES RESULTING FROM WATER LEVEL CONTROL ...Mapping, North Carolina, Swamps-marshes, Water Level Fluctuation, ...**4.0184**

Coniferous Forests

COOPERATIVE WATERSHED MANAGEMENT IN SNOWLANDS AND LOWER CONIFER ZONES OF CALIFORNIA ...California, Forest Watersheds, Management, Moisture Tension, Snowmelt, ...**4.0022**

A STUDY OF SNOW INTERCEPTED BY CONIFEROUS TREE CROWNS AND ITS DISPOSITION UNDER THE CLIMATIC CONDITIONS OF CENTRAL NEW YORK ...Conifers -non-specific, Interception, New York, Snow, Snow-other, ...**2.0787**

Deserts, Arid Lands

ARID LAND ECOLOGY AND ENVIRONMENT STUDIES IV. WATER QUANTITY MANAGEMENT ...Arid and Desert, Big Horn, Deserts, Moisture Content, Wyoming, ...**4.0281**

VEGETATION CHANGES IN SOUTHWESTERN NORTH AMERICA ...Arid and Desert, Climate, Other Water Conditions, Soil-water-plant Relationships, Southwest, ...**2.0045**

Grasslands

ECOLOGICAL STUDIES OF GRASSLANDS, ETC. ...Kansas, Soil Environment, Soil Moisture -non-specific, ...**2.0513**

Distribution

Range Or Territorial Distr.

BLUE-GREEN ALGAE POISONING ...Algal Pollutant Sources, Algal Toxins, Arizona, Cyanophyta (non-specific & Ot), Vegetable Origin, ...**5.0041**

BIOLOGIC AND ENVIRONMENTAL CONTROL OF EURASIAN MILFOIL (MYRIOPHYLLUM SPICATUM L.) IN CHESAPEAKE BAY ...Biocontrol, Chesapeake Bay, Histology and Cytology, Water Milfoil, Waterweed... , ...**6.0251**

ECOLOGICAL STUDIES OF THE SURFACE WATERS OF THE WHITEWATER CREEK WATERSHED, WALWORTH, ROCK, AND JEFFERSON COUNTIES, WISCONSIN ...Bioindicators, Water Quality-general, Watersheds-general, Wisconsin, ...**5.1323**

STUDIES ON AQUATIC MYXOBACTERIA ...Bacterial Pollutant Sources, Bioindicators, Degradation, Myxobacteria, Nutrition, Streams, ...**5.0952**

TAXONOMY AND ECOLOGY OF INSHORE MARINE MICROBIOTA ...Algae- General, Animal Taxonomy, Aquatic Ecology, Plant Taxonomy, Protozoa -other, ...**7.0024**

A DETAILED STUDY OF LAKE MICHIGAN PLANKTON DIATOMS ...Lake Michigan, Phytoplankton, Planktonic - Floating, Plant Taxonomy, ...**5.0554**

THE ECOLOGY OF SELECTED SUBMERSED AQUATIC WEEDS ...Depth, Ions and Gases, Nutrients, of Aquatic Plants, Submerged Plants, ...**2.0620**

AQUATIC WEEDS ...Aquatic Plants (non-specific), Herbicides -non-specific, of Aquatic Plants, Physical-general, Plant Pollutants, ...**5.0735**

FLORA OF THE GENESEE COUNTRY--AQUATIC VASCULAR PLANTS CONESUS LAKE COMMUNITY STUDIES ...Aquatic Plants (non-specific), Bacterial Pollutant Sources, Budgets -other, Floras, New York, ...**6.0378**

STUDY OF THE DISTRIBUTION OF FOUR ASSOCIATIONS OF AQUATIC PLANTS IN THE VICINITY OF MONTREAL ...Amphibious Plants, Canada, Depth, Freshwater Ecology, St. lawrence River, ...**4.0047**

STUDIES ON AQUATIC MYXOBACTERIA ...Applied Ecology, Bacterial Pollutant Sources, Fresh Water, Myxobacteria, Pollution Abatement, ...**5.0954**

ECESIS AND STABILIZATION OF PRICKYPEAR (OPUNTIA SPP.) ON THE RIO GRANDE PLAINS ...Angiosperms, Arid and Desert, Cacti, Habitat Studies, of Specific Weeds, ...**6.0564**

MILWAUKEE RIVER WATERSHED LAKE VEGETATION SURVEY ...Aquatic Plants (non-specific), Lakes, Mapping, Survey Studies, Wisconsin, ...**2.1144**

DISTRIBUTION, LIFE HISTORY, AND ECOLOGY OF EURASIAN WATERMILFOIL ...Chesapeake Bay, Submerged Plants, Water Milfoil, Waterweed... , Weeds -other, ...**6.0263**

PLANKTON ECOLOGY ...Estuaries, Eutrophication, Gulf of Mexico, Gymnodinium, Phytoplankton, ...**6.0155**

NITRIFICATION BY MARINE MICROORGANISMS ...Autotrophic, Bact. morphology (general), Bacterial Culture, Isolation From Nat. environ. , Marine Bacteria (non-specific), Nitrification, Nitrogen Bacteria, ...**1.0066**

THE ECOLOGY OF CLOSTRIDUM BOTULINUM IN THE TVA LAKES AREA ...Bacterial Exotoxins, Bacterial Pollutant Sources, Clostridium Botulinum, Food, Microbiological, Tennessee, ...**2.0990**

Temporal Distribution

SEASONAL VARIATIONS IN THE PHYTOPLANKTON - BACTERIA POPULATIONS AND THE NUTRIENT CONCENTRATION IN BEAVER RESERVOIR ...Nitrogen, Phosphorus, Phytoplankton, Reservoirs and Impoundments, Water Bacteria, ...**6.0027**

ECOLOGICAL PERIODICITIES OF NITROGEN AND PHOSPHORUS IN SALT MARSH FLORA AND SURROUNDING WATERS ...Mineral Composition, Swamps-marshes, ...**6.0118**

THE ROLE OF TEMPERATURE AND ILLUMINATION IN THE BIOLOGY OF OSCILLATORIA RUBESCENS ...Lakes, Ohio, Optical Properties, Temperature, ...6.0435

VIBRIO PARAHAEMOLYTICUS IN THE ESTUARINE ENVIRONMENT ...Crustacea -non-specific, Estuaries, Isolation From Nat. environ. , Mollusks -non-specific & Other, Vibrio N S, ...2.1115

Vertical Distribution

BIOLOGY AND CHEMISTRY OF MARINE PLANKTON POPULATIONS ...Buoys, Chlorophyll, Food Chains, Nutrients, Phytoplankton, Zooplankton, ...6.0289

A STUDY OF COLIFORM BACTERIA AND ESCHERICHIA COLI ON POLLUTED AND UNPOLLUTED OYSTER BOTTOMS OF MISSISSIPPI ...Coliforms (non-specific), Identification, Mississippi River, Sewage, Water Sampling, ...5.0619

BUOYANCY AND SINKING CHARACTERISTICS OF FRESHWATER PHYTOPLANKTON ...Algal Pollutant Sources, Fresh Water, Herbicides -non-specific, Phytoplankton, Primary Productivity, ...5.1064

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FLORISTIC AND FAUNISTIC SURVEY IN THE CUYAHOGA RIVER WATERSHED ...Freshwater Ecology, Ohio, Physical-general, Pollution - Effects of , Survey Studies, ...6.0436

THE ALGAE AND ZOOPLANKTON OF PROTECTED AND EXPLOITED LENTIC HABITATS IN NORTHEASTERN OHIO ...Algae- General, Freshwater Ecology, Habitat Studies, Ohio, Zooplankton, ...6.0431

ECOLOGICAL STUDIES OF LARVAL TREMATODES AND THEIR SNAIL-HOSTS IN THE LAKE CHAMPLAIN WATERSHED ...Aquatic, Digenea -other, Effect of Parasite on Host, Gastropods -slugs,conch,snails, Survey Studies, ...6.0396

BOTTOM FAUNA IN THE NORTH ST. VRAIN CREEK, COLORADO ...Benthic Fauna, Colorado, Mountains-alpine, Streams, Vertical Distribution, ...2.0158

CHEMICAL ECOLOGY OF DIAPTOMID COPEPODS OF COLORADO ...Chemical Measurements -water, Colorado, Copepods, Environmental Ecology, Fresh Water, ...6.0088

A PARASITOLOGICAL STUDY OF FISHES FROM THE PINE HILLS AREA ...Fish -non-specific, Helminths, Illinois, Low Temp. -but Above 32f, Springs, ...6.0180

OPTIMUM ESCAPEMENT STUDIES OF CHIGNIK SOCKEYE SALMON ...Alaska, General Synoptic Observations, Lakes, Salmon -coho,chinook,sockeye.., Water Properties-general, ...6.0623

ESTUARINE ECOLOGY ...Contamination - Water, Estuaries, Mathematical Analysis, Washington, Water Quality-general, ...6.0620

STUDY OF TEMPERATURE EFFECTS IN COOLING WATER LAKE ...Lakes, Pollution - Effects of , Temperature, Thermal Pollution, Water Temperature-non-specific, ...6.0566

INTER-DISCIPLINARY RESEARCH IN THE AREA OF THE KANO PLAINS, WESTERN KENYA ...Geography-cultural, Geomorphology-general, Kenya, ...3.0246

MUSQUODOBOIT - METERING BASINS NOVA SCOTIA, CANADA ...Canada, Mammals -other, Mapping, Water Fowl, N.s. , Water Level Fluctuation, Wetlands, ...4.0054

THERMAL EFFECTS ON MARINE AND ESTUARINE SHELLFISH ...Crustacea -non-specific, Environmental Physiology, Mollusks -non-specific & Other, Pollution - Effects of , Water Temperature-non-specific, ...5.1251

A LIMNOLOGICAL INVENTORY OF IOWA LAKES AND STREAMS ...Aquatic Plants (non-specific), Iowa, Lakes, Streams, Survey Studies, Water Properties-general, ...7.0042

INFLUENCES OF WATER QUALITY AND OTHER ENVIRONMENTAL CHANGES ON FISH AND ASSOCIATED ORGANISMS IN INLAND WATERS ...Environmental Ecology, Fish - non-specific, Mans Activities, Pollution - Effects of , Social Aspects, Water Quality-general, ...5.0965

ECOLOGY OF SPRING CHINOOK SALMON ...Life History Studies, Oregon, Productivity - Food Chain, Salmon -coho,chinook,sockeye.., Streams, ...6.0447

FACTORS INFLUENCING THE FRESHWATER RESIDENCE OF JUVENILE FALL CHINOOK SALMON ...Fresh Water, Life History Studies, Oregon, Salmon -coho,chinook,sockeye.., Streams, ...6.0448

ECOLOGY OF RECREATIONALLY IMPORTANT ESTUARINE FISHES IN OREGON ...Environmental Ecology, Estuaries, Fishing, Migration, Oregon, Population Dynamics, ...6.0458

EVALUATION OF ANADROMOUS FISH PASSAGE FACILITIES AT FALL CREEK DAM, BIG FALL CREEK, OREGON ...Engineering Structures-general, Migration, Oregon, Rainbow Trout, Steelhead Trout, Salmon & Trout - Non-specific, ...**8.0280**

SIGNIFICANCE OF STOCKING SUB-ADULT FIN CLIPPED CATFISH IN HUNTSVILLE STATE PARK LAKE ...Channel Catfish, Lakes, Other, Population Dynamics, Stocking of Fish & Shellfish, ...**6.0569**

ECOLOGICAL STUDIES OF CHUM AND COHO SALMON AT BIG BEEF CREEK ...Chemical-general, Reservoirs and Impoundments, Salmon -coho,chinook,sockeye.., Streams, Washington, ...**6.0629**

IMPACT OF LAGOONS AND SAND BLANKETS ON FISH, AQUATIC LIFE AND WATER EQUALITY ...Blankets, Lagoons, Lakes, Submergent, Water Quality-general, ...**6.0637**

WATER QUALITY MONITORING STUDIES ...Chemical-general, Dams, Land Use, Monitoring Systems, Survey Studies, Water Quality-general, ...**6.0639**

RADIONUCLIDE CYCLING IN AQUATIC ECOSYSTEMS AND THE USE OF ISOTOPES TO DELINEATE AND QUANTIFY BASIC ECOLOGICAL PROCESSES ...Environmental Ecology, Lakes, Productivity - Food Chain, Radioactive Pollution -ns, Strontium, ...**2.1000**

RADIATION EFFECTS IN AQUATIC SYSTEMS ...Chronic Radiation, Contamination - Water, Fish -non-specific, Low Level Radiation, Radiation Effects-non-specific, Radiation Treatment, Radioactivity-general, ...**5.1248**

COAL STRIP MINE WATERSHED STUDY ...Coal-general, Mining Activities, Pollution - Effects of , Soil Management -non-specific, Stream Rehabilitation, Strip Mines, ...**2.0980**

COAL STRIP MINE WATERSHED DEMONSTRATION--JACKSON COUNTY, ALABAMA ...Alabama, Coal-general, Mining Industry, Pollution - Effects of , Water Quality-general, ...**5.1124**

EFFECTS OF TEMPERATURE ON AQUATIC LIFE ...Fish -non-specific, Model Studies, Productivity - Food Chain, Temperature, Warm Water, ...**5.1121**

SEA NETTLE STUDIES IN CHESAPEAKE BAY, LIFE HISTORY AND ECOLOGY ...Bays, Biological Control, Chesapeake Bay, Jelly Fish, Life History Studies, ...**6.0127**

ARCTIC ECOSYSTEMS ...Alaska, Energy Budgets, Freshwater Ecology, Polar, Productivity - Food Chain, ...**5.0236**

POPULATION ECOLOGY OF FORAMINIFERA IN THE CHOPTANK RIVER ...Environmental Ecology, Foraminifera, Maryland, Population Dynamics, Water Properties-general, ...**6.0126**

BIOLOGICAL PRODUCTIVITY RELATED TO HYDROLOGIC CONDITIONS ...Plant Prod. (non-specific), Productivity - Food Chain, Swamps-marshes, Water Level Fluctuation, Water Quality-general, ...**2.0317**

FIELD INVESTIGATION OF THE SUBMERSED AQUATIC ENVIRONMENT ...Canals, Irrigation-general, Plant Pollutants, Reservoirs and Impoundments, Submerged Plants, Weeds - phenological Studies, ...**3.0125**

THE EFFECT OF OCEAN WATER INTRUSION INTO BACK BAY, VIRGINIA, AND CURRITUCK SOUND, NORTH CAROLINA, ON THE WATERFOWL AND FISH HABITAT ...Brackish Water, Fish -non-specific, Habitat Studies, Saline Water Intrusion, Water Fowl, N.s. , Water Salinity, ...**2.0585**

FISH POPULATION OR ABUNDANCE STUDIES IN LEWIS AND CLARK LAKE ...Fish -non-specific, Habitat Studies, Population Dynamics, Reservoirs and Impoundments, South Dakota, ...**6.0529**

DISTRIBUTION AND RELATIVE ABUNDANCE OR POPULATION OF YOUNG FISHES IN LAKE SHARPE RESERVOIR ...Fish -non-specific, Population Dynamics, Reservoirs and Impoundments, South Dakota, Vertical Distribution, ...**6.0500**

ABUNDANCE AND COMPOSITION OF ADULT FISH STOCK IN LAKE SHARPE ...Fish -non-specific, Number Or Density, Population Dynamics, Reservoirs and Impoundments, South Dakota, ...**6.0501**

GROWTH AND MORTALITY RATES OF YOUNG YELLOW PERCH IN OAHE RESERVOIR ...Growth Rate, Mortality Rates, Reservoirs and Impoundments, South Dakota, Yellow Perch, Darters, ...**6.0498**

ABUNDANCE OF YOUNG-OF-THE-YEAR FISHES IN OAHE RESERVOIR ...Age, Fish -non-specific, Population Dynamics, Reservoirs and Impoundments, South Dakota, ...**6.0499**

EARLY LIFE HISTORY OF WALLEYE IN LAKE FRANCIS CASE ...Life History Studies, Maturity & Growth Stages, Reservoirs and Impoundments, South Dakota, Walleyes, ...**6.0506**

ENVIRONMENTAL FACTORS AND YOUNG NORTHERN PIKE SURVIVAL IN RESERVOIRS ...Environmental Physiology, Pikes, Pickeral, Muskellunge, Reservoirs and Impoundments, Stocking of Fish & Shellfish, Temperature, ...**6.0510**

ENVIRONMENTAL FACTORS AND YOUNG YELLOW PERCH SURVIVAL IN RESERVOIRS ...Environmental Physiology, Reservoirs and Impoundments, Stocking of Fish & Shellfish, Temperature, Yellow Perch, Darters, ...**6.0511**

BENTHOS IN LEWIS AND CLARK LAKE ...Bloodworms, Aquatic Midges, Mayflies, Number Or Density, Reservoirs and Impoundments, South Dakota, ...**6.0514**

BENTHOS IN LAKE FRANCIS CASE ...Benthic Fauna, Reservoirs and Impoundments, South Dakota, ...**6.0515**

POPULATION ESTIMATES FROM MIDWATER TRAWL SAMPLING ...Alewife,menhaden,shad,herring, Arkansas, Nets, Population Dynamics, Reservoirs and Impoundments, ...**6.0019**

EARLY LIFE HISTORY STAGES OF OAHE AND BIG BEND RESERVOIR FISHES ...Animal Taxonomy, Life History Studies, Plankton Sampling, Reservoirs and Impoundments, South Dakota, ...**6.0522**

LIFE HISTORY OF RESERVOIR FISHES, SPAWNING OF OAHE AND BIG BEND RESERVOIR FISHES ...Biological Rhythms, Life History Studies, Reservoirs and Impoundments, South Dakota, Spawn Or Nesting Sites, ...**6.0523**

ESTIMATES OF COMPOSITION, ABUNDANCE AND FLUCTUATION IN FISH POPULATIONS IN BULL SHOALS AND BEAVER RESERVOIRS ...Arkansas, Fish -non-specific, Number Or Density, Population Dynamics, Reservoirs and Impoundments, ...**4.0017**

LIFE HISTORY OF WHITE BASS IN LEWIS AND CLARK LAKE ...Basses -sea,white, White Perch, Life History Studies, Reservoirs and Impoundments, South Dakota, ...**6.0528**

LIFE HISTORY OF CYCLOPS BICUSPIDATUS ...Copepods, Life History Studies, Number Or Density, Reservoirs and Impoundments, South Dakota, ...**6.0527**

FISH POPULATION IN TAILWATER OF LEWIS AND CLARK LAKE ...Fish -non-specific, Population Dynamics, Reservoirs and Impoundments, South Dakota, ...**6.0531**

PHYSIOLOGY AND BEHAVIOR OF LARVAE (PHYSIOECOLOGY OF SHELLFISH PROGRAM) ...Biological Rhythms, Environmental Ecology, Environmental Physiology, Water Properties-general, ...**6.0113**

ESTUARINE BIOLOGY--RESPONSE OF LARVAE TO TEMPERATURE AND SALINITY ...Alewife,menhaden,shad,herring, Environmental Ecology, Estuaries, Salinity, Temperature, ...**2.0817**

PINK SALMON INVESTIGATIONS - FRESHWATER ECOLOGY ...Environmental Ecology, Estuaries, Mortality Rates, Physical-general, Salmon -coho,chinook,sockeye.., ...**4.0002**

PHYSIOLOGY AND BEHAVIOR ...Biological-general, Environmental Physiology, Productivity - Food Chain, ...**6.0290**

LIFE HISTORY AND ABUNDANCE OF THE WALLEYE ...Commercial Fishing, Environmental Ecology, Life History Studies, Walleyes, Water Properties-general, ...**6.0440**

LIFE HISTORY AND ABUNDANCE OF THE YELLOW PERCH ...Environmental Ecology, Life History Studies, Population Dynamics, Water Properties-general, Yellow Perch, Darters, ...**6.0439**

ENVIRONMENTAL CHANGES IN LAKE ERIE ...Environmental Changes, Environmental Ecology, Ions and Gases, Lake Erie, Nutrients, ...**5.0540**

ASSESSMENT OF LAKE SUPERIOR LAKE TROUT ...Commercial Fishing, Lake Trout, Brook Trout, Lampreys, Life History Studies, ...**6.0636**

MONITORING FISH STOCKS AND ENVIRONMENTAL CONDITIONS ...Biological-general, Environmental Effects-geologic, Population Dynamics, Water Properties-general, ...**6.0635**

RELATION OF ENVIRONMENTAL FACTORS TO THE PRODUCTIVITY OF ESTUARINE SEDENTARY FAUNA ...Environmental Ecology, Estuaries, Florida, Productivity - Food Chain, ...**5.0269**

RESEARCH ON THE MACROBENTHOS OF THE GREAT LAKES ...Benthic Fauna, Earthworms, Food Supply, Great Lakes-general, Water Quality-general, ...**6.0292**

DISTRIBUTION AND ABUNDANCE OF ZOOPLANKTON IN LAKE ERIE ...Computers-general, Environmental Ecology, Interbiotic Relat.(non-specif), Lake Erie, Other Computers, Population Dynamics, ...**6.0294**

RELATION OF RIVER-RUN IMPOUNDMENTS TO SALMON PRODUCTION ...Engineering Structures-general, Environmental Changes, Environmental Ecology, Mans Activities, Pollution - Effects of , Salmon & Trout - Non-specific, ...**6.0616**

SALMON PRODUCTION IN AREAS MADE INACCESSIBLE BY DAMS ...Columbia River, Engineering Structures-general, Environmental Ecology, Salmon & Trout - Non-specific, Spawn Or Nesting Sites, ...8.0309

PINK SALMON INVESTIGATIONS - FRESHWATER ECOLOGY ...Alaska, Salmon -coho,chinook,sockeye.., Spawn Or Nesting Sites, Streams, Water Properties-general, ...6.0005

ADULT SALMON BEHAVIOR STUDIES IN RIVERS AND AT DAMS (SONIC TRACKING) ...Behavioral Ecology, Columbia River, Migration, Salmon & Trout - Non-specific, Tags, ...8.0305

FISH TRANSPORTATION ...Management -other, Migration, Salmon & Trout - Non-specific, Streams, Tags, ...8.0304

THE INVESTIGATION AND ANALYSIS OF BIOCHEMICAL PROCESSES OF AQUATIC ORGANISMS UNDER STRESS ...Animal Origin, Fish -non-specific, Metabolism -animal, Other, Stress, ...5.0585

EFFECTS OF HIGH TEMPERATURE, LOW OXYGEN, AND PH EXTREMES ON THE SURVIVAL OF AQUATIC INSECTS AND CRUSTACEA IMPORTANT AS TROUT FOOD ...Food Supply, Gases, Dissolved -water, High Temp. -85f Or Above, Lake Superior, Ph, Acidity -water, ...5.0593

DEVELOPMENT OF CULTURE METHODS FOR ECOLOGICALLY IMPORTANT MARINE ZOOPLANKTON SPECIES ...Copepods, Environmental Physiology, Invertebrate Cultures, Zooplankton, ...5.1096

RELATIONSHIP OF WATER AND LAND MANAGEMENT TO MOSQUITO BREEDING IN WATER IMPOUNDMENTS AND IRRIGATED FARM AREAS ...Computer Matching Code, Diseases, Management, Mosquitoes -non-specific, Predators and Parasite, Rearing, Water, ...6.0255

BIOLOGY AND CONTROL OF SALT-MARSH AND RICE-FIELD MOSQUITOES IN GULF COAST AREAS ...Computer Matching Code, Louisiana, Mosquitoes -non-specific, Predators and Parasite, Swamps-marshes, ...2.0576

THE EFFECT OF PREDATORS AND PARASITES ON THE BREEDING POTENTIAL OF MOSQUITOES ...Aedes Mosquitoes, Disease, Predators, Diseases, Louisiana, Predators and Parasite, ...2.0577

Distribution

Animal Distr. (non-specific)

FISHES OF THE SOUTH PLATTE RIVER BASIN, COLORADO ...Colorado, Environmental Changes, Environmental Ecology, Fish -non-specific, Pollution - Effects of , River Basins, ...5.0194

FISH GUIDING ...Fish -non-specific, Guidance, Instrumental Services, Management -other, Water Environment -other, ...8.0307

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ECOLOGICAL STUDIES OF THE SURFACE WATERS OF THE WHITEWATER CREEK WATERSHED, WALWORTH, ROCK, AND JEFFERSON COUNTIES, WISCONSIN ...Bioindicators, Water Quality-general, Watersheds-general, Wisconsin, ...5.1323

EFFECT OF RANGE AND WATER ON MULE DEER POPULATION ...New Mexico, Odocoileus, Population Dynamics, Relations - Forage - Timber, Water Utilization -animal, ...3.0338

ECOLOGY OF COLORADO MOLLUSKS ...Colorado, Mollusks - non-specific & Other, Pollution - Effects of , Pollution -non-specific, Pollution Effects, ...5.0178

INFLUENCE OF THE PHYSICAL ENVIRONMENT ON DISTRIBUTION OF YOUNG STAGES OF COASTAL GAME FISH ...Continental Shelf, Environmental Ecology, Fish -non-specific, Maturity & Growth Stages, Physical-general, ...6.0346

DISTRIBUTION, ABUNDANCE, TAXONOMY, AND BIOLOGY OF MOSQUITOES AFFECTING AGRICULTURE ...Animal Taxonomy, Insect Chemosterilants, N.s. , Mosquitoes -non-specific, Number Or Density, Radiation, ...6.0148

Temporal Distribution

DISTRIBUTION AND GROWTH PATTERNS OF THE GIZZARD SHAD (DOROSOMA CEPEDIANU) AND THREADFIN SHAD (DOROSOMA PETENENSE) IN RESERVOIRS ...Alewife,menhaden,shad,herring, Arkansas, Growth Rate, Number Or Density, Reservoirs and Impoundments, ...6.0029

Vertical Distribution

BIOLOGY AND CHEMISTRY OF MARINE PLANKTON POPULATIONS ...Buoys, Chlorophyll, Food Chains, Nutrients, Phytoplankton, Zooplankton, ...6.0289

ABUNDANCE AND DISTRIBUTION OF BENTHIC MACRO-INVERTEBRATES IN A STREAM RECEIVING OILFIELD WASTEWATERS ...Benthic Fauna, Bioindicators, Contamination - Water, Industrial Wastes, Number Or Density, ...5.1028

STREAM BIOLOGY AND ITS RELATION TO FISH PRODUCTION ...Food Supply, Growth Rate, Mississippi River, Shiners, Streams, ...6.0223

ATCHAFALAYA RIVER - CALLIOU LAKE SYSTEM ...Lakes, Louisiana, Number Or Density, Physical-general, Plankton (non-specific), ...2.0545

SEASONAL AND DIURNAL ASPECTS OF ZOOPLANKTON MICRODISTRIBUTION AND VERTICAL MIGRATION IN RELATION TO WATER POLLUTION ...Environmental Ecology, Fresh Water, Pollution Effects, Water Quality-general, Zooplankton, ...5.1126

THE MICRODISTRIBUTION OF STREAM BENTHOS ...Aquatic Ecology, Benthic Fauna, Organic-general, Productivity - Food Chain, Streams, ...5.1020

DISTRIBUTION OF DEMERSAL FISHES IN INSHORE WATERS ...Environmental Ecology, Fish -non-specific, Marine Biology, Mortality Rates, Nets, ...5.1260

DISTRIBUTION OF LIFE WITH DEPTH ...Continental Shelf, Marine Photography-television, North Carolina, Photography-other, ...5.0272

BOTTOM FAUNA IN THE NORTH ST. VRAIN CREEK, COLORADO ...Aquatic Ecology, Benthic Fauna, Colorado, Mountains-alpine, Streams, ...2.0158

RELATIONSHIP OF TUBE-AND REEF BUILDING MARINE ANNELIDS TO COASTAL ENGINEERING AND CONSERVATION PROBLEMS IN FLORIDA ...Coastal Engineering-other, Environmental Ecology, Florida, Lugworms, Marine Segmented-worm, ...3.0187

DEPTH DISTRIBUTION OF FISH IN LAKE GLENDALE ...Bluegills, Bream, Food Supply, Illinois, Lakes, Largemouth Bass, ...6.0197

OREGON FISHES - THEIR CLASSIFICATIONS, DISTRIBUTIONS AND LIFE HISTORIES ...Animal Taxonomy, Fresh Water, Life History Studies, Oregon, ...6.0450

DISTRIBUTION AND RELATIVE ABUNDANCE OR POPULATION OF YOUNG FISHES IN LAKE SHARPE RESERVOIR ...Aquatic Ecology, Fish -non-specific, Population Dynamics, Reservoirs and Impoundments, South Dakota, ...6.0500

FAUNAL PRODUCTION ...Estuaries, Pollution Effects, Pollution-general, Productivity - Food Chain, Water Environment -other, ...6.0154

ESTUARINE STUDIES OF SOUTHEASTERN ALASKA ...Alaska, Benthic Fauna, Environmental Ecology, Estuaries, Number Or Density, ...2.0017

Environmental Ecology

AQUATIC COMMUNITIES ...Aquatic Ecology, Lakes, Productivity - Food Chain, Salinity, Water Salinity, ...6.0625

DIVERSITY AND ECOLOGICAL NICHES IN MULTI-SPECIES ASSOCIATIONS OF CHYORID CLADOCERA (CRUSTACEA) ...Cladocera, Habitat Studies, Interbiotic Relat.(non-specif), Lakes, Microfossils, ...2.0911

THE EFFECT OF EVAPORATION BARRIERS ON FISH GROWTH AND LIMNOLOGY ...Antitranspirants, Aquatic Ecology, Fish -non-specific, Growth Rate, ...2.0060

FISHES OF THE SOUTH PLATTE RIVER BASIN, COLORADO ...Animal Distr. (non-specific), Colorado, Environmental Changes, Fish -non-specific, Pollution - Effects of , River Basins, ...5.0194

FACTORS AFFECTING ZOOPLANKTON PRODUCTION IN FOUR ARIZONA LAKES ...Lakes, Productivity - Food Chain, Trace Element Analysis, Water Bacteria, Zooplankton, ...5.0047

INVESTIGATION OF THE RELATIONSHIP OF THE AMERICAN SMELT, OSMERUS MORDAX - MITCHILL, TO THE WEWEANTIC RIVER ESTUARY, WAREHAM, MASSACHUSETTS ...Aquatic Ecology, Estuaries, Smelts, Spawn Or Nesting Sites, Temperature, ...5.0510

COVER AS A LIMITING FACTOR IN TROUT PRODUCTION ...Colorado, Number Or Density, Salmon & Trout - Non-specific, Soil (wildlife) Cover, Streams, ...4.0070

MASS MORTALITY OF PACIFIC OYSTERS ALONG THE WASHINGTON COAST ...Bays, Mortality Rates, Oysters, Pathology, Puget Sound, ...5.1230

EFFECTS OF CHANGES IN WATER QUALITY ON FRY AND FINGERLINGS ...Aquatic Ecology, Basses -sea,white, White Perch, Chemical-general, Louisiana, Water Quality-general, ...5.0454

VEGETATIVE SUCCESSION IN NEWLY CONTROLLED MARSHES ...Growth Rate, Plant Succession, South Carolina, Swamps-marshes, Water Level Fluctuation, ...4.0215

STUDY OF THE RIVER PHASE OF THE LIFE HISTORIES OF ALOSA PSEUDOHARENGUS AND AESTIVALIS ...Alewife,menhaden,shad,herring, Aquatic Ecology, Connecticut River, Life History Studies, Spawn Or Nesting Sites, ...6.0111

POTENTIAL FISHERY FOR RIVER HERRINGS IN CONNECTICUT RIVER ...Alewife,menhaden,shad,herring, Connecticut River, Life History Studies, Nets, Spawn Or Nesting Sites, ..4.0075

COOPERATIVE GULF OF MEXICO INVENTORY AND STUDY - II HYDROLOGY ...Aquatic Ecology, Atlases-maps, Estuaries, Gulf of Mexico, Water Properties-general, ...2.0670

COOPERATIVE GULF OF MEXICO INVENTORY AND STUDY - III SEDIMENTOLOGY ...Aquatic Ecology, Atlases-maps, Distribution, Estuaries, Gulf of Mexico, ...2.0671

COOPERATIVE GULF OF MEXICO INVENTORY AND STUDY - IV BIOLOGY ...Aquatic Ecology, Atlases-maps, Estuaries, Gulf of Mexico, Mississippi River, ...2.0672

WATER RESOURCES NEMATOLOGY ...Animal Pollutant Sources, Aquatic Ecology, Mans Activities, Nematoda -other, Productivity - Food Chain, ...5.0001

MANIPULATION OF RESERVOIR WATER FOR IMPROVED QUALITY AND FISH POPULATION RESPONSE ...Eutrophication, Fish -non-specific, Flow Augmentation, Freshwater Ecology, Population Dynamics, Reservoirs and Impoundments, ...5.1294

EFFECTS OF THERMAL POLLUTION ON PRODUCTIVITY AND STABILITY OF ESTUARINE COMMUNITIES ...Aquatic Ecology, Estuaries, Plant Prod. (non-specific), Pollution - Effects of , Thermal Pollution, ...5.0498

TRACE ELEMENT CHEMISTRY OF A SMALL POND IN RELATION TO PRODUCTIVITY ...Geochemical Analysis, Ponds, Population Dynamics, Trace Element Analysis, Zooplankton, ...6.0232

EFFECTS OF WATER DIVERSION ON BIOTA AND WATER QUALITY IN THE STATE OF ARKANSAS ...Fish -non-specific, Population Dynamics, Reservoirs and Impoundments, Temperature, Water Quality-general, ...6.0030

EFFECT OF WATER QUALITY ON FIRST-YEAR MORTALITY OF LARGEMOUTH BASS ...Aquatic Ecology, Largemouth Bass, Mortality Rates, Pollution - Effects of , Water Properties-general, ...5.0772

THE INSECT ORDER PLECOPTERA AS A BIOLOGICAL INDEX OF FRESH WATER QUALITY IN RHODE ISLAND ...Bioindicators, Number Or Density, Pollution - Effects of , Pollution Effects, Stone Flies, Plecoptera, Streams, ...5.1057

AQUATIC ENVIRONMENT AND FOOD HABITS OF MAYFLIES ...Aquatic Ecology, Chemical-general, Mayflies, Nutrition and Metabolism, Physical-general, ...5.0323

SEASONAL AND DIURNAL ASPECTS OF ZOOPLANKTON MICRODISTRIBUTION AND VERTICAL MIGRATION IN RELATION TO WATER POLLUTION ...Fresh Water, Pollution Effects, Vertical Distribution, Water Quality-general, Zooplankton, ...5.1126

CHEMICAL RESPONSES BY MARINE ORGANISMS TO STRESS ...Environmental Changes, Environmental Physiology, Protein, Salinity, Thermal, ...5.1056

DISSOLVED OXYGEN REQUIREMENTS OF FRESHWATER FISH ...Aquatic Ecology, Fish -non-specific, Gases, Dissolved - water, Ions and Gases, Oxygen, ...5.0962

DISTRIBUTION OF DEMERSAL FISHES IN INSHORE WATERS ...Fish -non-specific, Marine Biology, Mortality Rates, Nets, Vertical Distribution, ...5.1260

BIOLOGICAL SURVEY OF STREAMS OF COLES COUNTY, ILLINOIS ...Aquatic Ecology, Contamination - Water, Fish -non-specific, Illinois, Streams, ...5.0333

BIONOMICS OF FISHES AND SHELLFISHES ...Aquaculture & Fish-farming, Bays, Economics-general, Oregon, Productivity - Food Chain, ...2.0896

CHEMICAL ECOLOGY OF DIAPTOMID COPEPODS OF COLORADO ...Aquatic Ecology, Chemical Measurements -water, Colorado, Copepods, Fresh Water, ...6.0088

ST. JOHNS RIVER FISHERY PROJECT ...Florida, Mans Activities, Pollution Effects, Population Dynamics, Streams, ...3.0173

RELATIONSHIP OF TUBE-AND REEF BUILDING MARINE ANNELIDS TO COASTAL ENGINEERING AND CONSERVATION PROBLEMS IN FLORIDA ...Coastal Engineering-other, Florida, Lugworms, Marine Segmentedworm, Vertical Distribution, ...3.0187

FISH MOVEMENTS IN THE NORTH INLET OF WOLF LAKE, HUNTINGTON FOREST ...Behavioral Ecology, Lake Trout, Brook Trout, Locomotion -animal, New York, Streams, ...2.0813

INFLUENCES OF WATER QUALITY AND OTHER ENVIRONMENTAL CHANGES ON FISH AND ASSOCIATED ORGANISMS IN INLAND WATERS ...Aquatic Ecology, Fish -non-specific, Mans Activities, Pollution - Effects of , Social Aspects, Water Quality-general, ...5.0965

ECOLOGY OF RECREATIONALLY IMPORTANT ESTUARINE FISHES IN OREGON ...Aquatic Ecology, Estuaries, Fishing, Migration, Oregon, Population Dynamics, ...6.0458

RADIONUCLIDE CYCLING IN AQUATIC ECOSYSTEMS AND THE USE OF ISOTOPES TO DELINEATE AND QUANTIFY BASIC ECOLOGICAL PROCESSES ...Aquatic Ecology, Lakes, Productivity - Food Chain, Radioactive Pollution -ns, Strontium, ...2.1000

POPULATION ECOLOGY OF FORAMINIFERA IN THE CHOPTANK RIVER ...Aquatic Ecology, Foraminifera, Maryland, Population Dynamics, Water Properties-general, ...6.0126

AQUATIC PLANT CONTROL ...Fish -non-specific, Herbicides - non-specific, of Aquatic Plants, Wildlife, ...8.0168

WATER QUALITY AND NUTRIENTS, SACRAMENTO-SAN JOAQUIN RIVER SYSTEM ...Eutrophication, Fish -non-specific, Nutrients, Plankton (non-specific), Water Quality-general, ...2.0127

INFLUENCE OF THE PHYSICAL ENVIRONMENT ON DISTRIBUTION OF YOUNG STAGES OF COASTAL GAME FISH ...Continental Shelf, Fish -non-specific, Maturity & Growth Stages, Physical-general, Range Or Territorial Distr. , ...6.0346

LIFE HISTORY OF CHANNEL CATFISH IN LEWIS AND CLARK LAKE ...Channel Catfish, Life History Studies, Number Or Density, Reservoirs and Impoundments, South Dakota, ...6.0530

EFFECTS OF ENVIRONMENTAL FACTORS ON STANDING CROP AND HARVEST OF FISHES IN U. S. RESERVOIRS ...Environmental Effects-geologic, Fish -non-specific, Reservoirs and Impoundments, ...6.0021

SPOTTED BASS REPRODUCTION IN BULL SHOALS ...Arkansas, Biological Rhythms, Centrarchidae -other, Reproduction Studies (general), Reservoirs and Impoundments, ...6.0023

THE INFLUENCES OF ENVIRONMENTAL CONDITIONS ON THE TOXICITY OF PESTICIDES ...Bioassay, Fish -non-specific, Pollution - Effects of , Wildlife, ...5.0656

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STUDIES ON PLANTED BROOK TROUT IN RELATION TO NUMBERS PLANTED, LIMNOLOGICAL CONDITIONS AND FOOD SUPPLIES IN UNFISHED LAKES ...Food Supply, Lake Trout, Brook Trout, Lakes, Michigan, Stocking of Fish & Shellfish, ...**6.0303**

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LAKE BASTROP NETTING STUDY ...Commercial Fishing, Ictaluridae -other, Lakes, Nets, Texas, ...**6.0570**

EFFECTS OF WATERSHED MANIPULATION ON DEER AND ELK USE ...Cover Crops, Habitat Studies, Management, Water Yield, Watersheds-general, ...**4.0003**

EVALUATION OF HABITAT AND REPRODUCTIVE FACTORS WHICH INFLUENCE POPULATIONS OF NESTING WATERFOWL ...Habitat Studies, Mapping, Spawn Or Nesting Sites, Water Fowl, N.s. , Water Level Fluctuation, ...**4.0108**

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LIMESTONE DRUM PRODUCTIVITY STUDY ...Aquatic Ecology, Chemical-general, Limestone - General, Ph, Acidity -water, Productivity (agricultural), ...**5.1273**

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THE ECOLOGY OF THE YOUNG FISHES OF THE WEWEANTIC RIVER ESTUARY ...Aquatic Ecology, Estuaries, Massachusetts, Pesticides -non-specific, Pollution - Effects of , ...**2.0607**

MANIPULATION OF RESERVOIR WATER FOR IMPROVED QUALITY AND FISH POPULATION RESPONSE ...Environmental Ecology, Eutrophication, Fish -non-specific, Flow Augmentation, Freshwater Ecology, Reservoirs and Impoundments, ...**5.1294**

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CANNERY WASTE RESEARCH PROJECT ...Canning Wastes, Dynamic Programming, in Plant Treatment Wastes, Process Design, Waste Treatment-economics, ...**5.0099**

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AN ECONOMIC EVALUATION OF WATER POLLUTION CONTROL, YAQUINA BAY, ORE ..Alternative Planning, Bays, Benefit-cost Analysis, Model Studies, Oregon, Water Quality Control-general, ...**6.0454**

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THE DEVELOPMENT OF METHODS USED IN EVALUATING RECREATIONAL BENEFITS OF MULTIPLE-PURPOSE WATER RESOURCE PROJECTS ...Benefit-cost Analysis, Consumption, Demand Analysis, Methods, Multiple-purpose Projects, Recreation Sites, ...**6.0534**

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A PHYSICAL AND ECONOMIC ANALYSIS OF ALTERNATIVE IRRIGATION METHODS IN A SUB-HUMID CLIMATE ...Irrigation-general, North Dakota, Production & Processing, Sub - Humid, ...**6.0415**

ECONOMIC ANALYSIS OF IRRIGATION SYSTEMS APPLICABLE TO THE NORTHERN GREAT PLAINS ...Economic Efficiency, Great Plains Province, Irrigation Engineering, Irrigation-general, Systems Analysis, ...**6.0496**

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ECONOMIC AND LEGAL FACTORS IN PROVIDING, USING, AND MANAGING WATER RESOURCES IN AGRICULTURE ...Irrigation-general, Legal Review, Management, North Central, Optimization, ...**6.0323**

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RURAL LAND USAGE ...Land, Land Use, Land Use -non-specific, Rural Areas, Social Aspects, Types of Resources, ...**6.0471**

A FORECAST OF AGRICULTURAL DEVELOPMENT IN THE IRRIGATED AREAS OF SPAIN ...Benefit-cost Analysis, Irrigation, Irrigation-general, Production & Processing, Spain, ...**6.0532**

JORDANS EAST GHOR DEVELOPMENT PROJECT ...Income, Irrigation-general, Jordan, Land, Land & Water Use -other, ...**4.0180**

EFFECTS OF ON-FARM IRRIGATION WATER SUPPLIES AND COSTS ON CROPPING SYSTEMS AND PRODUCTION ADJUSTMENTS ...California, Irrigation-general, Production & Processing, Water Costs, Water Demand, ...**6.0052**

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A STUDY OF THE SOCIAL MECHANISM OF RURAL-URBAN WATER TRANSFERS WITH SPECIAL REFERENCE TO EXTERNAL EFFECTS ...Administrative Structures, Base Studies, Economic Efficiency, Fiscal, Model Studies, Social Aspects, Water Allocation, Water Transfer, Welfare Economics, ...**6.0105**

AN ECONOMIC AND LEGAL APPRAISAL OF THE USE OF WATER FOR IRRIGATION AND OTHER PURPOSES ON ILLINOIS FARMS ...Illinois, Irrigation-general, Legal Review, Legislative Processes, Water Law-general, ...**6.0214**

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THE POTENTIAL DEMAND FOR WATER AND LAND IN SELECTED AREAS OF UTAH ...Economic Impact, Income, Industry, Utah, Water Demand, ...**6.0578**

ECONOMIC ANALYSIS OF AGRICULTURAL WATER MANAGEMENT IN THE SOUTHEAST ...Benefit-cost Analysis, Economic Impact, Impact, Irrigation-general, Water Demand, ...**6.0169**

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INDUSTRIAL WATER USE IN THE UNITED STATES ...Economics-general, Industry, Manufacturing, Multiple-purpose Projects, Water Utilization -general, ...**5.0239**

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ECONOMIC EFFECTS OF WATER ALLOCATION AMONG ALTERNATIVE INDUSTRIAL (NON-AGRICULTURAL) USES ...Economic Impact, Mineral Processing Industry, Model Studies, Water - Alternative Uses, Water Allocation, ...**6.0597**

THE POTENTIAL DEMAND FOR WATER AND LAND IN SELECTED AREAS OF UTAH ...Agriculture, Economic Impact, Income, Utah, Water Demand, ...**6.0578**

INDUSTRIAL WATER USE IN THE UNITED STATES ...Economics-general, Extractive Natural Resources, Manufacturing, Multiple-purpose Projects, Water Utilization -general, ...**5.0239**

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INDUSTRIAL WATER USE IN THE UNITED STATES ...Economics-general, Extractive Natural Resources, Industry, Multiple-purpose Projects, Water Utilization -general, ...**5.0239**

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HIDDEN COSTS OF USING SUBSTANDARD QUALITY WATER, AS EXPERIENCED BY WATER USERS IN WEBSTER, SOUTH DAKOTA ...Brackish Water, Desalination, Economic Impact, Potable Water, South Dakota, ...**6.0495**

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ON-FARM IRRIGATION WATER SUPPLIES AND COSTS IN RELATION TO CROPPING SYSTEMS AND PRODUCTION ADJUSTMENTS IN THE SACRAMENTO VALLEY ...California, Economic Efficiency, Irrigation-general, Water - Alternative Uses, Water Quantity-general, ...**6.0051**

VALUE OF WATER FOR IRRIGATION IN THE KANSAS RIVER VALLEY ...Benefit-cost Analysis, Consumptive Use, Irrigation-general, Projections and Estimations, Water Demand, ...**6.0236**

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THE ENGINEERING AND ECONOMIC ASPECTS OF USING SEWAGE EFFLUENT FOR IRRIGATION ...Irrigation-general, Louisiana, Sewage, Use of Impaired Water, ...**5.0463**

POLLUTION TAXES AND THE COSTS OF WATER QUALITY MANAGEMENT ...Benefit-cost Analysis, Economic Efficiency, Management, Self-purification, Water Quality Control-general, ...**6.0423**

A CONTINUATION OF THE STUDY TO DETERMINE THE COSTS OF WATER IN INDUSTRIAL USES ...Benefit-cost Analysis, Computers-general, Industrial-general, Model Studies, Water Demand, ...**6.0468**

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RELATIONSHIP OF PUMPING LIFT TO ECONOMIC USE OF GROUND WATER FOR IRRIGATION ...Groundwater, Irrigation-other, Optimization, Pumping, Water Allocation, ...**6.0177**

ECONOMIC AND ENGINEERING ASPECTS OF WATER IN DELAWARE'S AGRI-BUSINESS INDUSTRY ...Industrial Wastes, ...**6.0121**

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ECONOMIC EVALUATION OF CHANGES IN LAND USE OF A MUNICIPAL WATERSHED AS A GUIDE TO DECISION-MAKING ...Discharge-general, Land Use, North Carolina, Reservoirs and Impoundments, Urban Environments, ...**6.0408**

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DEMAND FOR WATER UNDER DYNAMIC CONDITIONS ...Colorado, Public Utilities, Social Aspects, Water Demand, ...**6.0087**

DOMESTIC WATER USE IN EAST AFRICA ...Kenya, Tanzania, Uganda, Water Sources -general, Water Utilization -domestic, ...**4.0092**

EFFECTS OF ON-FARM IRRIGATION WATER SUPPLIES AND COSTS ON CROPPING SYSTEMS AND PRODUCTION ADJUSTMENTS ...Agriculture, California, Irrigation-general, Production & Processing, Water Demand, ...**6.0052**

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WATER REQUIREMENTS FOR CROP PRODUCTION IN THE ROSWELL UNDERGROUND WATER BASIN ...Groundwater Basins, Irrigation, Irrigation-general, Requirements for Water, Tillage, Cropping Systems, ...**3.0334**

SUPPLY AND DEMAND FOR WATER ...Model Studies, Projections and Estimations, Water Demand, Water Supply-general, Water Transfer, ...**6.0385**

IRRIGATION FEASIBILITY ON THE DAYTON, AMITY, WOODBURN, WILLAMETTE AND RELATED SOILS OF THE WILLAMETTE VALLEY ...Benefit-cost Analysis, Irrigation-general, Modified Water Use, Soil Environment, Tillage, Cropping Systems, ...**2.0888**

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THE EFFECT OF BENCH LEVELING AND CONTRIBUTING WATERSHED AREAS ON SOIL MOISTURE STORAGE AND CROP YIELDS IN THE ROLLING PLAINS ...Agricultural Watersheds, Clay, Conservation & Management Eng, Soil Management -other, Yield, ...**3.0449**

ECONOMICS OF AGRICULTURAL WATER USE NORTH OF CANADIAN RIVER ...Agriculture Industry, Application, Cost Analysis, Regression Analysis, Texas, ...**6.0559**

VARIABLE ROW SPACING AS A MEANS FOR REDUCING COSTS AND CONSERVING WATER IN IRRIGATED COTTON PRODUCTION ...Cotton, Irrigation, Irrigation-general, Modified Water Use, Space Competition, ...**3.0448**

ECONOMIC ANALYSIS OF ALTERNATIVE WATER USE TECHNIQUES IN PRODUCTION OF COTTON, GRAIN SORGHUM & RELATED CROPS - SOUTHERN HIGH PLAINS OF TEXAS ...Conjunctive Use, Conservation-general, Economic Efficiency, Irrigation-general, Water - Alternative Uses, ...**6.0571**

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IRRIGATION AND OTHER PRODUCTION RELATIONS IN FLORIDA CITRUS ENTERPRISES ...Benefit-cost Analysis, Citrus, Florida, Input - Output Analysis, Irrigation-general, Water Demand, ...**6.0135**

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ECONOMIC EVALUATION OF NAVIGATION IMPROVEMENTS ...Benefit-cost Analysis, Modes, Navigation, Optimization, Price & Value, Water Transportation, ...**6.0190**

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AN ECONOMIC EVALUATION OF THE TOLEDO BEND RESERVOIR PROJECT ...Benefit-cost Analysis, Louisiana, Multiple-purpose Projects, Policy Making, Reservoirs and Impoundments, Texas, Water Law-general, ...**6.0246**

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THE ECONOMICS OF WATER TRANSFER - AN APPRAISAL OF INSTITUTIONS ...Administrative Structures, Alternative Planning, Economic Efficiency, Legal Review, Model Studies, Water Transfer, ...**4.0169**

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A STUDY OF THE SOCIAL MECHANISM OF RURAL-URBAN WATER TRANSFERS WITH SPECIAL REFERENCE TO EXTERNAL EFFECTS ...Administrative Structures, Agriculture, Base Studies, Economic Efficiency, Fiscal, Model Studies, Social Aspects, Water Allocation, Water Transfer, ...**6.0105**

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CAPACITOR SWITCHING DUTY EVALUATION ...Control, Evaluation Other, Field Testing, Switching, Switching Circuits, ...8.0055

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HIGH-VOLTAGE D-C TRANSMISSION INVESTIGATIONS ...Ac-dc, Dc-ac, Digital Computers, Electrical Engineering-general, Power Regulator, Power Transmission, ...8.0054

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UNDERGROUND TRANSMISSION AND EQUIPMENT DIELECTRICS--SOLID, LIQUID, AND INERT GAS ...Cables and Transmission Lines, Electric Power Plants, Evaluation Other, Field Testing, Power Transmission, ...8.0123

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DEVELOPMENT AND EVALUATION OF IMPROVED TECHNIQUES TO MEASURE WATER-CONTENT OF SNOW ...Composition, Instrumental Services, Moisture Meters, Other Telemetry, Technique Development, ...7.0103

A CONTINUOUS MULTIPARAMETER WATER QUALITY MONITOR ...Analyzing, Instrumental Services, Mobile, Recording Systems, Water Quality-general, ...7.0006

IMPROVE PRECIPITATION MEASURING EQUIPMENT - PRESSURE TRANSDUCER ANALYSIS ...Automatic Stations, Gages, Instrumental Services, ...2.0590

IMPROVE PRECIPITATION MEASURING EQUIPMENT - HYDROLOGIC EQUIPMENT IMPROVEMENT ...Atmospheric Pressure, Data Acquisition Systems, Gages, Instrumental Services, Technique Development, ...7.0051

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ELECTRICAL EARTH RESISTIVITY SURVEYS ...Clastic Aquifers, Electric Logging, Geophysical Analysis, Groundwater, Illinois, ...7.0033

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APPLICATION OF MODERN ELECTROANALYTICAL TECHNIQUES TO THE ANALYSIS OF HEAVY METALS IN WATER ...Analysis and Detection, Heavy Elements, Mineralization, Polarography, Trace Analyses-other, ...1.0040

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AN ANALYSIS OF PHOSPHORUS AND NITROGEN COMPOUNDS IN TIDAL MARSHLAND DRAINAGE - LABORATORY PROCEDURES ...Colorimetric, Computers-general, Management, Nitrogen, Phosphate, Phosphite, Swamps-marshes, ...1.0024

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DEVELOPMENT OF A COULOMETRIC METHOD FOR THE MEASUREMENT OF DISSOLVED OXYGEN IN SEA WATER ...Analysis and Detection, Electrolytic, Gases, Oxygen, Technique Development, ...2.0914

PROCEDURES FOR TRACE ANALYSIS OF DISSOLVED INORGANIC AND ORGANIC CONSTITUENTS IN WATER ...Atomic Absorption, Extraction, Titrimetry-other, Trace Analyses-other, ...5.0442

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ION SELECTIVE ELECTROCHEMICAL SENSORS ...Brackish Water, Brines, Detectors and Sensors, Electrode, Technique Development, ...5.1166

DIFFUSION OF OXYGEN ACROSS THE MUD-WATER INTERFACE IN AQUATIC ENVIRONMENTS ...Aquatic Environments, Diffusion-other, Ions and Gases, Oxygen, ...2.0797

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NITRATE DETERMINATION USING CHROMIUM (II) COMPLEXES ...Chromium, Complexes, Nitrate, Nitrite, Other, Reduction-other, ...1.0121

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OXYGEN STATUS OF SOIL AIR AND SOIL WATER AS INFLUENCED BY OXYGEN TRANSFER THROUGH THE SOIL PROFILE ...Activation Analysis, Moisture-other, Oxygen, Soil Chemical Properties, Soil Environment, ...2.0248

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EVALUATION OF INORGANIC MEMBRANES FOR ELECTRODIALYSIS OF BRACKISH WATERS ...Desalination, Ion Exchange-other, Membranes-other, Stability, Surfactants, ...**3.0209**

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CONCEPTUAL DESIGN STUDY ON ELECTRODIALYSIS MEMBRANE ASSEMBLY MODULAR UNIT DESIGN ...Cost Analysis, Desalination, Membranes-other, Pilot Plant, Potable, ...**3.0228**

CONCEPTUAL DESIGN STUDY FOR ELECTRODIALYSIS ...Cost Analysis, Gasket Materials, Membranes-other, Polarization, Saline Conversion, ...**3.0285**

IMPROVED ION EXCHANGE POLYMERS AND MEMBRANES FOR ELECTRODIALYSIS OF SALINE WATER ...Copolymers, Ion Exchange-other, Membranes-other, Other, ...**3.0395**

STUDIES OF MEMBRANE PHENOMENA - PREPARATION OF NEW ELECTRODIALYSIS MEMBRANES ...Copolymers, Desalination, Membranes-other, Organic, ...**3.0351**

BRACKISH WATER PURIFICATION BY BIOLOGICAL FUEL CELL POWERED ELECTRODIALYSIS ...Biological, Brackish Water, Cellulose Acetate, Desalination, Water Costs, ...**5.0704**

ORGANIC DECOMPOSITION AT POISED O-R POTENTIAL LEVELS ...Anaerobic, Digestion, Membranes-other, Saturated Hydrocarbons, ...**5.0550**

OPTIMAL DESIGN OF WASTE TREATMENT SYSTEMS ...Activated, Biological Treatment-other, Optimization, Oxidation-general, Process Design, ...**8.0202**

RECLAMATION OF BIOLOGICALLY, MECHANICALLY & CHEMICALLY TREATED WASTEWATER FOR POTABLE WATER SUPPLY USES (ABBREV) ...Activated Carbon, Chlorination, Ion Exchange-other, Risk & Uncertainty, Waste Water Pre-treatment, ...**5.0159**

DEMINERALIZATION OF WASTEWATER BY THE TRANSPORT-DEPLETION PROCESS ...Demineralization, Process Design, Sewage Treatment Plant, Waste Treatment-economics, Waste Water Pre-treatment, ...**5.0015**

MATHEMATICAL MODEL OF THE ELECTRODIALYSIS PROCESS FOR ADVANCED WASTE TREATMENT ...Mathematical Analysis, Process Design, Waste Water Treatment-general, ...**5.0531**

PRELIMINARY FEASIBILITY AND ECONOMICS OF DESALTING BRACKISH WATERS IN CANDIATE AREAS OF WEST TEXAS ...Cost Analysis, Desalination, Flash Distillation, Freezing, Reverse Osmosis, Water Costs, ...**3.0443**

PROGRAM FOR ELECTRODIALYSIS RESEARCH AND DEVELOPMENT ...High, Membranes-other, Other, ...**3.0116**

VALUE OF DESALTED WATER FOR IRRIGATION ...Brackish Water, Desalination, Irrigation-general, Saline Soils, Water Costs, ...**3.0128**

ENGINEERING ANALYSIS OF WASTE TREATMENT ...Activated Carbon, Development of Models, Digital Computers, Optimization, Sewerage Systems-other, ...**5.0861**

CONTROL OF MINERAL CONSTITUENTS IN WASTE WATER BY ELECTRODIALYSIS ...Activated Carbon, Membranes-other, Organics, Solid Waste, Waste Treatment-economics, ...**5.0845**

ELECTRODIALYSIS TREATMENT OF SECONDARY EFFLUENT ...Activated Carbon, Demineralization, Pollutant-other, Recycle, Waste Treatment-economics, ...**5.0896**

REMOVAL OF SUSPENDED SOLIDS AND PHOSPHATE FROM A SECONDARY EFFLUENT BY ALUM COAGULATION AND DUAL MEDIA FILTRATION ...Filter-other, Ion Exchange-other, Reverse Osmosis, Sedimentation, Waste Treatment-economics, ...**5.0848**

SINGLE STAGE LIME TREATMENT WASTEWATER ...Concentration, Demineralization, Filter-other, Precipitation, Sedimentation, ...**5.0897**

EXPLORATORY STUDIES ON SIMPLIFYING DISPOSAL OF FOOD PROCESSING WASTES ...Activated Carbon, Canning Wastes, Ion Exchange-other, Other, Regeneration-other, Reverse Osmosis, ...**5.0057**

Electrophoresis

Other

ELECTROPHORETIC CLARIFICATION OF WATER ...Bacterial Pollutant Sources, Colloidal Phenomena, Desalination, Pesticides -non-specific, Tertiary Treatment, Waste Water Treatment-general, ...**5.1157**

THE REMOVAL OF IMPURITIES IN TRICKLING FILTER EFFLUENTS ...Coagulation, Colloidal Phenomena, Secondary Treatment, Tertiary Treatment, Trickling, ...**5.1106**

EXPLORATORY STUDIES ON SIMPLIFYING DISPOSAL OF FOOD PROCESSING WASTES ...Activated Carbon, Canning Wastes, Electrodialysis, Ion Exchange-other, Regeneration-other, Reverse Osmosis, ...**5.0057**

Electromechanical Design

INSTRUMENTATION DEVELOPMENT FOR HYDROLOGIC DATA COLLECTION ...Field Testing, Instrumental Services, Instrumentation-general, Technique Development, ...**7.0089**

Electronic Evaluations

Evaluation Other

EVALUATION OF HYDROLOGIC INSTRUMENTATION ON MAYNARD CREEK WATERSHED ...Data Acquisition Systems, Data Processing Services, Montana, ...**7.0073**

TEST AND EVALUATION OF FLASH FLOOD ALARM SYSTEM ...Field Studies, Field Testing, Flash Floods, Laboratory Analysis, Warning-systems, ...**7.0110**

REACTOR SWITCHING DUTY EVALUATION ...Electrical Engineering-general, Power Transmission, Relay Circuits, Switching, ...**8.0121**

RELAY, CONTROL, AND METERING CIRCUIT INVESTIGATIONS ...Control, Power Transmission, Relay Circuits, ...**8.0122**

UNDERGROUND TRANSMISSION AND EQUIPMENT DIELECTRICS--SOLID, LIQUID, AND INERT GAS ...Cables and Transmission Lines, Electric Power Plants, Field Testing, Insulators, Power Transmission, ...**8.0123**

CAPACITOR SWITCHING DUTY EVALUATION ...Capacitors, Control, Field Testing, Switching, Switching Circuits, ...**8.0055**

CIRCUIT BREAKER RESEARCH ...Circuit Breaker, Electric Power Plants, Electrical Engineering-general, Power Transmission, Switching, ...**8.0052**

COORDINATION OF PLANT FREQUENCY, D-C-TRANSMISSION AND SYSTEM CONTROL ...Ac-dc, Electric Power Plants, Other Generators, Power Conditioner, Power Transmission, ...**8.0126**

Field Testing

TEST AND EVALUATION OF FLASH FLOOD ALARM SYSTEM ...Evaluation Other, Field Studies, Flash Floods, Laboratory Analysis, Warning-systems, ...**7.0110**

INSTRUMENTATION DEVELOPMENT FOR HYDROLOGIC DATA COLLECTION ...Electromechanical Design, Instrumental Services, Instrumentation-general, Technique Development, ...**7.0089**

FIELD TESTS OF POWER TRANSMISSION EQUIPMENT ...Colorado River, Power Transmission, Relay Circuits, Switching, Transmission Lines, ...**8.0036**

UNDERGROUND TRANSMISSION AND EQUIPMENT DIELECTRICS--SOLID, LIQUID, AND INERT GAS ...Cables and Transmission Lines, Electric Power Plants, Evaluation Other, Insulators, Power Transmission, ...**8.0123**

CAPACITOR SWITCHING DUTY EVALUATION ...Capacitors, Control, Evaluation Other, Switching, Switching Circuits, ...**8.0055**

Electronic Technical Services

Data Processing Services

OPERATIONAL HYDROMETEOROLOGICAL DATA MANAGEMENT SYSTEM ...Economics-business-management, Information Retrieval Methods, Management-general, Other Data Analysis, Southern, Streams, System Development, ...**7.0011**

EVALUATION OF HYDROLOGIC INSTRUMENTATION ON MAYNARD CREEK WATERSHED ...Data Acquisition Systems, Evaluation Other, Montana, ...**7.0073**

Instrumental Services

MARINE OIL-WATER MONITORING INSTRUMENTATION SYSTEM SUBGROUP V ...Detectors, Industrial Waste-other, Infrared, Infrared Radiation, Oil, Oil - Technological Testing, ...**5.0336**

TEST SITE INSTRUMENTATION ...Electronics - Applied, Instrumentation-general, Surface Environments, ...**6.0271**

OIL SLICK ANALYSES ...Aircraft, Oil, Optical Devices, Satellites, Transducers, ...**6.0275**

INFRARED IMAGER STUDIES ...Detectors, Geophysical Equipment, Image Amp, Infrared Radiation, Mineralogy, ...**6.0299**

DEVELOPMENT AND EVALUATION OF IMPROVED TECHNIQUES TO MEASURE WATER-CONTENT OF SNOW ...Composition, Moisture Meters, Other Telemetry, Technique Development, Transducers, ...**7.0103**

DIGITAL INSTRUMENTATION AND TELEMETRY FOR WATER RESOURCES RESEARCH ...Automatic Data Aquisition, Digital Computers, Electronics - Applied, ...**7.0072**

INTERNAL WATER STATUS OF PLANTS ...Dielectric Parameters, Plant Water Use-other, Refractometry, Technique Development, Translocation, ...**2.0722**

A CONTINUOUS MULTIPARAMETER WATER QUALITY MONITOR ...Analyzing, Mobile, Recording Systems, Transducers, Water Quality-general, ...**7.0006**

WATER QUALITY TELEMETRY ...Automatic Data Aquisition, Benefit-cost Analysis, Other Telemetry, Water Quality-general, ...**5.1197**

SYSTEM MONITORING AND REMOTE CONTROL ...Automatic Data Aquisition, Effluents-waste Water, Gages, Other Telemetry, Physical Parameters, ...**5.0559**

SACRAMENTO-SAN JOAQUIN DELTA ANALOG MODEL STUDIES ...Analog Computers, Deltas, Electronics - Applied, Model Studies, Sacramento River, ...**7.0008**

IMPROVE COMPONENTS OF THE DATA ACQUISITION SYSTEM - SATELLITE COMMUNICATIONS EQUIPMENT ...Automatic Data Aquisition, Data Acquisition Systems, Rain-general, Satellites & Deep Space Probes, Streams, ...**7.0050**

IMPROVE PRECIPITATION MEASURING EQUIPMENT - PRESSURE TRANSDUCER ANALYSIS ...Automatic Stations, Gages, Transducers, ...**2.0590**

IMPROVE PRECIPITATION MEASURING EQUIPMENT - HYDROLOGIC EQUIPMENT IMPROVEMENT ...Atmospheric Pressure, Data Acquisition Systems, Gages, Technique Development, Transducers, ...**7.0051**

DEVELOPMENT OF HYDROLOGIC EQUIPMENT ...Design Instrumentation-other, Hydraulic Engineering-other, Hydrology-general, Instrumentation-general, Other Telemetry, ...**7.0064**

INSTRUMENTATION DEVELOPMENT FOR HYDROLOGIC DATA COLLECTION ...Electromechanical Design, Field Testing, Instrumentation-general, Technique Development, ...**7.0089**

DENVER MULTIPHASE FLOW ...Analog Computers, Infiltration, Internal Water Movement, Transducers, Unsaturated Flow, ...**2.0192**

INSTRUMENTATION FOR RESEARCH ...Doppler, Fluid Dynamics, Recording Systems, Turbulence, Velocity, ...**7.0109**

PROJECT SKYWATER - NEW MEXICO ...Automatic Stations, Gages, New Mexico, Other Telemetry, Snow-general, Technique Development, ...**2.0203**

PROJECT SKYWATER - COLORADO - STEAMBOAT SPRINGS ...Automatic Stations, Colorado, Gages, Other Telemetry, Snow-general, ...**2.0204**

FISH GUIDING ...Animal Distr. (non-specific), Fish -non-specific, Guidance, Management -other, Water Environment -other, ...**8.0307**

Electronics

Electric Circuits and Networks

Circuit Breaker

CIRCUIT BREAKER RESEARCH ...Electric Power Plants, Electrical Engineering-general, Evaluation Other, Power Transmission, Switching, ...**8.0052**

Control

RELAY, CONTROL, AND METERING CIRCUIT INVESTIGATIONS ...Evaluation Other, Power Transmission, Relay Circuits, ...**8.0122**

CAPACITOR SWITCHING DUTY EVALUATION ...Capacitors, Evaluation Other, Field Testing, Switching, Switching Circuits, ...**8.0055**

Network Synthesis

GEOHYDROLOGIC SYSTEM ANALYSIS WITH AN ELECTRIC ANALOG COMPUTER ...Analog, Analog Computers, Aquifers-general, Digital Computers, Groundwater, Induced Infiltration, Systems Analysis, ...**2.0417**

Relay Circuits

REACTOR SWITCHING DUTY EVALUATION ...Electrical Engineering-general, Evaluation Other, Power Transmission, Switching, ...**8.0121**

FIELD TESTS OF POWER TRANSMISSION EQUIPMENT ...Colorado River, Field Testing, Power Transmission, Switching, Transmission Lines, ...**8.0036**

RELAY, CONTROL, AND METERING CIRCUIT INVESTIGATIONS ...Control, Evaluation Other, Power Transmission, ...**8.0122**

Switching

REACTOR SWITCHING DUTY EVALUATION ...Electrical Engineering-general, Evaluation Other, Power Transmission, Relay Circuits, ...**8.0121**

FIELD TESTS OF POWER TRANSMISSION EQUIPMENT ...Colorado River, Field Testing, Power Transmission, Relay Circuits, Transmission Lines, ...**8.0036**

CAPACITOR SWITCHING DUTY EVALUATION ...Capacitors, Control, Evaluation Other, Field Testing, Switching Circuits, ...**8.0055**

HIGH-VOLTAGE A-C TRANSMISSION ...Analog Computers, Development of Models, Digital Computers, Electrical Engineering-general, Power Transmission, ...**8.0056**

CIRCUIT BREAKER RESEARCH ...Circuit Breaker, Electric Power Plants, Electrical Engineering-general, Evaluation Other, Power Transmission, ...**8.0052**

Electromagnetic Propagation

Microwave

VHF PROPAGATION THROUGH FRESH WATER AND ACROSS THE AIR-WATER INTERFACE ...Fish -non-specific, Telemetry, Transmitters, Very High Frequency, Water Properties-other, ...**1.0129**

Signal Analysis

Doppler

INSTRUMENTATION FOR RESEARCH ...Fluid Dynamics, Instrumental Services, Recording Systems, Turbulence, Velocity, ...**7.0109**

Solid State

Amplifiers

DEVELOPMENT OF ATMOSPHERIC LASER RADAR ...Humidity, Lasers, Lasers and Masers, Radar, Ruby, ...**2.0194**

Detectors

MARINE OIL-WATER MONITORING INSTRUMENTATION SYSTEM SUBGROUP V ...Industrial Waste-other, Infrared, Infrared Radiation, Instrumental Services, Oil, Oil - Technological Testing, ...**5.0336**

INFRARED IMAGER STUDIES ...Geophysical Equipment, Image Amp, Infrared Radiation, Instrumental Services, Mineralogy, ...**6.0299**

Image Amp

INFRARED IMAGER STUDIES ...Detectors, Geophysical Equipment, Infrared Radiation, Instrumental Services, Mineralogy, ...**6.0299**

Switching Circuits

CAPACITOR SWITCHING DUTY EVALUATION ...Capacitors, Control, Evaluation Other, Field Testing, Switching, ...**8.0055**

Transmission Lines

FIELD TESTS OF POWER TRANSMISSION EQUIPMENT ...Colorado River, Field Testing, Power Transmission, Relay Circuits, Switching, ...**8.0036**

POWER TRANSMISSION STRUCTURES, NEW TYPES ...Electric Power Plants, Electrical Engineering-general, Power Transmission, Public Utilities, Structural, ...**8.0120**

Electronics - Applied

TEST SITE INSTRUMENTATION ...Instrumental Services, Instrumentation-general, Surface Environments, ...**6.0271**

APPLICATIONS STUDIES RELATED TO SEA SURFACE TEMPERATURE ...Other Sea Water Properties, ...**6.0272**

OCEANOGRAPHIC USES OF RADAR ...Aircraft, Radar, Surface Environments, Waves, Wind-water Interaction, ...**6.0273**

RADAR DATA ACQUISITION OVER OCEANOGRAPHIC TEST SITES ...Data Acquisition Systems, Icebergs, Optical, Radar, Surface Environments, Waves, ...**6.0274**

DEPTH CONTOURING BY COLOR SEPARATION ...Bathymetry, Marine Photography-television, Optical, Photogrammetry, Satellites, ...**6.0276**

CRATER LAKE VERTICAL TEMPERATURE PROFILES ...Lakes, Oregon, Radioactive Fallout, Temperature, Water Sampling, ...**2.0101**

(U) RADAR MEAS REMENT OF RAINFALL ...Radar, ...**2.0423**

DIGITAL INSTRUMENTATION AND TELEMETRY FOR WATER RESOURCES RESEARCH ...Automatic Data Aquisition, Digital Computers, ...**7.0072**

FEASIBILITY STUDY OF ELECTRICAL GEOPHYSICAL METHODS IN THE DETERMINATION OF SUBSURFACE HYDROGEOLOGIC ENVIRONMENTS IN SOUTH CAROLINA ...Electric Logging, Hydrology-general, Induction, Piedmont Province, Porosity-permeability, Water Table Fluctuation, ...**2.0950**

SACRAMENTO-SAN JOAQUIN DELTA ANALOG MODEL STUDIES ...Analog Computers, Deltas, Instrumental Services, Model Studies, Sacramento River, ...**7.0008**

REMOTE SENSING OF WATER VAPOR ...Humidity, Optics, Radio, Temperature, Turbulence-general, ...**7.0015**

Electrophoresis

Electrophoresis -other

FACTORS AFFECTING FISH PRODUCTION PONDS ...Blood Proteins -non-specific, Bluegills, Bream, Environmental Physiology, Protein, Purif and Isol, ...**6.0221**

Encapsulation

ENCAPSULATION AND SOLIDIFICATION OF INTERMEDIATE LEVEL RADIOACTIVE WASTES IN THERMOPLASTICS ...Accidental, Fire Research-other, Instrumentation, Plant Equip. , Polymer-other, Radioisotopes, Recovery, Scrap and Wastes, ...**5.1142**

Endocrine System

Endocrine -other

SERUM ANALYSIS OF CUTTHROAT TROUT EXPOSED CHRONICALLY TO METHOXYCHLOR PESTICIDE EFFECTS ON FISH ENDOCRINE FUNCTIONS ...Blood Plasma and Serum, Cutthroat Trout, Methoxychlor, Mode of Action -animal, ...**5.0629**

THE CONSTITUENTS AND PHVSICO-CHEMICAL PROPERTIES OF SERUM FROM GOLD-FISH EXPOSED CHRONICALLY TO MALATHION AND ENDRIN ...Blood Plasma and Serum, Endrin, Goldfish, Malathion, Mode of Action -animal, ...**5.0630**

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Gonadotropins

EFFECTS OF MALATHION ON THE SEXUAL DEVELOPMENT OF MALE RAINBOW TROUT - PESTICIDE EFFECTS ON FISH ENDOCRINE FUNCTIONS ...Gonadotrophins, Malathion, Mode of Action -animal, Pollution - Effects of , Rainbow Trout, Steelhead Trout, ...5.0633

Thyroid

THYROID FUNCTION OF GOLDFISH AND RAINBOW TROUT EXPOSED CHRONICALLY TO MALATHION AND ENDRIN - PESTICIDE EFFECTS ON FISH ENDOCRINE FUNCTIONS ...Endrin, Goldfish, Malathion, Mode of Action -animal, Rainbow Trout, Steelhead Trout, ...5.0631

Endrin X Biocid

INTERACTION OF ENDRIN AND PROLACTING-INDUCED FAT SYNTHESIS IN THE PLAINS KILLIFISH - PESTICIDE EFFECTS ON FISH ENDOCRINE FUNCTIONS ...Adipose, Killifishs - Cyprinodon, Metabolism -animal, Photoperiod, ...5.0657

Energy Loss -water

SPATIAL BEHAVIOR OF ROUGHNESS IN LABORATORY WATERSHED, PHASE II ...Model Studies, Roughness, Runoff, Structure-size, Surface Flow, Synthetic Hydrology-general, ...2.0703

FLOW LOSSES IN AN EPHEMERAL STREAM CHANNEL ...Conservation-general, Ephemeral, Infiltration, Morphology-general, Open Channel Flow, Water Cycle, ...2.0178

PROTECTION OF ERODIBLE CHANNELS AND SURFACES WITH GRAVEL OR RIPRAP ...Canals, Channels, Engineering Structures-general, Flow Characteristics -water, Groundwater, Linings-pavings, Scouring, Seepage, ...8.0040

Engineering Mechanics

Analysis

Analysis-other

TURBULENT BOUNDARY LAYERS IN PRESSURE CRADIENTS ...Integrals, Laminar - Turbulent, Pressure Gradient, Separation, ...8.0181

Ultimate

HYDRAULIC AND STRUCTURAL DESIGN - SPILLWAYS AND OUTLET WORKS ...Concrete-other, Hydraulic Structures, Models, Spillways, ...8.0139

Deflection

PROTOTYPE ANALYSES - LOCK BEHAVIOR INVESTIGATION ...Concrete-general, Hydraulic Structures, Internal, Locks, Pressure-general, ...8.0256

Deformations

FLUID ELASTIC OPERATORS FOR UNDER-STREAMLINED STRUCTURES ...Compressible Fluid, Geometric Configuration, Hydraulic Equipment, ...2.0472

Forces and Loading

Axial

EFFECTIVENESS OF WEB REINFORCEMENT IN REINFORCED CONCRETE BEAMS SUBJECT TO AXIAL FORCES ...Beams - Bars, Moments, Reinforced, Shearing, Strength, ...8.0152

Dynamic-other

STRUCTURAL RESPONSE, DYNAMIC LOADS ...Computers-general, Earthquakes, Electric Power Plants, Industrial Structures, Other Computers, Rock Mechanics, ...8.0032

BEHAVIOR OF STRUCTURAL ELEMENTS OR MODELS UNDER TEMPERATURE AND DYNAMIC LOADS ...Earthquakes, Engineering Structures-general, Mechanical Vibrations-other, Model Studies, Structures-other, ...8.0100

EARTHQUAKE THEORY AS APPLIED TO DAMS AND APPURTENANT STRUCTURES ...Arch Dams, California, Earthquakes, Engineering Structures-general, ...8.0096

Moving

DYNAMIC PROPERTIES OF GRANULAR BASE MATERIALS IN SATURATED AND PARTIALLY SATURATED CONDITIONS ...Granular-general, Moisture Content, Pavement, Soil Dynamics, Soil Mechanical Properties, ...2.0305

Fracture Mechanics

EPOXY RESINS FOR CIVIL WORKS PROJECTS ...Concrete-other, Construction-other, Epoxies, Maintenance, Repairing, ...8.0248

EFFECTS OF CRACKING IN ARCH DAMS ...Analysis Structural, Arch Dams, Computers-general, Engineering Structures-general, Tensile, ...8.0092

REINFORCEMENT OF OPENINGS IN MASSIVE CONCRETE STRUCTURES ...Analysis Structural, Gravity Dams, Reinforced, Stress Concentration, Thermal, ...8.0093

Layered System

BEDDING AND INFILTRATION STUDIES OF SANITARY SEWERS IN THE GULF COAST AREA ...Appurtenances, Infiltration - Percolation, Pipe-laying, South Central, ...5.0461

Mechanical Vibrations

Linear

R.I.-LIQUEFACTION OF SAND DUE TO LONG TERM, SMALL AMPLITUDE VIBRATIONS ...Sand, Saturated-unsaturated, Shearing, Soil Dynamics, Soil Liquefaction, ...7.0045

Mechanical Vibrations-other

BEHAVIOR OF STRUCTURAL ELEMENTS OR MODELS UNDER TEMPERATURE AND DYNAMIC LOADS ...Dynamic-other, Earthquakes, Engineering Structures-general, Model Studies, Structures-other, ...8.0100

REVIBRATION OF CONCRETE AND MASONRY ...Cement, Concrete, Concrete-other, Physical Properties-general, Standards, Specifications, Vibration, ...8.0108

Non-linear

VIBRATION OF LOW-CREST SPILLWAYS ...Hydrodynamic Structures, Spillways, ...7.0068

Moments

EFFECTIVENESS OF WEB REINFORCEMENT IN REINFORCED CONCRETE BEAMS SUBJECT TO AXIAL FORCES ...Axial, Beams - Bars, Reinforced, Shearing, Strength, ...8.0152

Stability

CONVECTIVE INSTABILITY IN TRANSIENT SYSTEMS ...Approximations, Partial, Transport-other, ...1.0048

WAVE ACTION ON STRUCTURES ...Engineering Structures-general, Hydrodynamic Structures, Models, Shoreline Structures, Wave Action, ...8.0150

Strain

Shearing

R.I.-LIQUEFACTION OF SAND DUE TO LONG TERM, SMALL AMPLITUDE VIBRATIONS ...Linear, Sand, Saturated-unsaturated, Soil Dynamics, Soil Liquefaction, ...7.0045

RHEOLOGY OF SOIL-WATER SYSTEMS ...Compressibility, Creep and Rheology, Moisture Content, Soil Dynamics, Viscoelasticity, ...2.0082

EFFECTIVENESS OF WEB REINFORCEMENT IN REINFORCED CONCRETE BEAMS SUBJECT TO AXIAL FORCES ...Axial, Beams - Bars, Moments, Reinforced, Strength, ...8.0152

Strain-general

DEVELOPMENT OF INSTRUMENTS FOR PROTOTYPE TESTING ...Concrete-general, Laboratory Analysis, Model Studies, Stresses-general, ...8.0239

Strength

DURABILITY OF CONCRETE DRAIN TILE AND IRRIGATION PIPE ...Drainage, Pipes, Plain, Specifications, Techniques, ...8.0221

EFFECTIVENESS OF WEB REINFORCEMENT IN REINFORCED CONCRETE BEAMS SUBJECT TO AXIAL FORCES ...Axial, Beams - Bars, Moments, Reinforced, Shearing, ...8.0152

Stress Concentration

REINFORCEMENT OF OPENINGS IN MASSIVE CONCRETE STRUCTURES ...Analysis Structural, Fracture Mechanics, Gravity Dams, Reinforced, Thermal, ...8.0093

Stresses

Internal

PROTOTYPE ANALYSES - LOCK BEHAVIOR INVESTIGATION ...Concrete-general, Deflection, Hydraulic Structures, Locks, Pressure-general, ...**8.0256**

Stresses-general

DEVELOPMENT OF INSTRUMENTS FOR PROTOTYPE TESTING ...Concrete-general, Laboratory Analysis, Model Studies, Strain-general, ...**8.0239**

MASSIVE-HEAD BUTTRESS DAMS ...Dams-other, Foundations-general, Gravity Dams, Uplift, ...**8.0094**

Tensile

EFFECTS OF CRACKING IN ARCH DAMS ...Analysis Structural, Arch Dams, Computers-general, Engineering Structures-general, Fracture Mechanics, ...**8.0092**

Thermal

REINFORCEMENT OF OPENINGS IN MASSIVE CONCRETE STRUCTURES ...Analysis Structural, Fracture Mechanics, Gravity Dams, Reinforced, Stress Concentration, ...**8.0093**

Techniques

Optical

DEVELOPMENT OF THREE-DIMENSIONAL PHOTOELASTIC TECHNIQUES ...Epoxies, Photoelasticity, ...**8.0109**

Engineering Structures-general

WATERSHED SHAPE-FACTOR ...Culvert , Design Criteria, Drainage, North Dakota, Peak Flow, ...**2.0277**

HYDRAULIC PERFORMANCE OF BRIDGES ...Bridges & Culverts, Culvert, Design Criteria, Dike, Drainage, ...**8.0158**

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High Temp. - 85f Or Above

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POLITICAL PROCESSES IN THE PROMOTION OF WATER RESOURCE DEVELOPMENT PROGRAMS ...Intergovernmental Relations, Management and Administration, Mississippi, State-local Government, Water Resources Development, ...**6.0316**

ECONOMIC ANALYSIS OF RESOURCE AREAS ...Economics-general, History, Social Aspects, Water Resources Development, ...**6.0098**

SCENIC RIVERS STUDY ...Intergovern Relations, Recreation Sites, Wild Rivers, ...**3.0170**

Feed Science and Technology

Fish Meals

REMOVAL OF PESTICIDES FROM FRESHWATER FISH ...Bioassay, Fish -non-specific, Mode of Action -animal, Pesticides -non-specific, Removal of Residues, ...**5.0543**

Forages, N. s.

DEER FOODS ON WATERSHEDS TREATED FOR INCREASED WATER YIELD ...Arizona, Deer Ns, Food Supply, Water Yield, ...**4.0004**

Methods of Feeding

Grazing

ANIMAL, FORAGE AND WATER RESOURCES FOR BEEF PRODUCTION ...Management, Quality and Utilization, ...**5.0086**

EFFECTS OF RANGE PLANT FOLLIAGE REMOVAL ON SOIL MOISTURE REGIME ...Management and Fertility, Modified Water Use, Moisture Content, Seasonal, ...**2.1063**

THE INFLUENCE OF GRAZING MANAGEMENT SYSTEMS ON VEGETATION COMPOSITION AND LIVESTOCK REACTION ...Agricultural Watersheds, Conservation-general, Management and Fertility, Water Loss-general, ...**5.1160**

Processing and Preservation

Pelleted

A COMPARISON OF THE GROWTH RATE OF BLUE CATFISH AND CHANNEL CATFISH FINGERLINGS FOR A PELLETED COMMERCIAL FEED ...Aquaculture & Fish-farming, Channel Catfish, Growth Rate, ...**5.1179**

Rations

Fish Rations

PRODUCTION OF ADULT GAME FISHES BY ARTIFICIAL FEEDING ...Aquaculture & Fish-farming, Fish -non-specific, Food Supply, ...**6.0181**

Ferrous Alloys

Alloy & Systems

CORROSION AND MASS TRANSFER FROM CYLINDERS OF METALS ROTATING IN SEAWATER AT HIGH TEMPERATURES AND PRESSURES ...Aluminum, Desalination, High, Water, ...**3.0247**

DEVELOPMENT OF A LOW-COST IRON-BASE ALLOY TO RESIST CORROSION IN HOT SEA-WATER ...Desalination, Orientation, Polarization, Saline Conversion, Water, ...**3.0418**

INVESTIGATION OF CORROSION FUNDAMENTALS AS RELATED TO ALLOYING ...Additives, Aluminum, Copper, Corrosion General, ...**3.0415**

APPLICATION OF IRON-ALUMINUM BASE ALLOYS TO SALINE WATER CONVERSION ...Cost Analysis, Desalination, Pipe, Tube, Stainless Steels-other, Water, ...**3.0099**

Ferrous Alloys - Other

EVALUATION OF CONCRETE AND RELATED MATERIALS FOR USE IN DESALINATION PLANTS ...Cement, Concrete, Coatings-general, Corrosion General, Saline Conversion, Sealant Materials, ...**8.0062**

Low Alloy Steels

SEAWATER CORROSION CONTROL BY ENVIRONMENT MODIFICATION ...Environment General, Inhibitors, Other, Saline Conversion, Water, ...**3.0454**

CORROSION OF UNDERGROUND STEEL PILING ...Corrosion Prevention-other, Deep, Soil Chemical Properties, Soil Electrical Properties, Soils, ...**8.0223**

CORROSION MITIGATION ...Corrosion Prevention-other, Deep, Marine Fouling, Pre-stressed, Water, ...**8.0157**

CORROSION MITIGATION -CATHODIC PROTECTION OF WATER-IMMERSED STEEL STRUCTURES ...Cathodic Protection, Coatings-general, Engineering Studies-general, Hydraulic Structures, ...**8.0172**

CORROSION OF METALS IN CONCRETE ...Cement, Concrete, Chloride, Stress, Strain, Water, ...**8.0023**

Ores

IRON ORE FLOTATION ...Beneficiation, Flotation, Industrial Processes-other, Mining Industry, Pollution Abatement, Recovery, Scrap and Wastes, ...**5.0616**

Reinforcing Steel

TENSILE CRACK EXPOSURE TESTS ...Beams - Bars, Cement, Concrete, Crack Initiation, Propagation, Standards, Specifications, Weathering, ...**8.0252**

Stainless Steels

Austenitic

EFFECT OF ELECTROCHEMICAL AND METALLURGICAL FACTORS ON CORROSION OF METALS AND ALLOYS ...Chemicals, Galvanic, Passivation, Pitting, Water, ...**3.0282**

THE ROLE OF BRITTLE SURFACE FILMS IN STRESS-CORROSION CRACKING ...Alloys and Systems, Brittleness, Copper, Film, Stress Corrosion, Titanium, ...**3.0254**

Stainless Steels-other

EFFECT OF ELECTROCHEMICAL AND METALLURGICAL FACTORS ON CORROSION OF METALSAND ALLOYS ...Brines, Desalination, Pitting, ...**3.0283**

APPLICATION OF IRON-ALUMINUM BASE ALLOYS TO SALINE WATER CONVERSION ...Alloy & Systems, Cost Analysis, Desalination, Pipe, Tube, Water, ...**3.0099**

Fertilizer Technology

Fertilizer Losses

UREA TRANSFORMATIONS AND RETENTION IN FLOODED SOILS ...Drainage, Nitrogen, Soil and Rock Leaching, Soil Environment, ...**4.0123**

RELATION OF SOIL FERTILITY TO THE EXCHANGE COMPLEX ...Drainage, Mineral Nutrition, Missouri, Soil Environment, Soil pH , ...**5.0678**

NITRATES IN PLANTS ...Fertilizers, Management, Nitrate, Nitrite, Pollution - Effects of , Survey Studies, ...**5.0680**

BEHAVIOR OF NITROGEN IN THE SOIL ...Nitrogen, Soil and Rock Leaching, Soils and Fertilizer, ...**5.0715**

THE LOSS OF FERTILIZERS BY LEACHING FROM THE SOILS OF PUERTO RICO ...Fertilizers, Methods of Application, Puerto Rico, Soil and Rock Leaching, ...**3.0428**

THE LOSS OF FERTILIZERS BY LEACHING FROM THE SUGARCANE SOILS OF PUERTO RICO ...Lysimeters, Methods of Application, Other, Puerto Rico, Sugar Cane, ...**2.0938**

Fertilizer Materials

Concentration Within Fertilize

CITRUS FERTILIZER TEST ON SEVERAL PRINCIPAL CITRUS SOIL TYPES IN THE LOWER RIO GRANDE VALLEY OF TEXAS ...Citrus , Irrigation, Irrigation-general, Rates Or Levels of Application, Soil Types, ...**2.1034**

RICE CULTURE ...Management, Maturity & Growth Stages, Methods of Application, Other, Rates Or Levels of Application, Rice, Varietal Evaluation, Yield, ...**2.0570**

Formulation

CULTURAL MANAGEMENT PRACTICES OF FORAGE CROPS FOR PASTURES HAY OR SILAGE ...Irrigation, Quality and Utilization, Rates Or Levels of Application, Yield, ...**3.0176**

Source of Fertilizer

APPLICATION OF SEWAGE SLUDGE TO FIELD CROPS ...Disposal, Fertilizing, Planting & Cult, Methods of Application, Organic Fertility -other, Sewage, Waste Disposal -underground, ...**5.0363**

Fertilizer Technology -other

FIXATION AND AVAILABILITY OF ADDED PHOSPHORUS IN SOILS ...Absorption, Fixation, Exchange, Phosphorus, Soil Environment, ...**1.0053**

Methods of Application

APPLICATION OF SEWAGE SLUDGE TO FIELD CROPS ...Disposal, Fertilizing, Planting & Cult, Organic Fertility -other, Sewage, Source of Fertilizer, Waste Disposal -underground, ...**5.0363**

THE LOSS OF FERTILIZERS BY LEACHING FROM THE SOILS OF PUERTO RICO ...Fertilizer Losses, Fertilizers, Puerto Rico, Soil and Rock Leaching, ...**3.0428**

THE LOSS OF FERTILIZERS BY LEACHING FROM THE SUGARCANE SOILS OF PUERTO RICO ...Fertilizer Losses, Lysimeters, Other, Puerto Rico, Sugar Cane, ...**2.0938**

RICE CULTURE ...Concentration Within Fertilize, Management, Maturity & Growth Stages, Other, Rates Or Levels of Application, Rice, Varietal Evaluation, Yield, ...**2.0570**

Placement of Fertilizer

Band Width

THE EFFECT OF VARIOUS COMMERCIAL FERTILIZER PLACEMENTS AND IRRIGATION PRACTICES ON THE YIELD AND QUALITY OF RUSSET BURBANK POTATOES ...Irrigation, Irrigation-general, Potatoes, Soil Temp. -non-specific, Yield, ...**2.0228**

Depth

MANAGEMENT OF FLATWOOD SOILS ...Sand, Tillage, Cropping Systems, Water Table - Depth of , Water Table Fluctuation, ...**6.0153**

Rates Or Levels of Application

STUDIES IN SOILS AND AGRONOMIC PRACTICES - SHOSHONE PROJECT, WYOMING ...Air - Water - Plant Relations, Big Horn, Management, Physical Properties-general, Saline and Alkaline Soils, ...**3.0494**

THE EFFECT OF IRRIGATION METHOD, AND MOISTURE AND FERTILITY LEVELS UPON MAXIMIZING WATER USE EFFICIENCY AND QUALITY COTTON FIBER PRODUCTION ...Cotton, Furrow Irrigation, New Mexico, Soil Fertility, Subsurface Irrigation, Water Loss Control, ...**3.0337**

THE EFFECT OF VARYING SOIL MOISTURE REGIMES ON THE YIELD AND LEAF NITROGEN COMPOSITION OF CORN ...Corn, Fertility Competition - Soil, Management, Nitrogen, Soil-water-plant Relationships, ...**2.0446**

NITROGEN REQUIREMENT FOR SKIP-ROW COTTON ...Cotton, Nitrogen, Soil Tillage Methods -other, ...**3.0303**

INFLUENCE OF SOIL MOISTURE AND SOIL FERTILITY LEVELS ON ASPARAGUS YIELD AND QUALITY ...Asparagus, Coastal Plain, Moisture Content, Moisture Levels, ...**2.0760**

NITROGEN FERTILIZATION AND IRRIGATION OF TOBACCO ...Irrigation, Management, Moisture Deficiency, Nitrogen, ...**2.0870**

IRRIGATION OF COTTON AND CORN. ...Corn, Cotton, Irrigation, Irrigation-general, Yield, ...**2.0960**

FERTILIZER TREATMENTS AND CULTURAL PRACTICES ON VEGETABLES ...Aerial, Quality -non-specific, Root, Texas, Yield, ...**6.0553**

CITRUS FERTILIZER TEST ON SEVERAL PRINCIPAL CITRUS SOIL TYPES IN THE LOWER RIO GRANDE VALLEY OF TEXAS ...Citrus, Concentration Within Fertilize, Irrigation, Irrigation-general, Soil Types, ...**2.1034**

PRUNE ORCHARD MANAGEMENT ...Internal Necrosis, Nitrogen, Plums, Trees, ...**6.0611**

DIFFERENTIAL RESPONSE OF SORGHUMS TO DIFFERENCES IN CULTURE AND ENVIRONMENT ...Drought, Growth Rate, Milo and Grain Sorghum, Modified Water Use, Moisture Deficiency, ...**2.0578**

RICE CULTURE ...Concentration Within Fertilize, Management, Maturity & Growth Stages, Methods of Application, Other, Rice, Varietal Evaluation, Yield, ...**2.0570**

CULTURAL MANAGEMENT PRACTICES OF FORAGE CROPS FOR PASTURES HAY OR SILAGE ...Formulation, Irrigation, Quality and Utilization, Yield, ...**3.0176**

RELATION OF NITROGEN LEVEL, HIGH WATER TABLE AND SOIL SALINITY TO GROWTH, YIELD AND FRUIT QUALITY OF DATES ...Saline Soils, Trees, Water Table - Depth of , Water Table Fluctuation, ...**3.0185**

ECONOMIC ANALYSIS OF WATER USE IN IRRIGATION IN THE NORTHERN PLAINS ...Benefit-cost Analysis, Costs, Great Plains Province, Irrigation-general, Production & Processing, Water - Alternative Uses, ...**4.0077**

Timing of Application

Other

THE LOSS OF FERTILIZERS BY LEACHING FROM THE SUGARCANE SOILS OF PUERTO RICO ...Fertilizer Losses, Lysimeters, Methods of Application, Puerto Rico, Sugar Cane, ...**2.0938**

RICE CULTURE ...Concentration Within Fertilize, Management, Maturity & Growth Stages, Methods of Application, Rates Or Levels of Application, Rice, Varietal Evaluation, Yield, ...**2.0570**

Types of Applied Fertilizer

Fertilizer Types -other

LETTUCE PHYSIOLOGY ...Growth, Irrigation, Moisture Content, Moisture Levels, ...**2.0032**

Fiber, Filament, Whisker

DEVELOPMENT OF IMPROVED CELLULOSE ACETATE MEMBRANES FOR REVERSE OSMOSIS ...Cellulose Acetate, Desalination, Reverse Osmosis, ...**3.0264**

DEVELOPMENT OF A WATER DESALINATION SYSTEM BASED ON HOLLOW FINE FIBER MEMBRANES ...Cellulosics, Desalination, Membranes-other, Pilot Plant, Reverse Osmosis, ...**3.0274**

RESEARCH ON POROUS GLASS MEMBRANES FOR REVERSE OSMOSIS ...Desalination, Glass, Membranes-other, Porosity, Permeability, Reverse Osmosis, Waste Water Treatment-other, ...**3.0068**

TREATMENT OF MUNICIPAL SECONDARY EFFLUENT BY REVERSE OSMOSIS ...Carbon, Glass, Membranes-other, Pollutant-fouling, Reverse Osmosis, Waste Water Pre-treatment, ...**5.0131**

GLASS FIBER REINFORCED PLASTIC MORTAR PIPE FOR PRESSURE IRRIGATION DISTRIBUTION SYSTEM ...Glass, Irrigation Engineering, Pipe, Tube, Pipelines, Plastic Matrix, ...**8.0027**

Field Soils Compaction

SPECIAL STUDIES FOR CIVIL WORKS SOILS PROBLEMS ...Design Criteria, Earth & Rockfill Dams, Erosion Control, Slopes, Wave Action, ...**8.0255**

VIBRATORY COMPACTION OF COHESIVE SOILS ...Cohesive Soil-general, Compaction, Dams, Embankments, Soil Dynamics, ...**8.0135**

Field Studies

TEST AND EVALUATION OF FLASH FLOOD ALARM SYSTEM ...Evaluation Other, Field Testing, Flash Floods, Laboratory Analysis, Warning-systems, ...**7.0110**

GEOLOGIC ASPECTS OF SEA-WATER ENCROACHMENT - RECOGNITION OF LATE GLACIAL SUBSTAGES IN NEW YORK AND NEW ENGLAND ...New York, Quaternary Period, Saline Water Intrusion, Sea Level Variations, Shoreline - Coastline, ...**2.0300**

Film

MEMBRANES FOR REVERSE OSMOSIS DESALINATION BY DIRECT CASTING ON POROUS SUPPORTS ...Cellulosics, Cost Analysis, Natural Occurring, Reverse Osmosis, Saline Conversion, ...**3.0309**

STUDY OF ORIENTED CELLULOSE MEMBRANES FOR REVERSE OSMOSIS AND THE RELATIONSHIP BETWEEN MORPHOLOGY AND SALT REJECTION ...Desalination, Membranes-other, Orientation, Reverse Osmosis, Structure-materials-general, ...**3.0248**

INVESTIGATION OF THE USE OF LOW-COST PLASTIC FILMS FOR SOLAR STILL CONSTRUCTION ...Costs, Distilling Units, Glass, Plastics - General, Structural, Weathering, ...**3.0391**

CHARACTERIZATION OF CELLULOSE ACETATE MEMBRANES AND ULTRATHIN FILMS FOR REVERSE OSMOSIS ...Desalination, Electrical Properties, Membranes, Membranes-other, Natural Occurring, Reverse Osmosis, ...**3.0362**

DEVELOPMENT OF DIRECT CONTACT CONDENSATION MULTISTAGE FLASH (DCC-MSF) DISTILLATION PROCESS ...Brines, Condensation, Desalination, Flash Distillation, Heat Transfer, Plastics - General, ...**3.0040**

PREPARATION OF REVERSE OSMOSIS MEMBRANES BY SURFACE MODIFICATION OF CELLULOSE AND RELATED MATERIALS ...Cellulosics, Desalination, Membranes-other, Morphology-other, Reverse Osmosis, ...**3.0212**

EVALUATION OF DESALINATION PROPERTIES OF CELLULOSE ACETATE MEMBRANES IN FLAT, TUBULAR AND SPIRAL WOUND CONFIGURATIONS ...Desalination, Membranes-other, Natural Occurring, Saline Conversion, Stress, Strain, ...**3.0052**

THE ROLE OF BRITTLE SURFACE FILMS IN STRESS-CORROSION CRACKING ...Alloys and Systems, Austenitic, Brittleness, Copper, Stress Corrosion, Titanium, ...**3.0254**

CONTROL OF SEEPAGE FROM WATER CONVEYANCE AND STORAGE STRUCTURES IN THE INTER-MOUNTAIN AREA ...Linings-pavings, Seepage, Storage of Water, Water Loss Control, Water Transfer, ...**8.0291**

FACILITIES AND SYSTEMS FOR WATER HARVEST IN THE INTER-MOUNTAIN BASIN ...Durability, Deterioration, Mountains-alpine, Storage of Water, Water Harvesting, Water Loss Control, ...**8.0292**

Film Deposition

Vapor

DEVELOPMENT OF PERMANENT SYSTEMS FOR DROPWISE CONDENSATION ...Condensation, Distillation-other, Films, Heat Transfer, Pilot Plant, ...**3.0411**

Filter Materials

COUPLING OF FLOWS AROUND AND THROUGH POROUS MEDIA ...Boundary-layer-other, Liquid - Solid Interactions, Porous Media - Flow Through, ...**2.0661**

Filters

Membrane

RAPID IDENTIFICATION OF MICROBIAL POPULATIONS IN WATER ...Biological Pollutants -general, Fresh Water, Identification, Water Bacteria, ...**5.1167**

QUANTITATIVE DETECTION AND ENUMERATION OF POLLUTION INDICATOR BACTERIA OF WASTE WATERS AND SEWAGE TREATMENT PLANT EFFLUENTS ...Bacteria, Bacterial Pollutant Sources, Bioindicators, Detection, Sewage Testing, ...**5.0853**

Millipore

ECOLOGY OF YEASTS IN LAKE CHAMPLAIN ...Lakes, New York, Plant Taxonomy, Yeast N S, ...**6.0395**

Finland

BIOLOGICAL (ENRICHMENT) CHAINS OF RADIONUCLIDES IN FINNISH LAKES ...Cesium, Eutrophication, Nutrients, Radioactive Fallout, Radioisotopes, ...**2.0309**

Fish

Alewife,menhaden,shad,herring

DISTRIBUTION AND ABUDANCE OF JUVENILE AMERICAN SHAD, ALOSA SAPIDISSIMA (WILSON), IN THE CONNECTICUT RIVER ABOVE HOLYOKE DAM, MASSACHUSETTS ...Connecticut River, Engineering Structures-general, Massachusetts, Migration, Number Or Density, ...**3.0271**

FOOD HABITS OF LARVAL AND JUVENILE SHAD IN THE CONNECTICUT RIVER ...Aquatic Ecology, Connecticut River, Food Supply, Massachusetts, Recreation Sites, ...**3.0272**

DISTRIBUTION AND GROWTH PATTERNS OF THE GIZZARD SHAD (DOROSOMA CEPEDIANU) AND THREADFIN SHAD (DOROSOMA PETENENSE) IN RESERVOIRS ...Arkansas, Growth Rate, Number Or Density, Reservoirs and Impoundments, Temporal Distribution, ...**6.0029**

FISH POPULATION STUDIES. (DEWEY RESERVOIR) ...Aquatic Ecology, Fertilizers -aquatic, Kentucky, Population Dynamics, Reservoirs and Impoundments, ...**5.0437**

STUDY OF THE RIVER PHASE OF THE LIFE HISTORIES OF ALOSA PSEUDOHARENGUS AND AESTIVALIS ...Aquatic Ecology, Connecticut River, Environmental Ecology, Life History Studies, Spawn Or Nesting Sites, ...**6.0111**

POTENTIAL FISHERY FOR RIVER HERRINGS IN CONNECTICUT RIVER ...Connecticut River, Environmental Ecology, Life History Studies, Nets, Spawn Or Nesting Sites, ...**4.0075**

EFFECTS OF THERMAL AND OTHER FORMS OF POLLUTION ON SOME ANADROMOUS FISHES ...Aquatic Ecology, Basses - sea,white, White Perch, Pollution - Effects of , Pollution Effects, Thermal Pollution, ...**5.0739**

FARMINGTON RIVER SHAD STUDIES ...Bottom Sampling, Migration, Plankton Sampling, Water Properties-general, Water Sampling, ...**6.0117**

POPULATION ESTIMATES FROM MIDWATER TRAWL SAMPLING ...Aquatic Ecology, Arkansas, Nets, Population Dynamics, Reservoirs and Impoundments, ...**6.0019**

DESIGN AND CONSTRUCTION OF GEAR FOR MIDWATER TRAWLING ...Arkansas, Nets, Population Dynamics, Reservoirs and Impoundments, ...**4.0016**

ESTUARINE BIOLOGY--RESPONSE OF LARVAE TO TEMPERATURE AND SALINITY ...Aquatic Ecology, Environmental Ecology, Estuaries, Salinity, Temperature, ...**2.0817**

Atlantic Salmon, Sebago Salmon

EFFECTS OF CHRONIC SUBLETHAL DOSAGES OF DDT ON THE SWIMMING PERFORMANCE OF ATLANTIC SALMON PARR ...DDT , Locomotion -animal, Mode of Action -animal, Stamina, Wildlife, ...**5.0472**

Basses -sea,white, White Perch

STUDY OF STRIPED BASS POPULATIONS IN MAINE COASTAL WATERS ...Aquatic Ecology, Estuaries, Maine, Migration, ...**5.0470**

COMPILATION OF WATER QUALITY DATA ...Aquatic Ecology, Data Acquisition-general, Data Analysis - General, Lakes, Water Quality-general, ...**5.0459**

EFFECTS OF WATER QUALITY ON HATCHING SUCCESS ...Captive Rearing, Hatchability, Louisiana, Pollution - Effects of , Water Properties-general, ...**5.0453**

EFFECTS OF CHANGES IN WATER QUALITY ON FRY AND FINGERLINGS ...Aquatic Ecology, Chemical-general, Environmental Ecology, Louisiana, Water Quality-general, ...**5.0454**

DEVELOPMENT AND IMPROVEMENT OF INSTRUMENTATION AND SAMPLING GEAR FOR USE IN LIMNOLOGY AND FISHERY BIOLOGY ...Nets, Plankton Sampling, Salmon & Trout - Non-specific, Tags, Telemetry, ...**7.0115**

STATEWIDE FISHERIES RESEARCH ...Environmental Physiology, Incubation, Low Temp. -but Above 32f, Maturity & Growth Stages, Temperature, ...**5.0818**

PHYSICAL AND CHEMICAL PROPERTIES OF ALABAMA WATERS LIKELY TO SUPPORT STRIPED BASS, ROCCUS SAXATILIS ...Aquatic Ecology, Chemical Measurements -water, Chemical-general, Physical Measurements -water, Physical-general, ...**6.0003**

EFFECTS OF THERMAL AND OTHER FORMS OF POLLUTION ON SOME ANADROMOUS FISHES ...Alewife,menhaden,shad,herring, Aquatic Ecology, Pollution - Effects of , Pollution Effects, Thermal Pollution, ...**5.0739**

EFFECTS OF TEMPERATURE AND SILT ON WHITE BASS DEVELOPMENT IN THE LABORATORY ...Basic Embryology, Laboratory, Turbidity, Turbidity & Suspended Matter, Water Temperature-non-specific, ...**6.0509**

ENVIRONMENTAL FACTORS AND YOUNG WHITE BASS SURVIVAL IN RESERVOIRS ...Basic Embryology, Captive Rearing, Environmental Physiology, Reservoirs and Impoundments, ...**6.0512**

MOVEMENTS OF SPORT FISHES IN BEAVER RESERVOIR ...Arkansas, Fishery Development -other, Migration, Reservoirs and Impoundments, Tags, ...**6.0017**

LIFE HISTORY OF WHITE BASS IN LEWIS AND CLARK LAKE ...Aquatic Ecology, Life History Studies, Reservoirs and Impoundments, South Dakota, ...**6.0528**

Bluegills, Bream

FACTORS AFFECTING FISH PRODUCTION PONDS ...Blood Proteins -non-specific, Electrophoresis -other, Environmental Physiology, Protein, Purif and Isol, ...**6.0221**

STATEWIDE FISHERIES RESEARCH ...Bioindicators, Environmental Effects, Pollution - Effects of , Rotenone, Temperature, ...**5.0817**

EFFECTS OF POSSIBLE POLLUTANTS ON ENERGY PRODUCTION BY BLUEGILL LIVER MITOCHONDRIA ...Metallic Ions, Mineral, Mineral Origin, Respiration, ...**5.0348**

DEPTH DISTRIBUTION OF FISH IN LAKE GLENDALE ...Food Supply, Illinois, Lakes, Largemouth Bass, Vertical Distribution, ...**6.0197**

CHRONIC EFFECTS OF MALATHION ON BLUEGILLS ...Channel Catfish, Malathion, Mode of Action -animal, Pollution - Effects of , Wildlife, ...**5.0646**

PROJECT 2203 EFFECTS ON PHYSIOLOGY WORK UNIT 53 CHRONIC EFFECTS OF ENDRIN ON BLUEGILLS ...Alabama, Computer Matching Code, Endrin, Residue Analysis -other, Wildlife, ...**5.0022**

CHRONIC EFFECTS OF METHOXYCHLOR ON BLUEGILLS AT COLUMBIA, MISSOURI ...Methoxychlor, Missouri, Pollution - Effects of , ...**5.0647**

COMPARISON OF METHODS USED TO MEASURE ESTERASE ACTIVITY. INTERACTIONS BETWEEN PESTICIDE ON FISH ENZYME SYSTEMS ...Channel Catfish, Cholinesterase, Cutthroat Trout, Manometers, Pesticides -non-specific, Visible, ...**5.0637**

SEASONAL CHANGES IN ESTERASE ACTIVITY IN FISH AND INVERTEBRATES. INTERACTIONS BETWEEN PESTICIDES ON FISH ENZYME SYSTEMS ...Biochemical Analysis, Cholinesterase, Invertebrates -non-specific, Mode of Action - animal, Pesticides -non-specific, ...**5.0638**

MINERAL IMBALANCE IN BLUEGILLS EXPOSED TO MALATHION PESTICIDE-INDUCED MINERAL IMBALANCE IN FISH ...Malathion, Mineral, Wildlife, ...**5.0658**

Brown Trout

EFFECTS OF ORGANIC POLLUTION ON HATCHABILITY AND SURVIVAL OF BROOK TROUT, SALVELINUS FONTINALIS, AND GROWTH OF BROWN TROUT, SALMO TRUTTA ...Lake Trout, Brook Trout, Nutrients, Pollution - Effects of , Population Dynamics, Streams, ...**5.1027**

WATER VELOCITY AND SPATIAL CO-ACTIONS OF HATCHERY TROUT AND WILD BROWN TROUT ...Behavioral Ecology, Colorado, Flume Studies, Rainbow Trout, Steelhead Trout, Velocity -water, ...**5.0198**

Bullheads

SMALL IMPOUNDMENT STOCKING ...Centrarchidae -other, Colorado, Control of Nuisance Species, Lakes, Stocking of Fish & Shellfish, ...**5.0201**

GROWTH OF THE BROWN BULLHEAD, ICTALURUS NEBULOSUS (LESUEUR), IN MINE ACID POLLUTED WATER ...Acidity, Contamination - Water, Growth Rate, Mining Activities, Ph, Acidity -water, Pollution Effects, ...**5.1278**

Centrarchidae -other

MARSH HABITAT STUDY ...Chemical-general, Florida, Habitat Studies, Life History Studies, Swamps-marshes, ...**6.0157**

SMALL IMPOUNDMENT STOCKING ...Bullheads, Colorado, Control of Nuisance Species, Lakes, Stocking of Fish & Shellfish, ...**5.0201**

EVALUATION OF MARINE AND ALKALI TOLERANT SPECIES INTRODUCTION IN THE LOWER PECOS RIVER ...Drums, Fish -other, Migration, New Mexico, Stocking of Fish & Shellfish, ...**6.0368**

HYBRID SUNFISH STUDIES ...Laboratory, Maturity & Growth Stages, Ponds, Selection & Breeding, ...**6.0195**

SPOTTED BASS REPRODUCTION IN BULL SHOALS ...Arkansas, Biological Rhythms, Environmental Ecology, Reproduction Studies (general), Reservoirs and Impoundments, ...**6.0023**

LIFE HISTORY OF LONGEAR SUNFISH ...Arkansas, Behavioral Ecology, Life History Studies, Reservoirs and Impoundments, Scuba, ...**6.0016**

Channel Catfish

SPORT FISHERY POTENTIAL IN RECLAIMED WASTEWATER ...Growth Rate, Other, Salmon & Trout - Non-specific, Stream Rehabilitation, Tilapia, Cichlids, ...**5.0050**

INVESTIGATIONS OF THE RELATION BETWEEN THE USE OF CHLORINATED HYDROCARBONS AND THEIR RESIDUES IN CHANNEL CATFISH ...Chlorinated Hydrocarbons, Environmental Effects, Missouri River, Nebraska, Wildlife, ...**5.0702**

A COMPARISON OF THE GROWTH RATE OF BLUE CATFISH AND CHANNEL CATFISH FINGERLINGS FOR A PELLETED COMMERCIAL FEED ...Aquaculture & Fish-farming, Growth Rate, Pelleted, ...**5.1179**

SIGNIFICANCE OF STOCKING SUB-ADULT FIN CLIPPED CATFISH IN HUNTSVILLE STATE PARK LAKE ...Aquatic Ecology, Lakes, Other, Population Dynamics, Stocking of Fish & Shellfish, ...**6.0569**

LIFE HISTORY OF CHANNEL CATFISH IN LEWIS AND CLARK LAKE ...Environmental Ecology, Life History Studies, Number Or Density, Reservoirs and Impoundments, South Dakota, ...**6.0530**

CHRONIC EFFECTS OF MALATHION ON BLUEGILLS ...Bluegills, Bream, Malathion, Mode of Action -animal, Pollution - Effects of , Wildlife, ...**5.0646**

COMPARISON OF METHODS USED TO MEASURE ESTERASE ACTIVITY. INTERACTIONS BETWEEN PESTICIDE ON FISH ENZYME SYSTEMS ...Bluegills, Bream, Cholinesterase, Cutthroat Trout, Manometers, Pesticides -non-specific, Visible, ...**5.0637**

CHRONIC EFFECTS OF METYHL PARATHION AND ENDRIN ON CHANNEL CATFISH AND GOLDFISH IN PONDS. PESTICIDE-INDUCED CHANGES IN POND ECOLOGY ...Endrin, Goldfish, Parathion, Ponds, ...**5.0648**

2,4-D UPTAKE AND METABOLISM - METABOLISM OF PESTICIDES IN FISH ...Goldfish, Laboratory Animals, Metabolism - animal, Rainbow Trout, Steelhead Trout, 2,4-d, ...**5.0659**

Cisco, Lake Herring

EARLY LIFE HISTORY OF COREGONIDS ...Environmental Ecology, Life History Studies, Maturity & Growth Stages, Technique Development, Water Environment -other, ...**6.0295**

CULTURING, PROPAGATION AND CONDITION EVALUATION OF FISHES ...Bioassays, Blood -other, Captive Rearing, Contamination - Water, Lake Trout, Brook Trout, Yellow Perch, Darters, ...**5.0586**

EFFECT OF TEMPERATURE AND RELATIVE HUMIDITY ON C. BOTULINUM SPORE SURVIVAL IN WHITEFISH CHUBS DURING SMOKE PROCESSING ...Clostridium Botulinum, Fish - other, Heat, Microbiological, Smoking, ...**5.1320**

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BEHAVIOR AND HABITAT INTERACTION OF BROOK TROUT AND CUTTHROAT TROUT ...Behavioral Ecology, Habitat Studies, Idaho, Lake Trout, Brook Trout, Regression Analysis, ...**5.0324**

EFFECTS OF WATER TEMPERATURE UPON RESPIRATORY METABOLISM OF CUTTHROAT TROUT, SALMO CLARKI ...Environmental Physiology, Respiration, Temperature, Utah, Water Temperature-non-specific, ...**5.1192**

DETERMINATION OF THE MAGNITUDE AND AGE COMPOSITION OF THE HARVEST, HABITAT PREFERENCES AND FOOD HABITS ...Aquatic Ecology, Number Or Density, Snake River, Wyoming, ...**6.0649**

BIOCHEMISTRY OF FISH SEMEN ...Endrin, Fertility, Male Gametes, Mode of Action -animal, ...**5.0627**

COMPARISON OF METHODS USED TO MEASURE ESTERASE ACTIVITY. INTERACTIONS BETWEEN PESTICIDE ON FISH ENZYME SYSTEMS ...Bluegills, Bream, Channel Catfish, Cholinesterase, Manometers, Pesticides -non-specific, Visible, ...**5.0637**

METHOXYCHLOR-CAUSED EFFECTS ON CUTTHROAT TROUT PHYSIOLOGY CHRONIC TOXICITY OF INSECTICIDES TO COLD-WATER FISH ...Methoxychlor, Mode of Action -animal, Wildlife, Wyoming, ...**5.0666**

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EVALUATION OF MARINE AND ALKALI TOLERANT SPECIES INTRODUCTION IN THE LOWER PECOS RIVER ...Centrarchidae -other, Fish -other, Migration, New Mexico, Stocking of Fish & Shellfish, ...**6.0368**

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REPOPULATION OF EXPERIMENTALLY DECIMATED AREAS BY STREAM FISHES ...Aquatic Ecology, Control of Nuisance Species, Louisiana, Population Dynamics, Stream Rehabilitation, Streams, ...**5.0460**

FISHERIES-TURBINE RESEARCH COMPENDIUM COMPILATION ...Electric Power Plants, Migration, Mortality Rates, Turbine-other, ...**8.0310**

THE DISTRIBUTION OF FISH IN PENNSYLVANIA AS RELATED TO MINE ACID DRAINAGE ...Acidity, Contamination - Water, Mining Activities, Number Or Density, Pennsylvania, ...**5.1026**

THE EFFECT OF EVAPORATION BARRIERS ON FISH GROWTH AND LIMNOLOGY ...Antitranspirants, Aquatic Ecology, Environmental Ecology, Growth Rate, ...**2.0060**

INFLUENCE OF SEDIMENTATION UPON THE PRODUCTION OF GAME FISHES ...Montana, Pollution - Effects of , Population Dynamics, Sediments, Streams, ...**4.0069**

FISHES OF THE ARKANSAS RIVER BASIN, COLORADO ...Arkansas River, Colorado, Environmental Changes, Survey Studies, Water Environment -other, ...**6.0102**

FISHES OF THE SOUTH PLATTE RIVER BASIN, COLORADO ...Animal Distr. (non-specific), Colorado, Environmental Changes, Environmental Ecology, Pollution - Effects of , River Basins, ...**5.0194**

THE FEASIBILITY OF COLD WATER FISHES FOR LAKE SHARPE, SOUTH DAKOTA ...Bottom Sampling, Low Temp. - but Above 32f, Reservoirs and Impoundments, South Dakota, Temperature, ...**7.0041**

A STUDY OF THE PRIMARY PRODUCTIVITY OF NEW AND OLDER RESERVOIRS ...Algae- General, Climate-general, Primary Productivity, ...**2.0149**

ESTUARINE DREDGE HOLE INVESTIGATIONS ...Aquatic Ecology, Estuaries, Habitat Studies, Ocean Coring and Dredging, ...**6.0354**

ECOLOGY OF THE FISHES OF THE KASKASKIA RIVER ...Habitat Studies, Life History Studies, Population Dynamics, Reservoirs and Impoundments, Streams, ...**4.0094**

DOCUMENT LOGGING DAMAGE ...Biological-general, Chemical-general, Forest Debris, Logging, Transport, Equipment, Physical-general, Pollution - Effects of , Population Dynamics, ...**5.0145**

EFFECT OF LIMNOLOGICAL CHANGES ON SURVIVAL OF YOUNG FISH IN ONEIDA LAKE ...Food Supply, Lakes, New York, Urban Environments, Water Quality-general, ...**6.0372**

STABILIZATION STUDY OF FALCON RESERVOIR ...Biological-general, Chemical-general, Physical-general, Population Dynamics, Reservoirs and Impoundments, ...**4.0229**

FISH TOXICANT STUDIES ...Ammonium, Control of Nuisance Species, Evaluation, Piscicides -non-specific, Screening Potential Pesticides, ...**5.1147**

A STUDY OF A POLLUTED RIVER, THE ILLINOIS ...Aquatic Ecology, Bioindicators, Contamination - Water, Illinois River, Mollusks -non-specific & Other, ...**2.0408**

FISH ECOLOGY AND PHYSIOLOGY IN RELATION TO ACID MINE DRAINAGE ...Acidity, Aquatic Ecology, Mine Drainage Control, Pollution - Effects of , Pollution Effects, ...**5.1277**

MANIPULATION OF RESERVOIR WATER FOR IMPROVED QUALITY AND FISH POPULATION RESPONSE ...Environmental Ecology, Eutrophication, Flow Augmentation, Freshwater Ecology, Population Dynamics, Reservoirs and Impoundments, ...**5.1294**

EFFECTS OF WATER DIVERSION ON BIOTA AND WATER QUALITY IN THE STATE OF ARKANSAS ...Environmental Ecology, Population Dynamics, Reservoirs and Impoundments, Temperature, Water Quality-general, ...**6.0030**

ACTIVITY PATTERNS OF FISH EXPOSED TO TOXIC MATERIALS ...Contamination - Water, Industrial Wastes, Pollution - Effects of , Pollution Effects, ...**5.0421**

A STUDY OF THE ECOLOGY OF THE NAVASOTA RIVER, TEXAS ...Aquatic Ecology, Pre-impoundment Sites, Texas, Water Properties-general, Zooplankton, ...**6.0547**

WATER QUALITY CRITERIA TO PROTECT THE FISH POPULATION DIRECTLY BELOW SEWAGE OUTFALLS ...Effluent-standards, Population Dynamics, Sewage, Water Properties-general, Water Standards, ...**5.0501**

DISSOLVED OXYGEN REQUIREMENTS OF FRESHWATER FISH ...Aquatic Ecology, Environmental Ecology, Gases, Dissolved -water, Ions and Gases, Oxygen, ...**5.0962**

EFFECT OF PAPER FIBER WASTES ON FISH EGGS AND JUVENILES ...Minnesota, Oxygen, Pollution - Effects of , Pulp, Paper , and Logging, Sphaerotilus, ...**5.0614**

PESPONSES OF FISH TO ENVIRONMENTAL STRESSES ...Cardiovascular System, Environmental Physiology, Kidney and Urinary System, Stress, Water Environment -other, ...**5.1269**

DISTRIBUTION OF DEMERSAL FISHES IN INSHORE WATERS ...Environmental Ecology, Marine Biology, Mortality Rates, Nets, Vertical Distribution, ...**5.1260**

TUSCON WASTEWATER RECLAMATION PROJECT ...Biological-general, Chemical-general, Filter-other, Productivity (agricultural), Stream Rehabilitation, Water Standards, ...**5.0043**

BIOLOGICAL SURVEY OF STREAMS OF COLES COUNTY, ILLINOIS ...Aquatic Ecology, Contamination - Water, Environmental Ecology, Illinois, Streams, ...**5.0333**

SUBLETHAL INFLUENCE OF POLLUTANTS ON FISH METABOLISM ...Contamination - Water, Growth Rate, Metabolism -animal, Pollution - Effects of , Pollution Effects, ...**5.0901**

CYTOPATHOLOGICAL CHANGES IN NATIVE FISH SPECIES EXPOSED TO STREAM POLLUTANTS ...Contamination - Water, Histology and Cytology, Pollution - Effects of , Pollution Effects, Streams, ...**5.1021**

EFFECTS OF CHEMICAL VARIATIONS IN AQUATIC ENVIRONMENTS ...Bioindicators, Chemical-general, Mans Activities, Water Environment -other, ...**6.0103**

A PARASITOLOGICAL STUDY OF FISHES FROM THE PINE HILLS AREA ...Aquatic Ecology, Helminths, Illinois, Low Temp. -but Above 32f, Springs, ...**6.0180**

PRODUCTION OF ADULT GAME FISHES BY ARTIFICIAL FEEDING ...Aquaculture & Fish-farming, Fish Rations, Food Supply, ...**6.0181**

STUDY OF EFFECTS OF MILL WASTE WATER ON FISH LIFE ...Contamination - Water, Industrial Processes-other, Industrial Wastes, Pollution - Effects of , Pollution Effects, ...**5.1174**

PEACE RIVER POLLUTION INVESTIGATIONS ...Florida, Industrial Wastes, Phosphate, Phosphite, Pollution - Effects of , Pollution Effects, Streams, ...**5.0273**

INFLUENCE OF WATER POLLUTANTS AND WATER QUALITY ON EARLY LIFE HISTORY AND POPULATION DYNAMICS OF MINNESOTA FISHES ...Life History Studies, Minnesota, Pollution - Effects of , Pollution Effects, Population Dynamics, ...**5.0615**

INFLUENCES OF WATER QUALITY AND OTHER ENVIRONMENTAL CHANGES ON FISH AND ASSOCIATED ORGANISMS IN INLAND WATERS ...Aquatic Ecology, Environmental Ecology, Mans Activities, Pollution - Effects of , Social Aspects, Water Quality-general, ...**5.0965**

RELATIONS OF NUISANCE ALGAE TO FISH IN KLAMATH LAKE ...Algal Toxins, Bioassays, Cyanophyta (non-specific & Ot), Lakes, Oregon, ...**5.0937**

EFFECTS OF CHEMICAL AND BIOLOGICALLY MODIFIED PULPING EFFLUENTS ON THE PRODUCTION OF FISH ...Effluents-waste Water, Industrial Wastes, Pulp, Paper , and Logging, Self-purification, Tox & Allergenic Effects, Willamette River, ...**5.0936**

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TRANSLOCATION OF RADIONUCLIDES BY FISH ...Columbia River, Migration, Phosphorus, Radioactivity-general, Zinc, ...**2.1130**

RADIONUCLIDE METABOLISM IN AQUATIC ANIMALS ...Clams, Contamination - Water, Metabolism, Radiation Effects-non-specific, Reactor Sites & Rad Waste, ...**5.0101**

RADIATION EFFECTS IN AQUATIC SYSTEMS ...Aquatic Ecology, Chronic Radiation, Contamination - Water, Low Level Radiation, Radiation Effects-non-specific, Radiation Treatment, Radioactivity-general, ...**5.1248**

EFFECTS OF TEMPERATURE ON AQUATIC LIFE ...Aquatic Ecology, Model Studies, Productivity - Food Chain, Temperature, Warm Water, ...**5.1121**

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AQUATIC PLANT CONTROL ...Environmental Ecology, Herbicides -non-specific, of Aquatic Plants, Wildlife, ...**8.0168**

WATER QUALITY AND NUTRIENTS, SACRAMENTO-SAN JOAQUIN RIVER SYSTEM ...Environmental Ecology, Eutrophication, Nutrients, Plankton (non-specific), Water Quality-general, ...**2.0127**

THE EFFECT OF OCEAN WATER INTRUSION INTO BACK BAY, VIRGINIA, AND CURRITUCK SOUND, NORTH CAROLINA, ON THE WATERFOWL AND FISH HABITAT ...Aquatic Ecology, Brackish Water, Habitat Studies, Saline Water Intrusion, Water Fowl, N.s. , Water Salinity, ...**2.0585**

COLLECTION AND COLLATION OF AVAILABLE BIOLOGICAL, PHYSICAL AND CHEMICAL DATA ON U. S. RESERVOIRS ...Document and Literature Center, Productivity - Food Chain, Reservoirs and Impoundments, River Basins, Survey Studies, ...**6.0020**

FISH POPULATION OR ABUNDANCE STUDIES IN LEWIS AND CLARK LAKE ...Aquatic Ecology, Habitat Studies, Population Dynamics, Reservoirs and Impoundments, South Dakota, ...**6.0529**

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DISTRIBUTION OF YOUNG STAGES OF COASTAL FISHES ...Continental Shelf, Estuaries, Maturity & Growth Stages, Number Or Density, Ships and Cruises, ...**6.0345**

INFLUENCE OF THE PHYSICAL ENVIRONMENT ON DISTRIBUTION OF YOUNG STAGES OF COASTAL GAME FISH ...Continental Shelf, Environmental Ecology, Maturity & Growth Stages, Physical-general, Range Or Territorial Distr. , ...**6.0346**

DISTRIBUTION AND RELATIVE ABUNDANCE OR POPULATION OF YOUNG FISHES IN LAKE SHARPE RESERVOIR ...Aquatic Ecology, Population Dynamics, Reservoirs and Impoundments, South Dakota, Vertical Distribution, ...**6.0500**

ABUNDANCE AND COMPOSITION OF ADULT FISH STOCK IN LAKE SHARPE ...Aquatic Ecology, Number Or Density, Population Dynamics, Reservoirs and Impoundments, South Dakota, ...**6.0501**

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ABUNDANCE OF YOUNG-OF-THE-YEAR FISHES IN OAHE RESERVOIR ...Age, Aquatic Ecology, Population Dynamics, Reservoirs and Impoundments, South Dakota, ...**6.0499**

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THERMAL PREFERENCES OF MARINE FISHES AND INVERTEBRATES ...Behavior -animal, Invertebrates -non-specific, Water Temperature-non-specific, ...**5.0720**

EFFECTS OF HOT WATER MASSES ON MARINE FISHES ...Atlantic Ocean-north, Behavior -animal, High Temp. -85f Or Above, Thermal, ...**5.0721**

EFFECTS OF ENVIRONMENTAL FACTORS ON STANDING CROP AND HARVEST OF FISHES IN U. S. RESERVOIRS ...Environmental Ecology, Environmental Effects-geologic, Reservoirs and Impoundments, ...**6.0021**

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ESTIMATES OF COMPOSITION, ABUNDANCE AND FLUCTUATION IN FISH POPULATIONS IN BULL SHOALS AND BEAVER RESERVOIRS ...Aquatic Ecology, Arkansas, Number Or Density, Population Dynamics, Reservoirs and Impoundments, ...**4.0017**

FISH POPULATION IN TAILWATER OF LEWIS AND CLARK LAKE ...Aquatic Ecology, Population Dynamics, Reservoirs and Impoundments, South Dakota, ...**6.0531**

SCREENING AQUATIC INVERTEBRATES TO DETECT AN ORGANISM SUITABLE FOR USE IN A MONITORING PROGRAM ...Bioassays, Bioindicators, Cholinesterase, Invertebrates - non-specific, Metabolism, Monitoring Systems, ...**5.0639**

ROLE OF ENTERIC MICROORGANISMS IN DETOXIFICATION - INTERACTION BETWEEN MICROORGANISMS AND PESTICIDES ...Bacterial Culture, Biodegradation, Identification, Insecticides -non-specific, Intestinal Bacteria, ...**5.0641**

ACUTE TOXICITY OF PESTICIDES TO FRESHWATER FISH AND OTHER VERTEBRATES ...Pesticides -non-specific, Screening Potential Pesticides, Temperature, Water Quality-general, Wildlife, ...**5.0652**

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THE INVESTIGATION AND ANALYSIS OF BIOCHEMICAL PROCESSES OF AQUATIC ORGANISMS UNDER STRESS ...Animal Origin, Aquatic Ecology, Metabolism -animal, Other, Stress, ...**5.0585**

MARINE BIOLOGICAL ASSESSMENT OF POLLUTIONAL FATE ...Contamination - Water, Crustacea -non-specific, Nets, Pollution - Effects of , ...**5.0975**

WATER QUALITY REQUIREMENTS FOR AQUATIC LIFE ...Contamination - Water, Pollution - Effects of , Toxins and Poisons -other, Water Quality-general, ...**5.0844**

SYNERGISM OF PESTICIDES AND DETERGENTS ...Chlorinated Hydrocarbons, Mode of Action -animal, Other, Surfactants - Wetting Agents, Synergism and Synergists, ...**5.0800**

ECOLOGY OF CLOSTRIDIUM BOTULINUM TYPE E IN GREEN BAY ...Clostridium Botulinum, Fish, N.s. , Great Lakes-general, Microbiological, Repression, Vertical Distribution, ...**2.1162**

MARINE TOXINS OF THE TROPICAL PACIFIC ...Algal Metab.(non-specific &ot), Animal Origin, Other, Polynesia, Toxicology, ...**5.0315**

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INVESTIGATION OF RELATIONSHIP OF CUNNER, TAUTOGOLABRUS ADSPERSUS -(WALBAUM), TO WEWEANTIC RIVER ESTUARY, WAREHAM, MASSACHUSETTS ...Aquatic Ecology, Estuaries, Massachusetts, Swamps-marshes, Water Environment -other, ...**5.0511**

EFFECTS OF INCREASE IN SALTON SEA SALINITY ON THE SURVIVAL OF ORANGEMOUTH CORVINA, SARGO, BAIRDIELLA, AND NEANTHES ...Bioindicators, Captive Rearing, Pollution - Effects of , Salinity, Salton, Water Salinity, ...**5.0146**

EVALUATION OF MARINE AND ALKALI TOLERANT SPECIES INTRODUCTION IN THE LOWER PECOS RIVER ...Centrarchidae -other, Drums, Migration, New Mexico, Stocking of Fish & Shellfish, ...**6.0368**

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FISH OPERCULAR RESPONSE TO ENVIRONMENTAL VARIABLES ...Environmental Physiology, Fish, Gases, Dissolved -water, Minnows, Water Temperature-non-specific, ...**5.0865**

EFFECTS OF MALATHION ON LEARNING AND RETENTION IN THE GOLDFISH ...Escape and Avoidance, Malathion, Mode of Action -animal, Pesticides, Pollution - Effects of , ...**5.0667**

CHRONIC EFFECTS OF METYHL PARATHION AND ENDRIN ON CHANNEL CATFISH AND GOLDFISH IN PONDS. PESTICIDE-INDUCED CHANGES IN POND ECOLOGY ...Channel Catfish, Endrin, Parathion, Ponds, ...**5.0648**

2,4-D UPTAKE AND METABOLISM - METABOLISM OF PESTICIDES IN FISH ...Channel Catfish, Laboratory Animals, Metabolism -animal, Rainbow Trout, Steelhead Trout, 2,4-d, ...**5.0659**

THE CONSTITUENTS AND PHVSICO-CHEMICAL PROPERTIES OF SERUM FROM GOLD-FISH EXPOSED CHRONICALLY TO MALATHION AND ENDRIN ...Blood Plasma and Serum, Endocrine -other, Endrin, Malathion, Mode of Action -animal, ...**5.0630**

THYROID FUNCTION OF GOLDFISH AND RAINBOW TROUT EXPOSED CHRONICALLY TO MALATHION AND ENDRIN - PESTICIDE EFFECTS ON FISH ENDOCRINE FUNCTIONS ...Endrin, Malathion, Mode of Action -animal, Rainbow Trout, Steelhead Trout, Thyroid, ...**5.0631**

EFFECTS OF ENDRIN & MALATHION ON GONADAL HYDRATION RESPONSE OF MALE GOLDFISH & RAINBOW TROUT. PESTICIDE EFFECTS ON FISH ENDOCRINE FUNCTION ...Endrin, Malathion, Male Gametes, Mode of Action - animal, Pesticides, Rainbow Trout, Steelhead Trout, ...**5.0634**

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FLATHEAD CATFISH INVESTIGATIONS IN THE MISSOURI RIVER ...Life History Studies, Missouri River, Number Or Density, Population Dynamics, ...**6.0335**

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FLATHEAD CATFISH STUDY ...Aquatic Ecology, Behavior - animal, Food Supply, Growth Rate, Reproduction Studies (general), Texas, ...**6.0539**

Killifishs - Cyprinodon

RELATIONSHIPS BETWEEN SUB-LETHAL PESTICIDES AND REPRODUCTION AND BEHAVIOR OF FISHES ...Behavior - animal, DDT , Pesticides -non-specific, Reproduction Studies (general), Wildlife, ...**5.0292**

BEHAVIOR AND FOOD PREFERENCES OF INTRODUCED ANNUAL FISHES IN RELATION TO MOSQUITOES ...Aquatic Ecology, Behavioral Ecology, Food Supply, Mosquitoes -non-specific, Predators and Parasite, ...**2.0575**

EFFECTS OF CHRONIC EXPOSURE TO METHOXYCHLOR ON THE GROWTH AND REPRODUCTION OF GUPPIES - CHRONIC TOXIEITY OF PESTICIDES TO FISH ...Growth Rate, Maturity & Growth Stages, Methoxychlor, ...**5.0650**

INTERACTION OF ENDRIN AND PROLACTING-INDUCED FAT SYNTHESIS IN THE PLAINS KILLIFISH - PESTICIDE EFFECTS ON FISH ENDOCRINE FUNCTIONS ...Adipose, Endrin X Biocid, Metabolism -animal, Photoperiod, ...**5.0657**

HISTOPATHOLOGIC EFFECTS OF POLLUTANTS ON CELLS AND TISSUES OF MARINE FISHES ...Computer Matching Code, Contamination - Water, Pollution - Effects of , Pollution Effects, ...**5.1080**

EFFECT OF METAL POISONING ON VARIOUS ENZYMES IN FISH ...Atpase, Chemical Effect-other, Inhibitors, Metals Ns, Mineral Origin, ...**5.1091**

HEMATOLOGICAL CHANGES IN F. HETEROCLITUS UPON EXPOSURE TO TOXIC METALS ...Blood Cells, Blood Plasma and Serum, Cadmium, Lead, Mineral Origin, ...**5.1092**

PHARMACOLOGY OF METAL POISONING IN ESTUARINE FISHES ...Contamination - Water, Estuaries, Metals Ns, Stress, ...**5.1083**

COMPARATIVE TOXICITIES OF METALS TO ESTUARINE FISHES ...Bioassays, Estuaries, Industrial Wastes, Mineral Origin, Solid Waste, ...**5.1084**

Lake Trout, Brook Trout

RELATIONSHIPS BETWEEN DRIFT DENSITY AND PRODUCTION, GROWTH, CROPPING EFFICIENCY AND CONSUMPTION IN A NATURAL BROOK TROUT POPULATION ...Growth Rate, Number Or Density, Predation, Productivity (agricultural), Streams, ...**7.0094**

EFFECTS OF ORGANIC POLLUTION ON HATCHABILITY AND SURVIVAL OF BROOK TROUT, SALVELINUS FONTINALIS, AND GROWTH OF BROWN TROUT, SALMO TRUTTA ...Brown Trout, Nutrients, Pollution - Effects of , Population Dynamics, Streams, ...**5.1027**

AN ECOLOGICAL STUDY OF AN ALKALINE STREAM WITH HEAVY IRON DEPOSITS ORIGINATING FROM TREATMENT OF MINE ACID WATER ...Alkalinity, Mineral Content - water, Mining Activities, Productivity - Food Chain, Susquehanna River, Water Alkalinity, ...**5.1025**

BEHAVIOR AND HABITAT INTERACTION OF BROOK TROUT AND CUTTHROAT TROUT ...Behavioral Ecology, Cutthroat Trout, Habitat Studies, Idaho, Regression Analysis, ...**5.0324**

STUDIES ON PLANTED BROOK TROUT IN RELATION TO NUMBERS PLANTED, LIMNOLOGICAL CONDITIONS AND FOOD SUPPLIES IN UNFISHED LAKES ...Food Supply, Lakes, Michigan, Population Dynamics, Stocking of Fish & Shellfish, ...**6.0303**

STREAM RESTORATION AND CONTROLLED FLOWS ...Dams-other, Logging, Transport, Equipment, Maine, Salmon & Trout - Non-specific, Stream Rehabilitation, ...**4.0129**

EVOLUTION OF ALLOPATRIC POPULATIONS ...Captive Rearing, Ecological, Maine, Population Dynamics, ...**5.0464**

AQUATIC BIOLOGY INVESTIGATIONS ...Cricetidae -other, Lakes, New York, Streams, Water Fowl, N.s. , ...**2.0786**

FISH MOVEMENTS IN THE NORTH INLET OF WOLF LAKE, HUNTINGTON FOREST ...Behavioral Ecology, Environmental Ecology, Locomotion -animal, New York, Streams, ...**2.0813**

EFFECTS OF CHRONIC EXPOSURE TO SUBLETHAL LEVELS OF INSECTICIDES ON REPRODUCTION IN BROOK TROUT. CHRONIC TOXICITY OF PESTICIDES TO FISH ...Carbamates -non-specific, Chlorinated Hydrocarbons, Organophosphorous Cpds. , Pollution - Effects of , Reproduction Studies (general), Wildlife, ...**5.0654**

ASSESSMENT OF LAKE SUPERIOR LAKE TROUT ...Aquatic Ecology, Commercial Fishing, Lampreys, Life History Studies, ...**6.0636**

CULTURING, PROPAGATION AND CONDITION EVALUATION OF FISHES ...Bioassays, Blood -other, Captive Rearing, Cisco, Lake Herring, Contamination - Water, Yellow Perch, Darters, ...**5.0586**

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AN EVALUATION OF THE LAMPREY IN LAKE CHAMPLAIN ...Lakes, Maturity & Growth Stages, Predation, Spawn Or Nesting Sites, Vermont, ...**6.0598**

ASSESSMENT OF LAKE SUPERIOR LAKE TROUT ...Aquatic Ecology, Commercial Fishing, Lake Trout, Brook Trout, Life History Studies, ...**6.0636**

LAKE SUPERIOR CHEMICAL CONTROL OF SEA LAMPREY ...Control of Nuisance Species, Flow Characteristics -water, Lake Superior, Larvicides, Streams, ...**5.0577**

LAKE MICHIGAN CHEMICAL CONTROL OF SEA LAMPREY ...Animal Pollutant Sources, Control of Nuisance Species, Evaluation, Larvicides, ...**5.0576**

BIOASSAY ...Animal Pollutant Sources, Evaluation, Piscicides - non-specific, Streams, Water Properties-general, ...**5.0580**

Largemouth Bass

EFFECTS OF LIMNOLOGICAL FACTORS ON UPTAKE OF CS137 BY FISH ...Cesium, Metabolism -animal, ...**1.0068**

EFFECT OF INCUBATION TEMPERATURE ON SURVIVAL OF LARGEMOUTH BASS EMBRYOS ...Basic Embryology, Environmental Physiology, Incubation, Temperature, Warm Water, ...**6.0387**

DEVELOPMENT OF MARKING METHODS FOR SMALL FISH ...Dyes, Musculoskeletal System, Other, Tags, ...**7.0081**

FOOD HABITS OF LARGEMOUTH BASS LARVAE ...Aquatic Ecology, Behavior -animal, Food Supply, Ponds, Zooplankton, ...**7.0082**

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Control of Nuisance Species

REPOPULATION OF EXPERIMENTALLY DECIMATED AREAS BY STREAM FISHES ...Aquatic Ecology, Fish -non-specific, Louisiana, Population Dynamics, Stream Rehabilitation, Streams, ...5.0460

CHEMICAL TREATMENT OF NEBISH LAKE ...Aquatic Ecology, Chemical Treatment-general, Data Analysis - General, Lakes, Stocking of Fish & Shellfish, ...5.1293

FISH TOXICANT STUDIES ...Ammonium, Evaluation, Fish -non-specific, Piscicides -non-specific, Screening Potential Pesticides, ...5.1147

SMALL IMPOUNDMENT STOCKING ...Bullheads, Centrarchidae -other, Colorado, Lakes, Stocking of Fish & Shellfish, ...5.0201

FISH POPULATION MANIPULATION AT RIDGE LAKE ...Depth,water Level, Fluctuation, Illinois, Lakes, Population Dynamics, Water Level Fluctuation, ...6.0194

THIODAN AS A TOXICANT FOR ERADICATION OF FISHES IN LAKE MANAGEMENT ...Evaluation, Lakes, Management, Thiodan, ...6.0567

LAKE SUPERIOR CHEMICAL CONTROL OF SEA LAMPREY ...Flow Characteristics -water, Lake Superior, Lampreys, Larvicides, Streams, ...5.0577

LAKE MICHIGAN CHEMICAL CONTROL OF SEA LAMPREY ...Animal Pollutant Sources, Evaluation, Lampreys, Larvicides, ...5.0576

Dyes

DEVELOPMENT OF MARKING METHODS FOR SMALL FISH ...Largemouth Bass, Musculoskeletal System, Other, Tags, ...7.0081

Fertilizers -aquatic

FERN LAKE MINERAL METABOLISM PROGRAM ...Hardness-minerals, Lakes, Mineral Content -water, Productivity - Food Chain, Washington, ...6.0624

FERTILIZATION OF WOODS CANYON LAKE ...Arizona, Lakes, Rainbow Trout, Steelhead Trout, ...5.0040

FISH POPULATION STUDIES. (DEWEY RESERVOIR) ...Alewife,menhaden,shad,herring, Aquatic Ecology, Kentucky, Population Dynamics, Reservoirs and Impoundments, ...5.0437

NUTRIENT ASSIMILATION RATES - FIELD STUDIES ...Estuaries, Nutrients, Phosphorus, Ponds, ...5.0620

FARM FISH POND MANAGEMENT ...Farm Pond, Food Supply, Management, Nutrients, Productivity - Food Chain, ...6.0300

HIGH ANALYSIS FERTILIZER INVESTIGATIONS - FISHERIES ...Fish -non-specific, Productivity (agricultural), Reservoirs and Impoundments, Tennessee, ...6.0535

Fishery Development -other

MOVEMENTS OF SPORT FISHES IN BEAVER RESERVOIR ...Arkansas, Basses -sea,white, White Perch, Migration, Reservoirs and Impoundments, Tags, ...6.0017

Food Supply

FEEDING PATTERNS OF THE FRESHWATER ISOPOD LIRCEUS BRACHYURUS ...Aquatic Ecology, Behavioral Ecology, Isopods, Nutrition - Invertebrate, Pennsylvania, Streams, ...7.0093

FOOD HABITS OF LARVAL AND JUVENILE SHAD IN THE CONNECTICUT RIVER ...Alewife,menhaden,shad,herring, Aquatic Ecology, Connecticut River, Massachusetts, Recreation Sites, ...3.0272

STREAM BIOLOGY AND ITS RELATION TO FISH PRODUCTION ...Growth Rate, Mississippi River, Shiners, Streams, Vertical Distribution, ...6.0223

DYNAMICS OF FISH POPULATIONS IN NATURAL LAKES ...Iowa, Lakes, Life History Studies, Population Dynamics, ...6.0224

FOOD HABITS OF LARGEMOUTH BASS LARVAE ...Aquatic Ecology, Behavior -animal, Largemouth Bass, Ponds, Zooplankton, ...7.0082

THE ROLE OF FOOD IN THE MORTALITY OF LARGEMOUTH BASS LARVAE ...Environmental Physiology, Fasting - Starvation, Largemouth Bass, Maturity & Growth Stages, Mortality Rates, ...7.0079

A STUDY OF THE BENTHIC FAUNA OF MERLE COLLINS RESERVOIR (VIRGINIA RANCH RESERVOIR) ...California, Number Or Density, Productivity - Food Chain, Reservoirs and Impoundments, ...6.0071

WALLEYE FRY - ZOOPLANKTON RELATIONSHIPS IN SOUTHEASTERN WISCONSIN LAKES ...Aquatic Ecology, Lakes, Plankton Sampling, Walleyes, Zooplankton, ...6.0640

STUDIES ON PLANTED BROOK TROUT IN RELATION TO NUMBERS PLANTED, LIMNOLOGICAL CONDITIONS AND FOOD SUPPLIES IN UNFISHED LAKES ...Lake Trout, Brook Trout, Lakes, Michigan, Population Dynamics, Stocking of Fish & Shellfish, ...6.0303

EFFECT OF LIMNOLOGICAL CHANGES ON SURVIVAL OF YOUNG FISH IN ONEIDA LAKE ...Fish -non-specific, Lakes, New York, Urban Environments, Water Quality-general, ...**6.0372**

FOOD HABITS STUDY ...Aquatic Ecology, Benthic Organisms (non-specif), Lakes, Mississippi, Plankton (non-specific), ...**6.0314**

FLATHEAD CATFISH STUDY ...Aquatic Ecology, Behavior - animal, Growth Rate, Ictaluridae -other, Reproduction Studies (general), Texas, ...**6.0539**

EFFECTS OF PULP MILL EFFLUENTS ON THE GROWTH AND PRODUCTION OF FISH ...Industrial Wastes, Industry Land Use Effects, Pollution - Effects of , Pollution Effects, Pulp, Paper , and Logging, ...**5.0961**

RELATION OF FLOODPLAIN POOLS TO THE BIOLOGICAL PRODUCTION OF THE KASKASKIA RIVER AND ITS MAINSTEM RESERVOIRS ...Habitat Studies, Illinois, Productivity - Food Chain, Reservoirs and Impoundments, Streams, ...**2.0411**

BEHAVIOR AND FOOD PREFERENCES OF INTRODUCED ANNUAL FISHES IN RELATION TO MOSQUITOES ...Aquatic Ecology, Behavioral Ecology, Killifishs - Cyprinodon, Mosquitoes -non-specific, Fredators and Parasite, ...**2.0575**

FARM FISH POND MANAGEMENT ...Farm Pond, Fertilizers - aquatic, Management, Nutrients, Productivity - Food Chain, ...**6.0300**

AN EVALUATION OF WIDELY USED HERBICIDES ON AQUATIC PLANTS, FISH AND FISH-FOOD ORGANISMS ...Environmental Effects, Herbicides -non-specific, Wildlife, ...**5.0570**

PRODUCTION OF ADULT GAME FISHES BY ARTIFICIAL FEEDING ...Aquaculture & Fish-farming, Fish -non-specific, Fish Rations, ...**6.0181**

FOOD INTAKE OF LARGEMOUTH BASS ...Lakes, Largemouth Bass, Malnutrition -other, Size, ...**6.0182**

DEPTH DISTRIBUTION OF FISH IN LAKE GLENDALE ...Bluegills, Bream, Illinois, Lakes, Largemouth Bass, Vertical Distribution, ...**6.0197**

ECOLOGY AND DISTRIBUTION OF OYSTERS AND CLAMS ...Chesapeake Bay, Clams, Commercial Fishing, Food Webs, Oysters, ...**6.0268**

RESEARCH ON THE MACROBENTHOS OF THE GREAT LAKES ...Aquatic Ecology, Benthic Fauna, Earthworms, Great Lakes-general, Water Quality-general, ...**6.0292**

CULTURING AND PROPAGATION OF SELECTED INVERTEBRATES AND ASSOCIATED FOOD ORGANISMS ...Algal Culture, Chlorophyceae (non-specif.&ot), Chrysophyceae (non-specif.&ot), Cyanophyta (non-specific & Ot), Invertebrate Cultures, ...**5.0591**

EFFECTS OF D.O., TEMPERATURE AND POTENTIAL TOXICANTS UPON SELECTED MACROINVERTEBRATES (EMPHASIZING NON-ARTHROPODS) ...Contamination - Water, Gases, Dissolved -water, Pollution - Effects of , Pollution Effects, Water Temperature-non-specific, ...**5.0589**

EFFECTS OF HIGH TEMPERATURE, LOW OXYGEN, AND PH EXTREMES ON THE SURVIVAL OF AQUATIC INSECTS AND CRUSTACEA IMPORTANT AS TROUT FOOD ...Aquatic Ecology, Gases, Dissolved -water, High Temp. -85f Or Above, Lake Superior, Ph, Acidity -water, ...**5.0593**

Management -other

MIGRATORY RESPONSE OF ADULT SALMONIDS TO WATER TEMPERATURE ...Migration, Salmon -coho,chinook,sockeye.., Temperature, Thermal Pollution, Warm Water, ...**8.0300**

PASSAGE OF ADULT SALMONIDS THROUGH PIPES ...Construction Land Use Effects, Pipes, Salmon -coho,chinook,sockeye.., ...**8.0301**

POLLUTION AS A RESULT OF FISH CULTURAL ACTIVITIES ...Algal Pollutant Sources, Biological Pollutants -general, Captive Rearing, Pollution - Effects of , Water Quality Control-general, ...**5.1199**

EVALUATION OF UPSTREAM AND DOWNSTREAM ANADROMOUS FISH PASSAGE AT RIVER MILL AND FARADAY DAMS ON THE CLACKAMAS RIVER, OREGON ...Engineering Structures-general, Migration, Oregon, Rainbow Trout, Steelhead Trout, Reservoirs and Impoundments, ...**8.0279**

FISH PASSAGE THROUGH TURBINES ...Fish -non-specific, Hydraulic, Mortality Rates, Power Development, Stamina, ...**8.0312**

COLLECTION OF JUVENILE MIGRANTS FROM RIVERS AND STREAMS ...Engineering Structures-general, Fish -non-specific, Migration, Streams, ...**4.0271**

LAKE SUPERIOR EXPLORATIONS ...Commercial Fishing, Lake Superior, Nets, Smelts, Suckers, ...**6.0293**

FISH TRANSPORTATION ...Aquatic Ecology, Migration, Salmon & Trout - Non-specific, Streams, Tags, ...**8.0304**

FISH GUIDING ...Animal Distr. (non-specific), Fish -non-specific, Guidance, Instrumental Services, Water Environment -other, ...**8.0307**

FISHWAY RESEARCH (BONNEVILLE LABORATORY) ...Behavioral Ecology, Engineering Structures-general, Environmental Ecology, Migration, Salmon & Trout - Non-specific, ...**6.0618**

Nets

EVALUATION OF CLEARED SEINING AREAS ...Land Use, Pre-impoundment Sites, Reservoirs and Impoundments, Texas, ...**6.0540**

LAKE BASTROP NETTING STUDY ...Commercial Fishing, Ictaluridae -other, Lakes, Population Dynamics, Texas, ...**6.0570**

FISH STOCKING EVALUATION ...Captive Rearing, Largemouth Bass, Management, Ponds, Stocking of Fish & Shellfish, ...**6.0542**

DEVELOPMENT AND IMPROVEMENT OF INSTRUMENTATION AND SAMPLING GEAR FOR USE IN LIMNOLOGY AND FISHERY BIOLOGY ...Basses -sea,white, White Perch, Plankton Sampling, Salmon & Trout - Non-specific, Tags, Telemetry, ...**7.0115**

INVESTIGATION OF SPAWNING GROUND POTENTIALS AND GROWTH AND SURVIVAL OF JUVENILE SOCKEYE SALMON IN FRAZER LAKE SYSTEM ...Alaska, Censusing, Lakes, Salmon -coho,chinook,sockeye.., Spawn Or Nesting Sites, Tags, ...**6.0009**

ASSESSMENT OF ENVIRONMENT FACTORS INFLUENCING THE DISTRIBUTION OF BOTTOM FISHES IN RESERVOIRS ...Oklahoma, Organic, Physical Properties-general, Reservoirs and Impoundments, Turbidity & Suspended Matter, ...**5.0924**

LIFE HISTORY OF THE GOLDEYE (HIODON ALOSOIDES) IN GARRISON RESERVOIR, NORTH DAKOTA ...Biological Rhythms, Life History Studies, North Dakota, Reservoirs and Impoundments, Spawn Or Nesting Sites, ...**5.0827**

THE RELATIONSHIP BETWEEN TURBIDITY CURRENTS AND FISH MOVEMENTS IN GARRISON RESERVOIR ...Currents - water, North Dakota, Reservoirs and Impoundments, Turbidity, Turbidity & Suspended Matter, ...**5.0829**

POTENTIAL FISHERY FOR RIVER HERRINGS IN CONNECTICUT RIVER ...Alewife,menhaden,shad,herring, Connecticut River, Environmental Ecology, Life History Studies, Spawn Or Nesting Sites, ...**4.0075**

LAKEBORGNE-CHANDELEUR SOUND SYSTEM ...Aquatic Ecology, Louisiana, Number Or Density, Plankton Sampling, Tides, ...**2.0543**

BRETON SOUND - MOUTH OF MISSISSIPPI RIVER SYSTEM ...Aquatic Ecology, Mississippi River, Number Or Density, Plankton Sampling, ...**2.0544**

VERMILION - CALCASIEU - SABINE SYSTEM ...Aquatic Ecology, Data Acquisition-general, Louisiana, Number Or Density, Plankton Sampling, ...**2.0546**

TIMBALIER - TERREBONNE BAYS SYSTEM ...Aquatic Ecology, Data Acquisition-general, Louisiana, Number Or Density, Plankton Sampling, ...**2.0547**

DISTRIBUTION OF DEMERSAL FISHES IN INSHORE WATERS ...Environmental Ecology, Fish -non-specific, Marine Biology, Mortality Rates, Vertical Distribution, ...**5.1260**

A RUN TIMING STUDY IN THE LOWER COLUMBIA RIVER BY MEANS OF A TESTFISHING PROGRAM ...Columbia River, Migration, Number Or Density, Salmon -coho,chinook,sockeye.., Streams, ...**2.0884**

YOUNG-OF-THE-YEAR FISH IN LAKE FRANCIS CASE ...Age, Fish -non-specific, Reservoirs and Impoundments, South Dakota, Water Environment -other, ...**6.0505**

EXPLORATORY SAMPLING PROGRAM FOR YOUNG-OF-THE-YEAR FISH ...Age, Fish -non-specific, Population Dynamics, Reservoirs and Impoundments, ...**6.0022**

POPULATION ESTIMATES FROM MIDWATER TRAWL SAMPLING ...Alewife,menhaden,shad,herring, Aquatic Ecology, Arkansas, Population Dynamics, Reservoirs and Impoundments, ...**6.0019**

DESIGN AND CONSTRUCTION OF GEAR FOR MIDWATER TRAWLING ...Alewife,menhaden,shad,herring, Arkansas, Population Dynamics, Reservoirs and Impoundments, ...**4.0016**

LAKE SUPERIOR EXPLORATIONS ...Commercial Fishing, Lake Superior, Management -other, Smelts, Suckers, ...**6.0293**

MARINE BIOLOGICAL ASSESSMENT OF POLLUTIONAL FATE ...Contamination - Water, Crustacea -non-specific, Fish - non-specific, Pollution - Effects of , ...**5.0975**

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DEVELOPMENT OF MARKING METHODS FOR SMALL FISH ...Dyes, Largemouth Bass, Musculoskeletal System, Tags, ...**7.0081**

SIGNIFICANCE OF STOCKING SUB-ADULT FIN CLIPPED CATFISH IN HUNTSVILLE STATE PARK LAKE ...Aquatic Ecology, Channel Catfish, Lakes, Population Dynamics, Stocking of Fish & Shellfish, ...**6.0569**

POTENTIAL OYSTER SETTING CAPACITY - LOCAL AREAS ...Chesapeake Bay, Commercial Fishing, Oysters, Spawn Or Nesting Sites, Streams, ...**5.0507**

JUVENILE MIGRATION RATES ...Columbia River, Migration, Salmon & Trout - Non-specific, Snake River, Water Environment -other, ...**8.0308**

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MASS MORTALITY OF PACIFIC OYSTERS ALONG THE WASHINGTON COAST ...Bays, Environmental Ecology, Mortality Rates, Oysters, Puget Sound, ...**5.1230**

MASS MORTALITY OF OYSTERS ALONG THE OREGON COAST ...Bays, Invertebrate Pathology, Mortality Rates, Oregon, Oysters, ...**5.0985**

IMPOUNDMENT EFFECTS ON WATER QUALITY AS REFLECTED IN PARASITISM OF RESERVOIR BASSES ...Copepods, Pre-impoundment Sites, Reservoirs and Impoundments, Water Level Fluctuation, Water Quality-general, ...**6.0024**

SURVEY OF CLOSTRIDIUM BOTULINUM TYPE E ...Clostridium Botulinum, Growth (non-specific & Ot.), Media, Microbiological Analysis, ...**5.1310**

STUDIES IN OYSTER PATHOLOGY ...Histology and Cytology, Mortality Rates, Oysters, ...**6.0630**

SHELLFISH MORTALITY - CHESAPEAKE BAY ...Chesapeake Bay, Computer Matching Code, Mortality Rates, Oysters, Protozoa, ...**6.0264**

EFFECT OF SUPERSATURATION OF DISSOLVED NITROGEN ON MIGRATING SALMONIDS ...Gases, Dissolved -water, Mortality Rates, Nitrogen, Salmon & Trout - Non-specific, ...**6.0614**

PACIFIC OYSTER MORTALITY STUDIES ...Invertebrate Pathology, Invertebrates, Mortality Rates, Oysters, ...**6.0266**

EPIZOOTICS IN EXPERIMENTAL MARINE SHELLFISH POPULATIONS ...Epizootic, Freshwater Mussels, Scallops, Mortality Rates, Oysters, ...**6.0631**

ENVIRONMENT AND VIRUS-HOST INTERACTIONS IN FISHES ...Agricultural Chemicals-general, Environmental Ecology, Pollution - Effects of , Pollution Effects, Viral Pollutant Sources, ...**5.0786**

ACCUMULATION AND ELIMINATION OF VIRUSES BY SHELLFISH ...Enteroviruses of Humans, Oysters, ...**5.1227**

Stamina

EFFECTS OF CHRONIC SUBLETHAL DOSAGES OF DDT ON THE SWIMMING PERFORMANCE OF ATLANTIC SALMON PARR ...Atlantic Salmon, Sebago Salmon, DDT , Locomotion - animal, Mode of Action -animal, Wildlife, ...**5.0472**

FISH PASSAGE THROUGH TURBINES ...Fish -non-specific, Hydraulic, Management -other, Mortality Rates, Power Development, ...**8.0312**

ACUTE TOXICITY OF PESTICIDES TO FRESHWATER FISH AND OTHER VERTEBRATES ...Pesticides -non-specific, Pollution - Effects of , Wildlife, ...**5.0651**

Stocking of Fish & Shellfish

INVESTIGATE THE FEASIBILITY OF INTRODUCING SOCKEYE SALMON INTO RESERVOIRS ...Oregon, Reservoirs and Impoundments, Salmon -coho,chinook,sockeye.., ...**6.0464**

CHEMICAL TREATMENT OF NEBISH LAKE ...Aquatic Ecology, Chemical Treatment-general, Control of Nuisance Species, Data Analysis - General, Lakes, ...**5.1293**

STUDIES ON PLANTED BROOK TROUT IN RELATION TO NUMBERS PLANTED, LIMNOLOGICAL CONDITIONS AND FOOD SUPPLIES IN UNFISHED LAKES ...Food Supply, Lake Trout, Brook Trout, Lakes, Michigan, Population Dynamics, ...**6.0303**

NEUTRALIZATION OF ACID STRIP-MINE LAKES ...Acidity, Lakes, Mine Drainage Control, Mining Activities, Neutralization, ...**5.0626**

FISH STOCKING EVALUATION ...Captive Rearing, Largemouth Bass, Management, Nets, Ponds, ...**6.0542**

SMALL IMPOUNDMENT STOCKING ...Bullheads, Centrarchidae -other, Colorado, Control of Nuisance Species, Lakes, ...**5.0201**

EVALUATION OF MARINE AND ALKALI TOLERANT SPECIES INTRODUCTION IN THE LOWER PECOS RIVER ...Centrarchidae -other, Drums, Fish -other, Migration, New Mexico, ...**6.0368**

CHARTING OF SUBTIDAL OYSTER BEDS AND EXPERIMENTAL TRANSPLANTING OF SEED OYSTERS FROM POLLUTED SEED OYSTER BEDS ...Captive Rearing, Commercial Fishing, Estuaries, Oysters, South Carolina, ...**5.1101**

EXPERIMENTAL REARING OF SALMON AND STEELHEAD IN BRACKISH WATER IMPOUNDMENTS ...Brackish Water, Captive Rearing, Environmental Response, Mortality Rates, Rainbow Trout, Steelhead Trout, ...**6.0461**

SIGNIFICANCE OF STOCKING SUB-ADULT FIN CLIPPED CATFISH IN HUNTSVILLE STATE PARK LAKE ...Aquatic Ecology, Channel Catfish, Lakes, Other, Population Dynamics, ...**6.0569**

ENVIRONMENTAL FACTORS AND YOUNG NORTHERN PIKE SURVIVAL IN RESERVOIRS ...Aquatic Ecology, Environmental Physiology, Pikes, Pickerel, Muskellunge, Reservoirs and Impoundments, Temperature, ...**6.0510**

ENVIRONMENTAL FACTORS AND YOUNG YELLOW PERCH SURVIVAL IN RESERVOIRS ...Aquatic Ecology, Environmental Physiology, Reservoirs and Impoundments, Temperature, Yellow Perch, Darters, ...**6.0511**

GEAR RESEARCH-RICE FARM PRODUCED FISH ...Aquaculture & Fish-farming, Economic Efficiency, Farm Pond, Special Purpose Machines, ...**6.0032**

EXPERIMENTAL SEEDING (SHRIMP AQUACULTURE PROGRAM) ...Captive Rearing, Florida, Population Dynamics, Shrimps - Common, Spawn Or Nesting Sites, ...**6.0565**

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DEVELOPMENT OF MARKING METHODS FOR SMALL FISH ...Dyes, Largemouth Bass, Musculoskeletal System, Other, ...**7.0081**

PREDATION ON LARGEMOUTH BASS DURING THEIR FIRST YEAR OF LIFE ...Behavioral Ecology, Largemouth Bass, Maturity & Growth Stages, Predation, Strontium, ...**7.0080**

DEVELOPMENT AND IMPROVEMENT OF INSTRUMENTATION AND SAMPLING GEAR FOR USE IN LIMNOLOGY AND FISHERY BIOLOGY ...Basses -sea,white, White Perch, Nets, Plankton Sampling, Salmon & Trout - Non-specific, Telemetry, ...**7.0115**

INVESTIGATION OF SPAWNING GROUND POTENTIALS AND GROWTH AND SURVIVAL OF JUVENILE SOCKEYE SALMON IN FRAZER LAKE SYSTEM ...Alaska, Censusing, Lakes, Nets, Salmon -coho,chinook,sockeye.., Spawn Or Nesting Sites, ...**6.0009**

MOVEMENTS OF SPORT FISHES IN BEAVER RESERVOIR ...Arkansas, Basses -sea,white, White Perch, Fishery Development -other, Migration, Reservoirs and Impoundments, ...**6.0017**

ADULT SALMON BEHAVIOR STUDIES IN RIVERS AND AT DAMS (SONIC TRACKING) ...Aquatic Ecology, Behavioral Ecology, Columbia River, Migration, Salmon & Trout - Non-specific, ...**8.0305**

FISH TRANSPORTATION ...Aquatic Ecology, Management -other, Migration, Salmon & Trout - Non-specific, Streams, ...**8.0304**

Telemetry

VHF PROPAGATION THROUGH FRESH WATER AND ACROSS THE AIR-WATER INTERFACE ...Fish -non-specific, Microwave, Transmitters, Very High Frequency, Water Properties-other, ...**1.0129**

DEVELOPMENT AND IMPROVEMENT OF INSTRUMENTATION AND SAMPLING GEAR FOR USE IN LIMNOLOGY AND FISHERY BIOLOGY ...Basses -sea,white, White Perch, Nets, Plankton Sampling, Salmon & Trout - Non-specific, Tags, ...**7.0115**

Land Use Or Modification

Agricultural Land Use Effects

MOUNTAIN MEADOW RESTORATION ...Conservation, Conservation-general, Management and Fertility, Mountains-alpine, Other Water Conditions, ...**4.0166**

A PRELIMINARY STUDY OF THE ECOLOGY, PRESENT AND ALTERNATIVE FUTURE LAND USE PATTERNS IN THE DISMAL SWAMP AREA OF NORTH CAROLINA ...Economic Impact, Game Reserves & Preserves, Land Use, North Carolina, Wetlands, ...**6.0404**

Construction Land Use Effects

MCNARY ARTIFICIAL SPAWNING CHANNEL STUDIES ...Channels, Columbia River, Salmon -coho,chinook,sockeye.., Spawn Or Nesting Sites, Temperature, ...**8.0302**

PASSAGE OF ADULT SALMONIDS THROUGH PIPES ...Management -other, Pipes, Salmon -coho,chinook,sockeye.., ...**8.0301**

MONITORING THE EFFECTS OF LAND USE ON SALMON PRODUCTION ...Alaska, Land Use, Logging, Transport, Equipment, Pulp, Paper , and Logging, Water Sampling, ...**5.0039**

COLUMBIA RIVER CHINOOK SALMON ...Columbia River, Habitat Studies, Population Dynamics, Salmon -coho,chinook,sockeye.., Spawn Or Nesting Sites, ...**2.1129**

PROTECTION OF FINGERLING SALMON IN TURBINES ...Engineering Structures-general, Migration, Mortality Rates, Salmon & Trout - Non-specific, Snake River, ...**8.0306**

Industry Land Use Effects

EFFECTS OF PULP MILL EFFLUENTS ON THE GROWTH AND PRODUCTION OF FISH ...Food Supply, Industrial Wastes, Pollution - Effects of , Pollution Effects, Pulp, Paper , and Logging, ...**5.0961**

Land Use -non-specific

RURAL LAND USAGE ...Agriculture, Land, Land Use, Rural Areas, Social Aspects, Types of Resources, ...**6.0471**

EVALUATION OF ENGINEERING PROJECTS AND ESTUARINE DATA (ESTUARINE PROGRAM) ...Commercial Fishing, Conservation & Management Eng, Construction Sites, Estuaries, Gulf of Mexico, Habitat Studies, ...**8.0290**

MANAGEMENT OF FOREST GAME RANGES IN THE CENTRAL ROCKY MOUNTAINS, AND IMPROVEMENT OF FISH HABITAT BY MANIPULATION OF STREAMSIDE VEGETATION ...Habitat Studies, Management, Soil (wildlife) Cover, Streams, Wildlife -non-specific, ...**4.0074**

Mammals

Food Supply

DEER FOODS ON WATERSHEDS TREATED FOR INCREASED WATER YIELD ...Arizona, Deer Ns, Forages, N. s. , Water Yield, ...**4.0004**

Soil (wildlife) Cover

THE BEHAVIOR OF SMALLMOUTH BASS AS RELATED TO ARTIFICIAL COVER ...Acidity, Behavioral Ecology, Mining Industry, Smallmouth Bass, Water Movement, Currents,, ...**5.1024**

COVER AS A LIMITING FACTOR IN TROUT PRODUCTION ...Colorado, Environmental Ecology, Number Or Density, Salmon & Trout - Non-specific, Streams, ...**4.0070**

PHYSICAL & CHEMICAL PROPERTIES OF WATER & SOILS OF MARSHES AS THESE PROPERTIES RELATE TO THE SUCCESS OF WATERFOWL FOODS & COVER. ...Biological-general, Food Supply, Wetlands, ...**6.0371**

THE PHYSICAL AND CHEMICAL PROPERTIES OF WATER AND SOILS AS RELATED TO THE SUCCESSFUL GROWTH OF WATERFOWL FOOD AND COVER PLANTS ...Flooding, Food Supply, Oxygen, Phytotoxic, Soil Conditions, Water Fowl, N.s. , ...**2.0799**

EFFECTS OF REGULATED GRAZING ON WATERFOWL PRODUCTION ...Cutting &/or Grazing Effects, Productivity - Food Chain, Swamps-marshes, Water Fowl, N.s. , ...**6.0584**

MANAGEMENT OF FOREST GAME RANGES IN THE CENTRAL ROCKY MOUNTAINS, AND IMPROVEMENT OF FISH HABITAT BY MANIPULATION OF STREAMSIDE VEGETATION ...Habitat Studies, Land Use -non-specific, Management, Streams, Wildlife -non-specific, ...**4.0074**

Spawn Or Nesting Sites

MCNARY ARTIFICIAL SPAWNING CHANNEL STUDIES ...Channels, Columbia River, Construction Land Use Effects, Salmon -coho,chinook,sockeye.., Temperature, ...**8.0302**

EFFECTS OF EARLY WATER ON WATERFOWL PRODUCTION ...Benefit-cost Analysis, Irrigation-general, Water Fowl, N.s. , Water Supply-general, Water Utilization -animal, ...**2.0214**

INVESTIGATION OF THE RELATIONSHIP OF THE AMERICAN SMELT, OSMERUS MORDAX - MITCHILL, TO THE WEWEANTIC RIVER ESTUARY, WAREHAM, MASSACHUSETTS ...Aquatic Ecology, Environmental Ecology, Estuaries, Smelts, Temperature, ...**5.0510**

STUDY OF RED SALMON IN THE NUSHAGAK DISTRICT ...Alaska, Chemical-general, Physical-general, Salmon -coho,chinook,sockeye.., ...**6.0622**

GRAVEL PERMEABILITY IN SALMONID SPAWNING BEDS ...Cementing Material, Permeability, Silting, Size, Streams, ...**6.0619**

EFFECTS OF RESTORATION AND MANAGEMENT OF THE SAN SIMON MARSH ON ITS UTILIZATION BY MEXICAN DUCKS ...Food Supply, Management, Mexican Duck, Swamps-marshes, Water Utilization -animal, ...**6.0364**

IMPORTANCE OF TYPE I WETLAND COMMUNITIES TO WATERFOWL PRODUCTION ...Censusing, Land Use, Water Fowl, N.s. , Water Utilization -animal, Wetlands, ...**4.0218**

WALLEYE AND NORTHERN PIKE STUDY ...Aquatic Ecology, Life History Studies, Pikes, Pickeral, Muskellunge, Texas, Walleyes, ...**6.0541**

EVALUATION OF HABITAT AND REPRODUCTIVE FACTORS WHICH INFLUENCE POPULATIONS OF NESTING WATERFOWL ...Habitat Studies, Mapping, Population Dynamics, Water Fowl, N.s. , Water Level Fluctuation, ...**4.0108**

AN EVALUATION OF THE LAMPREY IN LAKE CHAMPLAIN ...Lakes, Lampreys, Maturity & Growth Stages, Predation, Vermont, ...**6.0598**

INVESTIGATION OF SPAWNING GROUND POTENTIALS AND GROWTH AND SURVIVAL OF JUVENILE SOCKEYE SALMON IN FRAZER LAKE SYSTEM ...Alaska, Censusing, Lakes, Nets, Salmon -coho,chinook,sockeye.., Tags, ...**6.0009**

RESTORATION AND REHABILITATION OF EARTHQUAKE DAMAGED PINK AND CHUM SALMON STUDIES IN PRINCE WILLIAM SOUND ...Alaska, Aquatic Ecology, Data Acquisition-general, Earthquakes, Flow Characteristics -water, Salmon -coho,chinook,sockeye.., Stream Rehabilitation, Tectonics-general, ...**2.0026**

LIFE HISTORY OF THE GOLDEYE (HIODON ALOSOIDES) IN GARRISON RESERVOIR, NORTH DAKOTA ...Biological Rhythms, Life History Studies, Nets, North Dakota, Reservoirs and Impoundments, ...**5.0827**

STUDY OF THE RIVER PHASE OF THE LIFE HISTORIES OF ALOSA PSEUDOHARENGUS AND AESTIVALIS ...Alewife,menhaden,shad,herring, Aquatic Ecology, Connecticut River, Environmental Ecology, Life History Studies, ...**6.0111**

POTENTIAL FISHERY FOR RIVER HERRINGS IN CONNECTICUT RIVER ...Alewife,menhaden,shad,herring, Connecticut River, Environmental Ecology, Life History Studies, Nets, ...**4.0075**

A STUDY OF SELECTED CHEMICAL AND BIOLOGICAL CONDITIONS OF THE LOWER TRINITY RIVER AND THE UPPER TRINITY BAY ...Commercial Fishing, Estuaries, Mans Activities, Pollution - Effects of , Texas, ...**6.0546**

AN EVALUATION OF SOME MARSH MANAGEMENT TECHNIQUES ...Management, Potholes, Swamps-marshes, Water Fowl, N.s. , Water Utilization -animal, ...**4.0107**

COLUMBIA RIVER CHINOOK SALMON ...Columbia River, Construction Land Use Effects, Habitat Studies, Population Dynamics, Salmon -coho,chinook,sockeye.., ...**2.1129**

COMPOSITION OF THE SPAWNING STOCKS IN OAHE RESERVOIR AND LAKE SHARPE ...Age, Fertility, Fish -non-specific, Size, South Dakota, ...**6.0519**

SEXUAL MATURATION AND SPAWNING OF NORTHERN PIKE ...Biological Rhythms, Maturity & Growth Stages, Pikes, Pickeral, Muskellunge, Reservoirs and Impoundments, South Dakota, ...**6.0520**

SPAWNING OF YELLOW PERCH ...Biological Rhythms, Ovary, Reservoirs and Impoundments, South Dakota, Yellow Perch, Darters, ...**6.0521**

DISTRIBUTION AND DENSITY OF BREEDING WATERFOWL POPULATIONS AS RELATED TO QUANTITY AND QUALITY OF WETLAND HABITAT IN NORTH DAKOTA ...Geography-physical, North Dakota, Number Or Density, Water Fowl, N.s. , Wetlands, ...**6.0420**

LIFE HISTORY OF RESERVOIR FISHES, SPAWNING OF OAHE AND BIG BEND RESERVOIR FISHES ...Aquatic Ecology, Biological Rhythms, Life History Studies, Reservoirs and Impoundments, South Dakota, ...**6.0523**

ECOLOGICAL FACTORS AFFECTING REPRODUCTION OF SHELLFISH (PHYSIOECOLOGY OF SHELLFISH PROGRAM) ...Connecticut, Environmental Ecology, Oysters, Reproductive System, Water Properties-general, ...**6.0114**

POTENTIAL OYSTER SETTING CAPACITY - LOCAL AREAS ...Chesapeake Bay, Commercial Fishing, Other, Oysters, Streams, ...**5.0507**

Fish & Wildlife Biology

AUKE LAKE STUDIES ...Biological-general, Chemical-general, Gulf of Alaska, Lakes, Physical-general, ...**6.0006**

SALMON PRODUCTION IN AREAS MADE INACCESSIBLE BY DAMS ...Aquatic Ecology, Columbia River, Engineering Structures-general, Environmental Ecology, Salmon & Trout - Non-specific, ...**8.0309**

PINK SALMON INVESTIGATIONS - FRESHWATER ECOLOGY ...Alaska, Aquatic Ecology, Salmon -coho,chinook,sockeye.., Streams, Water Properties-general, ...**6.0005**

EXPERIMENTAL SEEDING (SHRIMP AQUACULTURE PROGRAM) ...Captive Rearing, Florida, Population Dynamics, Shrimps - Common, Stocking of Fish & Shellfish, ...**6.0565**

Wildlife -non-specific

EPIDEMIOLOGICAL RELATIONSHIPS OF PESTICIDE APPLICATION TO PESTICIDE RESIDUES IN WILDLIFE TISSUES AND HABITATS ...Aquatic Ecology, Habitat Studies, Oregon, Terrestrial -other, ...**5.0960**

PESTICIDES AND WILDLIFE ...Biodegradation, Food Chains, Animal And/or Man, Habitat Studies, Insecticides -non-specific, Preventative Measures, ...**5.0138**

ECOLOGICAL STUDIES OF WILDLIFE MANAGEMENT PRACTICES ...Delaware, Depth,water Level, Fluctuation, Habitat Studies, Management, Swamps-marshes, ...**6.0119**

EFFECT OF PESTICIDES ON WILDLIFE,(SONGBIRDS, HERRING GULLS AND FISH) ...DDT , Pollution Effects, Wildlife, Wisconsin, ...**5.1309**

MANAGEMENT OF FOREST GAME RANGES IN THE CENTRAL ROCKY MOUNTAINS, AND IMPROVEMENT OF FISH HABITAT BY MANIPULATION OF STREAMSIDE VEGETATION ...Habitat Studies, Land Use -non-specific, Management, Soil (wildlife) Cover, Streams, ...**4.0074**

Fishing Gear

BRISTOL BAY ESTUARINE ECOLOGY ...Alaska, Estuaries, Life History Studies, Migration, Salmon -coho,chinook,sockeye.., Water Mass & Ocean Fronts, ...**2.0016**

Flame Research

Fire Research

Fire Research-other

ENCAPSULATION AND SOLIDIFICATION OF INTERMEDIATE LEVEL RADIOACTIVE WASTES IN THERMOPLASTICS ...Accidental, Encapsulation, Instrumentation, Plant Equip. , Polymer-other, Radioisotopes, Recovery, Scrap and Wastes, ...**5.1142**

Flash Floods

PRECIPITATION, STREAMFLOW AND SEDIMENT CONVEYANCE IN A SMALL ARID WATERSHED ...Climate, Deserts, Flow Characteristics -water, Patterns, Sediment Transport-other, ...**2.0496**

LIMNOLOGICAL EFFECTS OF ORGANIC WATERSHED LITTER ...Forest Debris, Lakes, Southwest, Watersheds-general, ...**5.0048**

TEST AND EVALUATION OF FLASH FLOOD ALARM SYSTEM ...Evaluation Other, Field Studies, Field Testing, Laboratory Analysis, Warning-systems, ...**7.0110**

Floodplains

HYDROLOGIC FORECASTING AND EFFECTS OF FLOODS ON MEANDERING ALLUVIAL RIVERS WITH LARGE FLOODPLAINS ...Floods, Forecasting-prediction, Meanders, Model Studies, Yugoslavia, ...**4.0283**

THE HYDRAULICS AND GEOMORPHOLOGY OF MEANDERING RIVERS WITH FLOOD PLAINS ...Floods, Flow Characteristics -water, Land Use, Meanders, Routing, ...**2.0473**

PHYSICAL TECHNIQUES AND INSTITUTIONAL MECHANISMS FOR INTEGRATED ADJUSTMENT IN THE FLOOD PLAIN THROUGH SOIL SURVEYS ...Alternative Planning, Floodproofing, Land Use, Mapping, Soil Survey, ...**6.0647**

CASE STUDY OF REMEDIAL FLOOD MANAGEMENT IN AN URBAN AREA-PHASE I ...Alternative Planning, Floods, Management, Planning, Urban Environments, ...**6.0166**

RECENT VARIATIONS IN COURSE AND REGIMEN, KANSAS RIVER AND NEARBY REACHES OF MISSOURI RIVER ...Geomorphology-general, Kansas, Meanders, Sedimentology-general, ...**2.0503**

AN APPRAISAL OF FLOOD REGULATIONS IN THE STATES OF ILLINOIS, INDIANA, IOWA, MISSOURI AND OHIO ...Alternative Planning, Central, Floodproofing, Management, Water Rights-other, ...**6.0209**

LAND AND WATER USE, CONSERVATION, AND DEVELOPMENT IN OKLAHOMA WATERSHEDS ...Administrative Structures, Agriculture, Floodproofing, Land, Land Use, Model Studies, ...**6.0443**

FREE SURFACE FLOW AND WAVE PROPAGATION THROUGH CHANNEL-FLOOD PLAIN GEOMETRIES ...Channels, Conduit Flow-other, Flow Characteristics -water, Free Surface Waves, Model Studies, ...**8.0196**

STREAMFLOW VARIABILITY ...Drainage, Low Flow, Peak Flow, Reservoirs and Impoundments, Water Supply-general, ...**2.0421**

FLOOD PLAIN DELINEATION - DRD - USGS, COOPERATIVE STUDY ...Floodproofing, Wisconsin, ...**6.0641**

SOURCES, MOVEMENT, AND DISTRIBUTION OF SEDIMENT IN A SMALL WATER SHED ...Reservoirs and Impoundments, Sediment Yield, Small Watersheds, Supply Rate, Transport Distance, ...**2.0568**

FLOOD PROFILES AND FLOOD-PLAIN INFORMATION, CEDAR RAPIDS, IOWA ...Floods, Iowa, Planning, Urban Environments, Water Law-general, ...**2.0490**

FLOOD PROFILES AND FLOOD-PLAIN INFORMATION, LINN COUNTY, IOWA ...Discharge-general, Floodproofing, Floods, Iowa, Low Flow, ...**2.0491**

THE HYDRAULICS AND MEASUREMENT OF CHANNEL, FLOOD PLAIN, AND OVERLAND FLOW IN THE SOUTHERN PLAINS ...Channel Roughness, Channels, Measurement, Open Channel, Unsteady, ...**8.0276**

Floodproofing

PHYSICAL TECHNIQUES AND INSTITUTIONAL MECHANISMS FOR INTEGRATED ADJUSTMENT IN THE FLOOD PLAIN THROUGH SOIL SURVEYS ...Alternative Planning, Floodplains, Land Use, Mapping, Soil Survey, ...**6.0647**

THE ECONOMIC IMPACT OF FLOOD CONTROL RESERVOIRS ...Benefit-cost Analysis, Economic Impact, Kentucky, Project Post-evaluation, Reservoirs and Impoundments, ...**6.0241**

PHYSICAL, LEGAL AND ECONOMIC ASPECTS OF ASSESSMENT OF COSTS AMONG DRAINAGE DISTRICTS ...Drainage, Floods, Flow Characteristics -water, Legal Review, Routing, ...**6.0228**

AN OPTIMAL WATER MANAGEMENT PLAN FOR THE MIAMI VALLEY ...Alternative Planning, Artificial Recharge, Augmentation-general, Conjunctive Use, Optimization Technique, Systems Analysis, ...**6.0467**

THEORETICAL AND EMPIRICAL STUDIES OF STOCHASTIC MODELS FOR THE ANALYSIS OF FLOOD CONTROL AND RELIEF POLICIES ...Alternative Planning, Intergovernmental Relations, Model Studies, Other, Policy Making, ...**6.0047**

ECONOMICS OF FLOOD CONTROL STRUCTURES IN THE LOWER MINNESOTA RIVER WATERSHED DISTRICT ...Economics-general, Floods, Minnesota, Water Control Works-other, Water Loss Control, ...**6.0305**

A PRELIMINARY ECOLOGICAL STUDY OF AREAS TO BE IMPOUNDED IN THE SALT RIVER BASIN OF KENTUCKY ...Economic Impact, Kentucky, Reservoirs and Impoundments, Social Aspects, Urban Environments, ...**6.0244**

AN APPRAISAL OF FLOOD REGULATIONS IN THE STATES OF ILLINOIS, INDIANA, IOWA, MISSOURI AND OHIO ...Alternative Planning, Central, Floodplains, Management, Water Rights-other, ...**6.0209**

SOCIOLOGICAL IMPACT OF A FLOOD-CONTROL RESERVOIR ...Attitudes & Attitude Change, Reservoirs and Impoundments, Social Aspects, Social Change, ...**6.0476**

LAND AND WATER USE, CONSERVATION, AND DEVELOPMENT IN OKLAHOMA WATERSHEDS ...Administrative Structures, Agriculture, Floodplains, Land, Land Use, Model Studies, ...**6.0443**

SCHUYLKILL RIVER SURVEY ...Recreation Sites, Streams, Survey Studies, Water Development, Water Resources Development, ...**2.0906**

FLOOD PLAIN DELINEATION - DRD - USGS, COOPERATIVE STUDY ...Floodplains, Wisconsin, ...**6.0641**

HYDROLOGIC RELATIONS IN HAWAII ...Amount, Data Networks, Hawaii, Hydrology-general, Runoff, ...**2.0365**

INFLUENCE ON LAND VALUES OF IMPROVED UTILIZATION THROUGH FLOOD PROTECTION ...Economic Impact, Land Use, Rural Areas, Urban Environments, Value, ...**6.0129**

HYDROLOGIC STUDIES (STORM STUDIES) ...Flood Control, Hydrology-general, Patterns, Storms-general, Tables, Compilations, Catalogs, ...**2.0549**

FLOOD INUNDATION MAPPING - JEFFERSON COUNTY, MISSOURI ...Design Flow-flood, Floods, Flow Characteristics -water, Mapping, Missouri, ...**4.0157**

FLOODS IN THE WAIAHOLE-WAIKANE AREA, OAHU, HAWAII ...Floods, Hawaii, Mapping, Peak Flow, Regional Areas, ...**4.0085**

FLOODS IN PUNALUU-HAUULA AREA, OAHU, HAWAII ...Floods, Hawaii, Peak Flow, Zoning, ...**4.0086**

FLOOD PROFILES AND FLOOD-PLAIN INFORMATION, LINN COUNTY, IOWA ...Discharge-general, Floodplains, Floods, Iowa, Low Flow, ...**2.0491**

FLOOD INUNDATION STUDY, WISCONSIN ...Channels, Design Flow-flood, Floods, Mapping, Wisconsin, ...**4.0278**

FLOOD AND SEDIMENT REDUCTION IN STEEP UNSTABLE BRUSHLANDS OF THE SOUTHWEST ...Erosion-general, Floods, Sediment Yield, Southwest, ...**4.0034**

Floods

FLOOD FREQUENCY STUDY ...Bridges & Culverts, Culvert, New Mexico, Peak Flow, Rio Grande, ...**2.0772**

FLOOD FREQUENCY OF SMALL STREAMS IN LOUISIANA ...Drainage, Louisiana, ...**2.0541**

INVESTIGATION AND ANALYSIS OF FLOODS FROM SMALL WATERSHEDS IN OKLAHOMA ...Flow Characteristics -water, Gaging, Oklahoma, Peak Flow, Small Watersheds, ...**2.0278**

INFLOW HYDROGRAPH STUDY ...Hydrographs, Inflow, Shape, Small Watersheds, Wyoming, ...**2.0302**

SMALL DRAINAGE AREA STUDY ...Arizona, Drainage, Gaging, Peak Flow, Small Watersheds, ...**2.0289**

ANALYSIS OF RUN-OFF FROM SMALL DRAINAGE AREAS ...Design Flow-flood, Drainage, Massachusetts, Runoff, Small Watersheds, ...**2.0612**

FLOOD FREQUENCY FOR SMALL DRAINAGE AREAS ...Discharge-general, Drainage, Mississippi, Small Watersheds, ...**2.0291**

HYDROLOGY STUDY ...Bridges & Culverts, Culvert, Engineering Structures-general, Flow Characteristics -water, Small Watersheds, ...**2.0292**

INVESTIGATION AND ANALYSIS OF FLOODS FROM SMALL DRAINAGE AREAS IN OHIO ...Drainage Systems, Ohio, Small Watersheds, ...**2.0275**

INVESTIGATION AND ANALYSIS OF FLOODS FROM SMALL DRAINAGE AREAS IN SOUTH CAROLINA ...Culvert, Design Flow-flood, Drainage, Small Watersheds, South Carolina, ...**2.0301**

SMALL STREAMS INVESTIGATIONS IN OREGON ...Data Analysis - General, Discharge-general, Gaging, Hydrographs, Peak Flow, ...**2.0293**

INVESTIGATION AND ANALYSIS OF FLOOD HYDROGRAPHS FROM SMALL DRAINAGE BASINS IN SOUTH DAKOTA ...Bridges & Culverts, Culvert, Drainage, Hydrographs, Rain-general, Small Watersheds, ...**2.0294**

PROGRAM FOR INVESTIGATION AND ANALYSIS OF FLOODS FROM SMALL DRAINAGE AREAS IN DELAWARE ...Drainage, Flow Characteristics -water, Forecasting-prediction, Open Channel, Small Watersheds, ...**2.0295**

PROGRAM FOR HYDROLOGIC INVESTIGATION OF SMALL DRAINAGE AREAS IN TEXAS ...Design Flow-flood, Drainage, Hydraulic Structures, Small Watersheds, Texas, ...**2.0296**

ENGINEERING INVESTIGATION PERTAINING TO FLOOD PROTECTION OF BRIDGES AND CULVERTS ...Bridges & Culverts, Culvert, Design Criteria, Drag, Drainage, Erosion Control, ...**8.0145**

PREDICTION OF THE MAGNITUDES AND FREQUENCIES OF FLOODS IN MICHIGAN ...Drainage, Forecasting-prediction, Michigan, Morphology-general, Rain-general, ...**2.0635**

INVESTIGATION OF WATER RESOURCES. FLOODS IN SMALL STREAMS IN TENNESSEE ...Drainage, Tennessee, ...**2.0298**

VERIFICATION OF HYDRAULIC DESIGN OF BRIDGES IN ALABAMA ...Alabama, Bridges & Culverts, Data Acquisition-general, Drainage, Engineering Structures-general, ...**8.0001**

HYDROLOGIC STUDIES ...Data Acquisition-general, Small Watersheds, Virginia, ...**2.0299**

HYDROLOGIC FORECASTING AND EFFECTS OF FLOODS ON MEANDERING ALLUVIAL RIVERS WITH LARGE FLOOD-PLAINS ...Floodplains, Forecasting-prediction, Meanders, Model Studies, Yugoslavia, ...**4.0283**

EXTREME HYDROLOGIC EVENTS & THEIR EFFECTS ON NUCLEAR FACILITIES ...Hydrology-general, Natural Recharge, Radioactivity-general, Runoff, Water Table Fluctuation, ...**2.0273**

A RECONNAISSANCE STUDY OF THE CHEAPEAKE BAY ...Chesapeake Bay, Erosion-general, Sedimentology-general, Shoreline - Coastline, Survey Studies, Thermal Pollution, ...**6.0254**

FORM, PROCESSES AND DEPOSITS OF THE KNIK RIVER, ALASKA ...Braided Stream, Deposition-other, Ice Jam, Sediment Transport-other, Sorting, ...**2.0782**

EXTREME RAINFALL FOR THE MEKONG RIVER BASIN ...Dam Sites, Management, Meteorological Extremes, Southeast Asia, Water Loss Control, ...**2.0596**

PROBABLE MAXIMUM PRECIPITATION FOR SOUTHWEST STATES ...Amount, Design Flow-flood, Patterns, Snowmelt, Southwest, Weather Forecasting, ...**2.0597**

THE HYDRAULICS AND GEOMORPHOLOGY OF MEANDERING RIVERS WITH FLOOD PLAINS ...Floodplains, Flow Characteristics -water, Land Use, Meanders, Routing, ...**2.0473**

FLOODS FROM SMALL WATERSHEDS ...Amount, Rural Areas, Small Watersheds, Synthetic Hydrology-general, Systems Analysis, ...**2.0231**

TRACING STORM AND BASE FLOW TO VARIABLE SOURCE AREAS ON FORESTED HEADWATERS ...Baseflow, Forest Watersheds, Georgia, Hydraulic Structures, Runoff, Subsurface Flow, ...**2.0339**

REVIEW AND ANALYSIS OF PRECIPITATION AND RUNOFF DATA FOR SELECTED WATERSHEDS IN MINNESOTA ...Hydrographs, Infiltration, Precipitation-general, Runoff, Watersheds-general, ...**4.0140**

HYDROLOGY OF FROZEN GROUND FLOODS ...Hydrographs, Infiltration, Moisture Content, Permafrost-frozen, Runoff, ...**2.0399**

PILOT STUDY OF SMALL WATERSHED FLOOD HYDROLOGY IN HAWAII, PHASE II ...Design Criteria, Discharge-general, Drainage Systems, Hawaii, Urban Environments, ...**2.0381**

PHYSICAL, LEGAL AND ECONOMIC ASPECTS OF ASSESSMENT OF COSTS AMONG DRAINAGE DISTRICTS ...Drainage, Floodproofing, Flow Characteristics -water, Legal Review, Routing, ...**6.0228**

COMMUNITY REACTIONS TO WATER RESOURCES PROBLEMS IN RELATION TO PLANNING ...Planning, Pollution - Effects of, Social Aspects, Urban Environments, ...**6.0425**

ECONOMICS OF FLOOD CONTROL STRUCTURES IN THE LOWER MINNESOTA RIVER WATERSHED DISTRICT ...Economics-general, Floodproofing, Minnesota, Water Control Works-other, Water Loss Control, ...**6.0305**

FACTORS RESTRICTING INFILTRATION RATES ON DECOMPOSED GRANITIC SOILS ...Infiltration, Intrusives, Organic-general, Sand, Sierra Nevada, ...**2.0732**

EFFECTS OF BANK SEEPAGE ON FLOOD HYDROGRAPHS ...Hydrographs, Leekage, Seepage, Storage of Water, Stream Banks, ...**2.0504**

PHASE TWO - EXPERIMENTAL INVESTIGATION OF SMALL WATERSHED FLOODS ...Mathematical Analysis, Model Studies, Rain-general, Runoff, Small Watersheds, ...**2.0233**

ANOMALOUS FLOOD RESPONSE IN REGIONS OF SIMILAR GEOMORPHIC CHARACTERISTICS ...Computers-general, Flow Characteristics -water, Morphology-general, Pennsylvania, ...**2.0927**

THE EFFECTS OF EXTREME FLOODS AND PLACER MINING ON THE BASIC PRODUCTIVITY OF SUBARCTIC STREAMS ...Alaska, Benthic Fauna, Bottom Sampling, Meteorological Extremes, Placer, Productivity - Food Chain, ...**2.0022**

COMPUTER ANALYSIS OF WATERSHED CHARACTERISTICS AFFECTING FLOOD HYDROLOGY ...Data Analysis - General, Economic Efficiency, Research - Development, Small Watersheds, Water Loss Control, ...**2.0523**

CASE STUDY OF REMEDIAL FLOOD MANAGEMENT IN AN URBAN AREA-PHASE I ...Alternative Planning, Floodplains, Management, Planning, Urban Environments, ...**6.0166**

HYDRODYNAMIC CHARACTERISTICS OF FLOW CONCENTRATION GROINS ...Aeration, Engineering Structures-general, Flow Characteristics -water, Groin, Streams, ...**8.0268**

SMALL AGRICULTURAL WATERSHED HYDROLOGY ...Agricultural Watersheds, Gages, Patterns, Runoff, Sediment Yield, ...**4.0138**

STAND TREATMENT ...Cutting Operations, Regeneration & Seed Production, Timber Stand Improvement, Water Table - Depth of , Water Table Fluctuation, ...**2.0697**

LAND SHAPING FOR WATER CONSERVATION ...Land Use, Moisture Content, Natural Recharge, Production & Processing, Runoff, Water Harvesting, ...**3.0311**

STATISTICAL ANALYSIS OF FLOOD PEAKS OF GEORGIA RIVERS ...Data Analysis Applications, Digital Computers, Discharge-general, Georgia, Peak Flow, ...**2.0357**

HYDRAULICS OF FLOOD MOVEMENTS ...Analog Computers, Mathematical Analysis, Open Channel Flow, Partial, Routing, Unsteady Flow, ...**2.0348**

AN EXPLORATION OF THE INFLUENCE OF ATTITUDES FOR DECISION-MAKING IN WATER MANAGEMENT ...Attitudes & Attitude Change, Decision Making, Management, ...**6.0187**

A SURVEY OF THE SEASONALLY-INUNDATED MARGINS OF LAKE VOLTA (GHANA) ...Agriculture Industry, Ghana, Soil Types, Topographical -other, ...**4.0084**

WATERFOWL HABITAT INVESTIGATIONS - OTTAWA RIVER ...Canada, Habitat Studies, Water Fowl, N.s. , Water Level Fluctuation, ...**4.0051**

FLOODS FROM SMALL DRAINAGE AREAS ...California, Gaging, Hydrographs, Small Watersheds, ...**4.0039**

MATHEMATICAL MODELING OF SMALL WATERSHED FLOODS ...Mathematical Analysis, Model Studies, Rain-general, Runoff, Small Watersheds, ...**4.0073**

EXPERIMENTAL INVESTIGATION OF SMALL WATERSHED FLOODS ...Amount, Runoff, Small Watersheds, Synthetic Hydrology-general, ...**2.0232**

PILOT-STUDY OF SMALL WATERSHED HYDROLOGY ...Data Analysis - General, Instrumentation-general, Mathematical Analysis, Rain-general, Runoff, Small Watersheds, ...**2.0379**

FLOOD FREQUENCY AND LOW-FLOW ANALYSES ...Flow Characteristics -water, Low Flow, Maryland, Peak Flow, Statistical Models, ...**5.0481**

DRAINAGE CORRELATION RESEARCH PROJECT ...Climatography, Drainage, Peak Flow, Precipitation-general, Small Watersheds, ...**2.0710**

FLOOD PREDICTION METHODS FOR PENNSYLVANIA HIGHWAY CROSSINGS ...Engineering Properties, Forecasting-prediction, Highway Sites, Small Watersheds, Systems Analysis, ...**2.0928**

SEDIMENT YIELD IN RELATION TO CLIMATIC AND WATERSHED CHARACTERISTICS IN THE EDWARDS PLATEAU ...Reservoirs and Impoundments, Runoff, Sediment Yield, Texas, Watersheds-general, ...**2.1020**

RUNOFF AND WATER YIELD AS AFFECTED BY CLIMATIC AND WATERSHED CONDITIONS IN THE BLACKLANDS OF TEXAS ...Agricultural Watersheds, Amount, Runoff, Texas, Water Yield, ...**2.1021**

FLOOD HYDROGRAPH SYNTHESIS - UNGAGED WATERSHEDS ...Hydrographs, Small Watersheds, Tennessee, ...**2.0981**

FLOOD FREQUENCY STUDIES ...Design Flow-flood, Tennessee, ...**2.0982**

HYDROLOGIC SIMULATION - DAILY STREAMFLOW ...Antecedent Moisture, Design Flow-flood, Forecasting-prediction, Hydrology-general, Reservoirs and Impoundments, ...**6.0073**

OPTIMIZATION TECHNIQUES FOR HYDROLOGIC ENGINEERING ...Hydrographs, Hydrology-general, Optimization, Reservoirs, Reservoirs and Impoundments, Routing, ...**6.0075**

ARTIFICIAL FLOODS ...Computers-general, Dam, Dams-other, Flow Characteristics -water, ...**6.0076**

FLOOD-FREQUENCY AND BASIN PARAMETER RELATIONSHIPS IN SMALL DRAINAGE AREAS ...Amount, Discharge-general, Morphology-general, Peak Flow, Small Watersheds, ...**2.0280**

FLOOD INUNDATION MAPPING - JEFFERSON COUNTY, MISSOURI ...Design Flow-flood, Floodproofing, Flow Characteristics -water, Mapping, Missouri, ...**4.0157**

FLOODS IN NORTH LOUISIANA - RAINFALL-RUNOFF RELATIONSHIPS ...Amount, Gaging, Louisiana, Runoff, Storms-general, ...**2.0537**

FLOOD INUNDATION MAPPING, NORTHEASTERN ILLINOIS ...Atlases-maps, Data Networks, Discharge-general, Gaging, Illinois, ...**4.0093**

UNIT HYDROGRAPHS FOR SOUTHWESTERN LOUISIANA ...Forecasting-prediction, Gaging, Hydrographs, Louisiana, ...**2.0539**

UNIT HYDROGRAPHS FOR NORTHERN LOUISIANA ...Forecasting-prediction, Gaging, Hydrographs, Louisiana, ...**2.0540**

HYDROLOGY OF STREAMS, ST. LOUIS METROPOLITAN AREA ...Missouri, Runoff, Streams, Urban Environments, ...**4.0158**

FLOOD FLOWS AND SEDIMENT YIELD OF COLMA CREEK BASIN, CALIFORNIA ...California, Construction, Projections and Estimations, Sediment Yield, Urban Environments, Water Yield, ...**4.0038**

FLOODS IN THE WAIAHOLE-WAIKANE AREA, OAHU, HAWAII ...Floodproofing, Hawaii, Mapping, Peak Flow, Regional Areas, ...**4.0085**

FLOODS IN PUNALUU-HAUULA AREA, OAHU, HAWAII ...Floodproofing, Hawaii, Peak Flow, Zoning, ...**4.0086**

FLOOD PROFILES AND FLOOD-PLAIN INFORMATION, CEDAR RAPIDS, IOWA ...Floodplains, Iowa, Planning, Urban Environments, Water Law-general, ...**2.0490**

FLOOD PROFILES AND FLOOD-PLAIN INFORMATION, LINN COUNTY, IOWA ...Discharge-general, Floodplains, Floodproofing, Iowa, Low Flow, ...**2.0491**

CITY OF JACKSON, WATER RESOURCES STUDY, MISSISSIPPI ...Control and Protection, Groundwater, Mississippi, Urban Environments, Water Supply-general, ...**4.0148**

FLOODING OF SMALL STREAMS IN NASHVILLE-DAVIDSON CO. AREA, TENN. ...Amount, Discharge-general, Gaging, Tennessee, Urban Environments, ...**2.0994**

FLOOD INUNDATION MAPPING AND URBAN RUNOFF INV., DALLAS, TEXAS ...Land Use, Mapping, Runoff, Texas, Urban Environments, ...**4.0232**

HYDROLOGIC INVESTIGATIONS OF URBAN AREAS - HOUSTON, TEXAS ...Amount, Discharge-general, Gaging, Texas, Urban Environments, ...**4.0233**

URBAN HYDROLOGY STUDY - SAN ANTONIO, TEXAS ...Discharge-other, Runoff, Texas, Urban Environments, ...**4.0234**

FLOOD INUNDATION STUDY, WISCONSIN ...Channels, Design Flow-flood, Floodproofing, Mapping, Wisconsin, ...**4.0278**

HYDROLOGIC ANALYSIS METHODS ...Forest Watersheds, Land Use, Reservoirs and Impoundments, Sediment Yield, Snowmelt, ...**2.0077**

FLOOD AND SEDIMENT REDUCTION IN THE CONIFEROUS TIMBER ZONE OF CALIFORNIA ...Creep, Land and Rock Slides, Management, Pulp, Paper , and Logging, Sediment Yield, ...**2.0078**

FLOOD AND SEDIMENT REDUCTION IN STEEP UNSTABLE BRUSHLANDS OF THE SOUTHWEST ...Erosion-general, Floodproofing, Sediment Yield, Southwest, ...**4.0034**

WATERSHED PROTECTION & REHABILITATION TO REDUCE WATER RUNOFF ...Erosion-general, Forest Watersheds, Infiltration, Land Use, Runoff, ...**4.0250**

FLOOD RUNOFF & WATER YIELD FROM GLACIATED MOUNTAINS ...Forest Watersheds, Glacial Environment, Heat Budget, Runoff, Water Balance-budget, Water Yield, ...**3.0372**

FLOOD REDUCTION AND IMPROVEMENT IN TIMING OF WATER YIELD IN THE OZARKOUACHITA UPLANDS ...Erosion-general, Infiltration, Land Use, Water Cycle, Water Yield, ...**5.0054**

DEVELOPMENT OF SPECIAL REHABILITATION TECHNIQUES AND FOREST MANAGEMENT PRACTICES FOR USE ON SEVERELY ERODED OR HIGHLY EROSIVE WATERSHEDS ...Conservation, Cover Crops, Erosion-general, Runoff, Site Index and Site Quality, ...**2.0674**

STORM RUNOFF AND FLOODS AS RELATED TO INTEGRATED CLIMATIC AND WATERSHED CHARACTERISTICS ...Climate, Land Use, Morphology-general, Runoff, Storm Water, ...**4.0071**

WATER ACCUMULATION, FLOOD-WAVE MOVEMENT AND WATER YIELD FROM COMPLEX WATERSHEDS OF THE PACIFIC NORTHWEST ...Channels, Forecasting-prediction, Hydrographs, Idaho, Peak Flow, Storage of Water, Water Yield, Watersheds-general, ...**3.0202**

CLIMATE, SOIL AND VEGETATION INFLUENCES ON HYDROLOGY OF RANGELANDS IN THE SOUTHWEST ...Hydrology-general, Runoff, Sediment Yield, Water Yield, ...**4.0007**

FLOOD WAVE MOVEMENT IN NATURAL EPHEMERAL STREAM CHANNELS ...Channels, Ephemeral, Runoff, Thunderstorms, Waves, ...**4.0008**

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MARSH HABITAT STUDY ...Centrarchidae -other, Chemical-general, Habitat Studies, Life History Studies, Swamps-marshes, ...**6.0157**

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URANIUM AND HYDROGEN RADIONUCLIDES AS NATURAL TRACERS IN THE FLORIDAN AQUIFER ...Aquifers-general, Quaternary Period, Radioisotopes, Recharge -general, Tritium, Uranium, ...**2.0326**

THE BIOLOGY OF THE INFAUNA OF A TROPICAL SOFT BOTTOM AREA ...Aquatic Ecology, Benthic Fauna, Estuaries, Intertidal Areas, Pollution - Effects of , ...**5.0263**

PRIMARY PRODUCTION AND DECOMPOSITION IN ESTUARINE WATER ...Estuaries, Methane Bacteria (non-specif.), Phaeophyta (non-specific & Ot), Primary Productivity, Rhodophyta (non-specific & Ot), Turnover (metabolic), ...**5.0257**

EUTROPHICATION FACTORS IN NORTH CENTRAL FLORIDA LAKES ...Administrative Structures, Eutrophication, Lakes, Model Studies, Systems Analysis, ...**5.0258**

STUDIES OF THERMAL POLLUTION IN BISCAYNE BAY ...Aquatic Ecology, Bays, Pollution - Effects of , Thermal Pollution, Warm Water, ...**5.0265**

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ST. JOHNS RIVER FISHERY PROJECT ...Environmental Ecology, Mans Activities, Pollution Effects, Population Dynamics, Streams, ...**3.0173**

SAND TRACING AT SPECIFIC INLETS AND AREAS ON THE LOWER EAST COAST OF FLORIDA ...Bays, By-passing, Longshore Currents, Shoreline - Coastline, Tracers, ...**8.0161**

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RELATIONSHIP OF TUBE-AND REEF BUILDING MARINE ANNELIDS TO COASTAL ENGINEERING AND CONSERVATION PROBLEMS IN FLORIDA ...Coastal Engineering-other, Environmental Ecology, Lugworms, Marine Segmentedworm, Vertical Distribution, ...**3.0187**

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WATER RESOURCES STUDY, DUVAL COUNTY, FLORIDA ...Carbonate Aquifers, Hydrology-general, Surface Water, Total Volume, Water Quality-general, ...**2.0330**

REMOTE SENSING, EVERGLADES AREA, FLORIDA ...Computers-general, Remote Areas, Swamps-marshes, Visible Light, Water Properties-general, ...**2.0329**

ESTUARINE INVENTORY (FORMERLY CHEMICAL ENVIRONMENT) ...Estuaries, Gulf of Mexico, Marine Biology, Physiography-general, Sedimentology-general, ...**2.0325**

RELATION OF ENVIRONMENTAL FACTORS TO THE PRODUCTIVITY OF ESTUARINE SEDENTARY FAUNA ...Aquatic Ecology, Environmental Ecology, Estuaries, Productivity - Food Chain, ...**5.0269**

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IRRIGATION AND OTHER PRODUCTION RELATIONS IN FLORIDA CITRUS ENTERPRISES ...Benefit-cost Analysis, Citrus, Input - Output Analysis, Irrigation-general, Water Costs, Water Demand, ...**6.0135**

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HYDROLOGY STUDY ...Bridges & Culverts, Culvert, Engineering Structures-general, Floods, Small Watersheds, ...**2.0292**

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PERFORMANCE OF CIRCULAR CULVERTS ON STEEP GRADES ...Channels, Culvert, Drainage, Engineering Structures-general, Erosion Control, ...**8.0289**

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RESTORATION AND REHABILITATION OF EARTHQUAKE DAMAGED PINK AND CHUM SALMON STUDIES IN PRINCE WILLIAM SOUND ...Alaska, Aquatic Ecology, Data Acquisition-general, Earthquakes, Salmon -coho,chinook,sockeye.., Spawn Or Nesting Sites, Stream Rehabilitation, Tectonics-general, ...**2.0026**

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STORAGE OF FRESH WATER IN UNDERGROUND RESERVOIRS CONTAINING SALINE WATER ...Artificial Recharge, Mixing, Model Studies, Recharge Pits - Wells, Storage of Water, ...**4.0115**

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THE INFLUENCE OF WETLANDS ON QUANTITY AND QUALITY OF STREAM FLOW ...Available Water, Evapotranspiration, Hydrology-general, Streams, Wetlands, ...**4.0170**

HYDRAULIC GEOMETRY OF STREAMS ...Flow Characteristics - water, Hydraulics-general, Ions and Gases, Physiography-general, River Basins, ...**2.0444**

WATER POLLUTION STUDY OF THE WABASH RIVER ...Data Acquisition-general, Indiana, Model Studies, Oxygen, Water Quality-general, ...**5.0390**

STREAMFLOW VARIABILITY ...Drainage, Floodplains, Peak Flow, Reservoirs and Impoundments, Water Supply-general, ...**2.0421**

ILLINOIS RIVER STUDY ...Illinois River, Ions and Gases, Self-purification, Streams & Rivers, Waste Water Treatment-general, ...**5.0351**

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BASIC RESEARCH IN VEGETATION AND HYDROLOGY ...Flooding, Groundwater, Land Use, Mapping, Movement, Water Quality-general, ...**2.1100**

LOW-FLOW ANALYSIS, WASHINGTON STREAMS ...Baseflow, Discharge-general, Gaging, Hydrographs, Washington, ...**2.1134**

LOW FLOW CHARACTERISTICS OF TENNESSEE STREAMS ...Annual, Gaging, Tennessee, Variation in Time, ...**2.0997**

LOW FLOW CHARACTERISTICS OF INDIANA STREAMS ...Discharge-general, Flow Characteristics -water, Gaging, Indiana, ...**2.0455**

LOW-FLOW STUDIES OF IOWA STREAMS ...Available Water, Iowa, Water Law-general, Water Quality Control-general, Water Standards, ...**2.0489**

FLOOD PROFILES AND FLOOD-PLAIN INFORMATION, LINN COUNTY, IOWA ...Discharge-general, Floodplains, Floodproofing, Floods, Iowa, ...**2.0491**

LOW-FLOW STUDY - WISCONSIN ...Baseflow, Data Acquisition-general, Flow Characteristics -water, Wisconsin, ...**2.1147**

HYDROLOGY OF HUNGRY HORSE RESERVOIR MONTANA ...Inflow, Montana, Reservoirs and Impoundments, Water Balance-budget, ...**2.0124**

Open Channel Flow

RADIOISOTOPE WATER FLOW MEASUREMENT IN HIGH-HEAD TURBINES AND PUMPS ...Fluids, Pump-other, Radioisotopes, Technique Development, Turbine-other, ...**4.0057**

WIND EFFECTS ON THE DISPERSION OF PARTICULATE POLLUTANTS IN TURBULENT OPEN-CHANNEL FLOW ...Dispersion -water, Flow of Dispersed Solids, Sediments, Turbulent Flow, Wind-other, ...**2.0229**

HYDRODYNAMIC FORCES ON NON-COHESIVE BED PARTICLES INCLUDING SEEPAGE ...Drag, Seepage, ...**2.1079**

MICROSCOPIC INVESTIGATION OF TRACTIVE FORCE DISTRIBUTION IN OPEN CHANNEL ...Suspension, Traction, Turbulent, Turbulent Flow, Velocity -water, ...**8.0183**

THE FLOW OF WATER IN FLUMES AND CANALS ...Canals, Channel Geometry, Flume, Open Channel, Turbulent, ...**8.0222**

HYDRAULICS OF FLOOD MOVEMENTS ...Analog Computers, Floods, Mathematical Analysis, Partial, Routing, Unsteady Flow, ...**2.0348**

ANALYSIS AND SYNTHESIS OF HYDROLOGIC SYSTEMS ...Computers-general, Flow Characteristics -water, Hydrology-general, Patterns, Technique Development, ...**2.0615**

OPEN-CHANNEL TRANSITIONS IN SUPERCRITICAL FLOW ...Channel Geometry, Critical, Cross-section, Hydraulics-general, Open Channel, ...**8.0283**

INCIPIENT MOTION OF LARGE ROUGHNESS ELEMENTS IN TURBULENT OPEN CHANNEL FLOW ...Erosion Control, Flow Characteristics -water, Open Channel, Sediment Transport-other, Turbulent Flow, ...**2.1062**

OPEN CHANNEL ROUGHNESS CHARACTERIZATION ...Channel Roughness, Discharge-general, Flume, Flume Studies, Open Channel, ...**2.1073**

SIMULATED OPEN CHANNEL HYDRAULICS ...Cumberland River, Mathematical Analysis, Model Studies, Numerical Analysis-other, Tennessee, ...**2.0983**

SALINITY INTRUSION AND RELATED PHENOMENA ...Currents -water, General Deposition, Mixing, Saline Water Intrusion, Sediment Transport-general, ...**2.0687**

VALUE OF STREAMFLOW DATA ...Benefit-cost Analysis, Data Networks, Gaging, Unsteady Flow, Water Resources Development, ...**6.0077**

FLOW LOSSES IN AN EPHEMERAL STREAM CHANNEL ...Conservation-general, Energy Loss -water, Ephemeral, Infiltration, Morphology-general, Water Cycle, ...**2.0178**

UNSTEADY FLOW AND SALINE INTRUSION IN ESTUARIES ...Channels, Estuaries, Model Studies, Saline Water Intrusion, Unsteady Flow, ...**2.1091**

REAERATION IN OPEN CHANNEL FLOW ...Aeration, Degradation, Freshwater Ecology, Oxygen, Oxygen Content -water, ...**2.0224**

NUMERICAL SIMULATION OF HYDRODYNAMIC PHENOMENA BY DIGITAL COMPUTER ...Groundwater, Model Studies, Porous Media - Flow Through, Subsurface Flow, Waves, ...**2.1096**

DESIGN CRITERIA FOR OPEN CHANNELS ...Design Criteria, Hydraulics-general, Irrigation Engineering, Open Channel, Surface Irrigation -general, ...**8.0136**

RADIOISOTOPE WATER FLOW MEASUREMENT IN HIGH-HEAD TURBINES AND PUMPS ...Fluids, Radioisotopes, Water, ...**8.0065**

TRANSIENT FLOW IN OPEN CHANNELS ...Channel Geometry, Hydraulic Gradient, Pump-other, Siphon, Transient, ...**8.0039**

Peak Flow

FLOOD FREQUENCY STUDY ...Bridges & Culverts, Culvert, Floods, New Mexico, Rio Grande, ...**2.0772**

HYDROLOGICAL STUDY ...Discharge-general, Drainage, Gaging, Rhode Island, Small Watersheds, ...**2.0943**

WATERSHED SHAPE-FACTOR ...Culvert, Design Criteria, Drainage, Engineering Structures-general, North Dakota, ...**2.0277**

INVESTIGATION AND ANALYSIS OF FLOODS FROM SMALL WATERSHEDS IN OKLAHOMA ...Floods, Flow Characteristics -water, Gaging, Oklahoma, Small Watersheds, ...**2.0278**

FLOOD FREQUENCY SYNTHESIS FOR SMALL STREAMS IN ALABAMA ...Alabama, Drainage, Forecasting-prediction, Gaging, Runoff, Small Watersheds, ...**3.0172**

SMALL DRAINAGE AREA STUDY ...Arizona, Drainage, Floods, Gaging, Small Watersheds, ...**2.0289**

RUNOFF STUDIES ON SMALL DRAINAGE AREAS ...Data Acquisition-general, Discharge-general, Drainage, Small Watersheds, West Virginia, ...**2.0290**

SMALL STREAMS INVESTIGATIONS IN OREGON ...Data Analysis - General, Discharge-general, Floods, Gaging, Hydrographs, ...**2.0293**

URBAN HYDROLOGIC STUDIES ...Digital Computers, Drainage, Forecasting-prediction, Louisiana, Urban Environments, ...**2.0551**

HYDROLOGIC CHARACTERIZATION OF SMALL WATERSHEDS ...Cold - Climates, Mathematical Analysis, Model Studies, Runoff, Small Watersheds, ...**4.0143**

STATISTICAL ANALYSIS OF FLOOD PEAKS OF GEORGIA RIVERS ...Data Analysis Applications, Digital Computers, Discharge-general, Floods, Georgia, ...**2.0357**

MATHEMATICAL MODEL OF STORM AND SANITARY INTERCEPTOR SYSTEM ...Design-other, Inflow, Model Studies, Rain Fall Intensity, Storm Water, ...**5.0597**

STREAMFLOW VARIABILITY ...Drainage, Floodplains, Low Flow, Reservoirs and Impoundments, Water Supply-general, ...**2.0421**

TRACER STUDIES - URBAN RUNOFF ...Dyes, Runoff, Urban Environments, Urban Research, Velocity -water, ...**4.0101**

FLOOD FREQUENCY AND LOW-FLOW ANALYSES ...Floods, Flow Characteristics -water, Low Flow, Maryland, Statistical Models, ...**5.0481**

DRAINAGE CORRELATION RESEARCH PROJECT ...Climatography, Drainage, Floods, Precipitation-general, Small Watersheds, ...**2.0710**

HYDROLOGIC MODEL FOR STREAMFLOW FORECASTING ...Flow Characteristics -water, Forecasting-prediction, Hydrographs, Model Studies, Precipitation-general, Runoff, ...**2.0600**

FLUVIAL SEDIMENTATION IN STONY BROOK WATERSHED ...Gaging, Runoff, Sedimentology-general, Small Watersheds, Total Volume, ...**2.0766**

FLOOD-FREQUENCY AND BASIN PARAMETER RELATIONSHIPS IN SMALL DRAINAGE AREAS ...Amount, Discharge-general, Floods, Morphology-general, Small Watersheds, ...**2.0280**

DETERMINATION OF CHANNEL CAPACITY OF THE MERCED RIVER, CALIFORNIA ...California, Channels, Cross-section, Dischargengeneral, Hydrographic, ...**2.0116**

CHANNEL CAPACITY IN STONY CREEK NEAR ORLAND, CALIFORNIA ...California, Channels, Design Flow-flood, Reservoirs and Impoundments, Water Transfer, ...**2.0122**

FLOODS IN THE WAIAHOLE-WAIKANE AREA, OAHU, HAWAII ...Floodproofing, Floods, Hawaii, Mapping, Regional Areas, ...**4.0085**

FLOODS IN PUNALUU-HAUULA AREA, OAHU, HAWAII ...Floodproofing, Floods, Hawaii, Zoning, ...**4.0086**

STREAMFLOW REGULATION AND SEDIMENT CONTROL IN NORTHERN ROCKY MOUNTAIN FORESTS ...Flow Characteristics -water, Forest Watersheds, Infiltration, Snowmelt, Water Yield, ...**5.0321**

WATER ACCUMULATION, FLOOD-WAVE MOVEMENT AND WATER YIELD FROM COMPLEX WATERSHEDS OF THE PACIFIC NORTHWEST ...Channels, Floods, Forecasting-prediction, Hydrographs, Idaho, Storage of Water, Water Yield, Watersheds-general, ...**3.0202**

Saturated Flow

DEEP SEEPAGE ON PIEDMONT WATERSHEDS ...Percolation, Physical Properties-general, Piedmont Province, Seepage, Unsaturated Flow, Water Table Fluctuation, ...**2.0955**

MIXING PROCESSES IN SATURATED AND UNSATURATED SOIL-WATER SYSTEMS IN RELATION TO POLLUTION ...Chemical-general, Internal Water Movement, Mixing, Pollutants - Path of , Unsaturated Flow, ...**2.0086**

THE FINITE ELEMENT METHOD IN FLUID MECHANICS ...Degradation, Finite Differences, Fluid Dynamics, Groundwater Movement, Non-autonomous, ...**5.0302**

VARIATION OF SATURATED HYDRAULIC CONDUCTIVITY OF HOUSTON BLACK CLAY WITH SOIL DEPTH AND WITH DIAMETER OF SOIL COVES ...Clay, Density, Permeability, Texas, ...**2.1022**

PERMEABILITY RESEARCH ...Groundwater Movement, Observation Wells, Permeability, Porous Media - Flow Through, Unsaturated Flow, ...**2.0183**

Sheetflow

CULTURAL PRACTICES ON EASTGATE BASIN ...Cultivated Soils, Moisture Content, Sediment Yield, Surface Flow, Tillage, Cropping Systems, ...**4.0168**

EFFECT OF RAINDROP IMPACT AND SURFACE ROUGHNESS ON SHEET FLOW ...Flow Characteristics -water, Model Studies, Rain-other, Rainfall Simulators, Roughness, ...**2.0447**

Stratified Flow

AN INVESTIGATION OF THE EFFECT OF CONTROLLED RELEASES ON THE PHYSICAL, CHEMICAL AND BACTERIOLOGICAL CHARACTERISTICS OF FORT LOUDOUN RESERVOIR ...Nitrogen, Phosphate, Phosphite, Suspension, Temperature-other, Tennessee, ...**5.1128**

INVESTIGATION OF THE CIRCULATION OF LAKE SUPERIOR ...Circulation -water, Model Studies, Temperature, Velocity - water, ...**2.1161**

TWO-PHASE FLOW IN A VERTICAL BEND ...Close Channel, Engineering Structures-general, Open Channel, Two-phase-other, Ventilated Cavities, ...**8.0163**

INTERNAL CURRENTS RESULTING FROM INTERMEDIATE DENSITY INFLOWS INTO STRATIFIED RESERVOIRS ...Inflow, Model Studies, Reservoirs and Impoundments, Stratification, Temperature, ...**5.1264**

ANALYSIS OF THERMAL POLLUTION DISPERSION ...Aeration, Dispersion -water, Effluents-waste Water, Temperature, Thermal Pollution, ...**5.0726**

FACTORS AFFECTING MINE DRAINAGE AND THE GROUND WATER INTERACTIONS IN SELECTED AREAS OF WESTERN PENNSYLVANIA (PART 2) ...Acidity, Baseflow, Groundwater Movement, Mine Drainage Control, Pyrite Group, ...**5.1044**

QUALITY OF WATER AS AFFECTED BY STRATIFIED FLOW (RESERVOIRS) ...Ions and Gases, Model Studies, Reservoirs and Impoundments, Stratification, Turbidity, ...**5.0185**

Subsurface Flow

RUNOFF STUDIES ON SMALL WATERSHEDS ...Hydrographs, Runoff, Small Watersheds, Surface Water, Water Yield, ...**2.1138**

RELATION OF BEDROCK FRACTURE SYSTEMS TO UNDERGROUND WATER IN STAFFORD SPRINGS, SOUTH COVENTRY, SPRING HILL & WESTFORD QUADS ...Groundwater Movement, Joints-fractures, Local Structure, Rocks - Bedrock, Water Quantity-general, ...**2.0243**

RATE AND DIRECTION OF GROUND WATER CIRCULATION IN CLOSE SPACED BEDROCK AND GRAVEL WELLS UNDER THE INFLUCENCE OF NON-SYNCHRONOUS PUMPING TIME ...Connecticut, Groundwater Movement, Land Use, Pumping, ...**2.0244**

THE EFFECT OF THE NATURAL SEALING OF POTHOLES UPON WATER MOVEMENT AND GROUNDWATER RESOURCES ...Groundwater, Internal Water Movement, Linings-pavings, Permeability, Potholes, ...**2.0667**

TRACING STORM AND BASE FLOW TO VARIABLE SOURCE AREAS ON FORESTED HEADWATERS ...Baseflow, Floods, Forest Watersheds, Georgia, Hydraulic Structures, Runoff, ...**2.0339**

WATER ADSORPTION AND ITS INTERACTIONS WITH CLAY AND QUARTZ ...Adsorption Capacity, Bonding, Clay, Internal Water Movement, Quartz, ...**2.0663**

THE EFFECT OF TEMPERATURE ON WATER FLOW IN SOILS ...Boundary Process (moisture), Flow Characteristics -water, Internal Water Movement, Soil Environment, Temperature, ...**2.0679**

NUMERICAL MODELING OF GROUND WATER FLOW ...Aquifers-general, Artificial Recharge, Groundwater Movement, Model Studies, ...**2.0506**

EVALUATION OF GROUNDWATER RESOURCES, LIVERMORE VALLEY, CALIFORNIA ...Data Acquisition-general, Groundwater Basins, Management, Model Studies, Water Yield, ...**4.0025**

AQUIFER PERFORMANCE TESTS UNDER TWO PHASE FLOW CONDITIONS ...Aquifers-general, Observation Wells, Synthetic Hydrology-general, Two-phase-other, ...**2.0008**

EFFECT OF PHYSICAL PROPERTIES OF POROUS MEDIA ON WATER MOVEMENT ...Mathematical Analysis, Permeability, Porosity, Porous Media - Flow Through, Size, ...**2.0391**

WATER CONTAMINATION BY FERTILIZER NITROGEN AND PHOSPHORUS ...Agricultural Watersheds, Fertilizers, Nitrogen, North Carolina, Phosphorus, Runoff, ...**5.0823**

FURTHER STUDIES OF INFILTRATION ...Infiltration, Porous Media - Flow Through, Unsaturated Flow, Unsteady Flow, ...**5.0124**

FACTORS INFLUENCING THE FLOW OF SUBSOIL WATER IN THE IMMEDIATE PROXIMITY OF, AND INTO DRAINAGE FACILITIES ...Compressibility, Internal Water Movement, Radioisotopes, ...**2.0147**

THE DRAINAGE OF IRRIGATED LANDS ...Drainage, Irrigation-general, Permeability, Steady, Water Table Fluctuation, ...**4.0251**

DESIGN OF OPEN CHANNELS TO PREVENT BANK FAILURE ...Piezometers, Seepage, ...**4.0253**

THE EFFECT OF HETEROGENEITIES OF THE SOIL UPON INFILTRATION ...Infiltration, Physical Properties -other, ...**2.1165**

PREDICTION OF WATER MOVEMENT IN UNSATURATED SOILS ...Absorption, Fixation, Exchange, Internal Water Movement, Moisture Tension, Unsaturated Flow, ...**2.0376**

THE ROLE OF SOIL WETTABILITY AND TREATMENT WITH WETTING AGENTS ON WATER MOVEMENT AND SOIL PHYSICAL PROPERTIES ...Adsorption Capacity, Formation Principles, Internal Water Movement, Moisture Content, Organic Content, Texture, ...**2.0141**

THEORETICAL ANALYSIS OF REGIONAL GROUND-WATER FLOW IN THE HAVANA AREA ...Groundwater Movement, Illinois, Mathematical Analysis, Model Studies, Water Table Fluctuation, ...**2.0410**

EFFECTS OF TREE ROOTS ON HYDRAULIC CONDUCTIVITY AND POROSITY OF FOREST SOILS IN THE ALLEGHENY-CUMBERLAND PLATEAU ...Forests, Roots, Soil Compaction Or Density, Soil Environment, Soils and Fertilizer, ...**2.0855**

DRAINAGE OF STRATIFIED FOILS ...Drainage, Drainage Engineering, Drainage Systems, Soil-water-plant Relationships, ...**5.0939**

PREDICTING SOLUTE MOVEMENT AND DISTRIBUTION IN SOILS ...Hydrolysis, Infiltration, Salinity, Soil and Rock Leaching, Soil Environment, ...**2.1043**

PERMIAN BASIN - ORIGIN OF SALINE WATER DISCHARGE ...Brines, Groundwater Movement, Permian Period, Saline Water Intrusion, Texas, ...**2.1004**

THERMAL CHARACTERISTICS OF AQUIFER SYSTEMS ...Carbonate Aquifers, Clastic Aquifers, Flow Characteristics -water, Permeability, Temperature, ...**2.1099**

GROUND-WATER HYDROLOGY AND DEVELOPMENT IN EAST-CENTRAL WASHINGTON ...Drawdown, Groundwater Basins, Groundwater Mining, Washington, Water Table Fluctuation, ...2.1135

NUMERICAL SIMULATION OF HYDRODYNAMIC PHENOMENA BY DIGITAL COMPUTER ...Groundwater, Model Studies, Open Channel Flow, Porous Media - Flow Through, Waves, ...2.1096

MANAGEMENT OF STORM RUNOFF AND THE IMPROVEMENT OF WATER YIELD ON FOREST LAND ...Forest Watersheds, Infiltration, Runoff, Storm Water, Water Yield, ...2.0863

WATER YIELD IN RELATION TO CLIMATIC & WATERSHED CHARACTERISTICS OF LAND ...Agricultural Watersheds, Climate, Morphology-general, Patterns, Water Yield, ...3.0419

AQUIFER-STREAMFLOW INTERRELATIONSHIPS IN UPSTREAM AGRICULTURAL WATERSHEDS OF THE PACIFIC NORTHWEST ...Agricultural Watersheds, Aquifers-general, Flow Characteristics -water, Permeability, Recharge -general, Structure, ...3.0201

DEVELOPMENT AND EVALUATION OF SURFACE AND SUBSURFACE DRAINAGE PRACTICES ...Drainage, Interception, Piezometers, Seepage, Surface Flow, ...4.0132

POLLUTION OF SUBSURFACE WATER BY SANITARY LANDFILL ...Contamination, Forecasting-prediction, Landfill, Pennsylvania, Pollutants - Path of , ...5.1009

Surface Flow

HYDROLOGIC MODELS FOR PREDICTING THE EFFECTS OF URBANIZATION ...Groundwater Movement, Land Use, Model Studies, Moisture Content, Seepage, Urban Environments, ...2.0913

CULTURAL PRACTICES ON EASTGATE BASIN ...Cultivated Soils, Moisture Content, Sediment Yield, Sheetflow, Tillage, Cropping Systems, ...4.0168

SPATIAL BEHAVIOR OF ROUGHNESS IN LABORATORY WATERSHED, PHASE II ...Energy Loss -water, Model Studies, Roughness, Runoff, Structure-size, Synthetic Hydrology-general, ...2.0703

HYDRAULICS OF SURFACE IRRIGATION ...Irrigation Engineering, Math Models, Measurement, Porous Media - Flow Through, Surface Irrigation -general, ...2.0047

HYDRAULICS OF SURFACE IRRIGATION ...Mathematical Analysis, Model Studies, Surface Irrigation -general, ...3.0307

EFFECT OF SURFACE IRRIGATION HYDRAULICS ON EFFICIENT APPLICATION OF WATE ...Channel Geometry, Channel Roughness, Flow Characteristics -water, Open Channel, Surface Irrigation -general, ...4.0239

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HYDRAULICS OF SURFACE IRRIGATION ...Mathematical Analysis, Model Studies, Other Models, Surface Irrigation -general, Unsteady Flow, ...4.0268

THE CHARACTERIZATION OF OVERLAND FLOW ON VERY ROUGH SURFACES ...Channel Roughness, Channels, Data Analysis Applications, Flow Characteristics -water, Model Studies, ...8.0192

INVESTIGATION OF SOIL AND WATER LOSSES THROUGH CROPPING SYSTEMS AND SOIL MANAGEMENT PRACTICES ...Runoff, Soil - Crop Relationships, Soil Environment, Tillage, Cropping Systems, ...3.0195

DEVELOPMENT AND EVALUATION OF SURFACE AND SUBSURFACE DRAINAGE PRACTICES ...Drainage, Interception, Piezometers, Seepage, Subsurface Flow, ...4.0132

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WIND EFFECTS ON THE DISPERSION OF PARTICULATE POLLUTANTS IN TURBULENT OPEN-CHANNEL FLOW ...Dispersion -water, Flow of Dispersed Solids, Open Channel Flow, Sediments, Wind-other, ...2.0220

R.I.-MIXING PROCESSES IN ESTUARIES ...Dispersion -water, Estuaries, Flume Studies, Mixing, Model Studies, ...5.0063

REDUCTION OF RIVER HEAT POLLUTION BY TURBULENCE STIMULATION ...Destratification, Electric Power Plants, Engineering Structures-general, Roughness, Stream Rehabilitation, Thermal Pollution, ...5.0214

APPLICATION OF MAGNETOHYDRODYNAMICS TO MEASUREMENT OF LIQUID VELOCITY AND TURBULENCE ...Analog Computers, Analog Computers Math, Technique Development, Turbulent, Velocity, Velocity -water, ...2.1166

TRANSPORT PROCESSES OF PARTICLES IN DILUTE SUSPENSIONS IN TURBULENT WATER FLOW ...Colloidal Phenomena, Flow Characteristics -water, Hydraulics-general, Sedimentation, Transport, ...5.0370

MICROSCOPIC INVESTIGATION OF TRACTIVE FORCE DISTRIBUTION IN OPEN CHANNEL ...Open Channel Flow, Suspension, Traction, Turbulent, Velocity -water, ...8.0183

TURBULENT DIFFUSION AND REAERATION IN NATURAL RIVERS ...Aeration, Flow of Gas in Liquid, Mixing, Model Studies, Tracers-general, ...5.1136

COMPUTE SIMULATION OF DIFFUSION STUDIES ...Dispersion -water, Monte Carlo Methods, Simulation Theory, Velocity - water, ...5.0785

PERFORMANCE CHARACTERISTICS OF LARGE SCALE HYDROMECHANICS LABORATORY EQUIPMENT ...Flume Studies, Inflow, Sedimentation, Synthetic Hydrology-general, ...8.0195

TURBULENT FLOW THROUGH POROUS MEDIA ...Digital Computers, Digital Computers, Finite Differences, Porous Media - Flow Through, Prediction Models, Turbulent, ...2.0354

TURBULENT FLOW SPECTRAL ANALYSIS ...Engineering Structures-general, Flow Characteristics -water, Turbulent, ...8.0166

EFFECTS OF OXYGEN DEMAND ON SURFACE REAERATION RATES ...Aeration, Biochemical Oxygen Demand, Chemical Oxygen Demand, Energy, Ions and Gases, ...5.0369

TURBULENT MIXING IN SURFACE AERATION ...Aeration, Diffuser, Dyes, Mixing, Synthetic Hydrology-general, ...5.1061

INCIPIENT MOTION OF LARGE ROUGHNESS ELEMENTS IN TURBULENT OPEN CHANNEL FLOW ...Erosion Control, Flow Characteristics -water, Open Channel, Open Channel Flow, Sediment Transport-other, ...2.1062

SHOALING PROCESSES ...Channels, Sand Bars, Scouring, Sediment Transport-other, Tidewater Areas, ...2.0690

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DELAWARE ESTUARY SEDIMENTATION STUDY ...Delaware River, Rate of Deposition, Sand Bars, Sediment Transport-general, Sediment Yield, ...2.0908

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THE EFFECT OF POTHOLE DRAINAGE UPON GROUNDWATER RESOURCES ...Drainage, Groundwater, Potholes, Radioisotopes, ...4.0144

ELECTRICAL EFFECTS ON WATER INFILTRATION INTO SOILS ...Electrical Properties, Electroosmosis, Infiltration, Soil Environment, Streaming Potential, Zeta Potential, ...2.0467

THE PREDICTION OF UNSATURATED FLOW RATES FROM PHYSICAL PROPERTIES OF THE POROUS MEDIUM ...Permeability, Pollutants - Path of , Porous Media - Flow Through, Water Cycle, ...2.0889

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TRANSPORT AND FATE OF POLLUTANTS IN SOIL ...Disposal, Internal Water Movement, Pollutants - Path of , Porous Media - Flow Through, Soil, ...5.0517

PREDICTION OF WATER MOVEMENT IN UNSATURATED SOILS ...Adsorption Capacity, Flow Characteristics -water, Internal Water Movement, Soil Environment, Soil Physical Properties, ...2.0049

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DENVER MULTIPHASE FLOW ...Analog Computers, Infiltration, Instrumental Services, Internal Water Movement, Transducers, ...2.0192

UNSATURATED FLOW STUDIES ...Artificial Recharge, Electrical Properties, Exchange Capacity, Groundwater Movement, Infiltration, ...2.0286

UNSATURATED FLOW THEORY APPLIED TO DRAINAGE AND INFILTRATION ...Drainage, Groundwater Movement, Infiltration, Internal Water Movement, Runoff, ...2.0125

PERMEABILITY RESEARCH ...Groundwater Movement, Observation Wells, Permeability, Porous Media - Flow Through, Saturated Flow, ...2.0183

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DYNAMIC GROUND-WATER STORAGE ...Groundwater Movement, Mathematical Analysis, Storage of Water, ...2.0765

WELL DRAWDOWN IN UNCONFINED AQUIFERS UNDER NON-STEADY CONDITIONS ...Aquifers-other, Drawdown, Flow Characteristics -water, Seepage, Water Wells, ...2.0862

UNSTEADY FLOW TOWARD PARTIALLY PENETRATING ARTESIAN WELLS ...Artesian Flow, Groundwater Movement, Mathematical Analysis, Seepage, Unsteady, ...2.0522

OVERLAND FLOW ANALYSIS FOR A SIMULATED VEGETATED SURFACE ...Flume Studies, Hydrographs, Rainfall Simulators, Runoff, Streams, ...2.0879

THE STORAGE COEFFICIENT AS A FUNCTION OF WATER TABLE CELERITY ...Drainage, Mathematical Analysis, Permeability, Storage of Water, Water Table Fluctuation, ...2.1121

EFFECTS OF RIVER CURVATURE ON RESISTANCE TO FLOW ...Channels, Flow Characteristics -water, Flume Studies, Roughness, Velocity -water, ...8.0198

UNSTEADY FLOW OF GROUNDWATER--DISPERSION AND SALT WATER INTRUSION IN NON-HOMOGENEOUS MEDIA ...Dispersion -water, Model Studies, Saline Water Intrusion, Unsteady, ...2.1159

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NON-STEADY 2 AND 3-DIMENSIONAL FLOW OF FLUID INTO POROUS MATERIAL ...Discharge-general, ...2.0394

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HYDRAULICS OF FLOOD MOVEMENTS ...Analog Computers, Floods, Mathematical Analysis, Open Channel Flow, Partial, Routing, ...2.0348

HYDRAULICS OF WELLS ...Aquifers-other, Drawdown, Hydraulic Engineering-other, Model Studies, Water Wells, ...7.0077

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LOW FLOW CHARACTERISTICS OF INDIANA STREAMS ...Discharge-general, Flow Characteristics -water, Indiana, Low Flow, ...2.0455

FLOODING OF SMALL STREAMS IN NASHVILLE-DAVIDSON CO. AREA, TENN. ...Amount, Discharge-general, Floods, Tennessee, Urban Environments, ...**2.0994**

HYDROLOGIC INVESTIGATIONS OF URBAN AREAS - HOUSTON, TEXAS ...Amount, Discharge-general, Floods, Texas, Urban Environments, ...**4.0233**

STREAMFLOW TEMPERATURE INVESTIGATION, TEXAS ...Flow Characteristics -water, Streams, Temperature, Texas, ...**7.0099**

WATER RESOURCES OF THE KENAI PENINSULA BOROUGH AREA, ALASKA ...Alaska, Aquifers-general, Groundwater Basins, Runoff, Water Resources Development, ...**2.0012**

WATER RESOURCES OF BRANCH-BLACKSTONE RIVER BASIN, RHODE ISLAND ...Groundwater Basins, Permeability, Rhode Island, Runoff, Water Yield, ...**2.0614**

SKYWATER ...Colorado, Data Acquisition-general, Streams, ...**2.0190**

LABORATORY CATCHMENT INVESTIGATIONS RELATING TO HYDROLOGIC SYSTEMS ANALYSIS ...Hydrology-general, Model Studies, Morphology-general, Systems Analysis, ...**6.0574**

Galapagos Islands

ENVIRONMENTAL HISTORY OF THE GALAPAGOS ISLANDS ...Floral, Lakes, Plant Succession, Plant Taxonomy, Productivity - Food Chain, ...**2.0852**

Gasket Materials

CONCEPTUAL DESIGN STUDY FOR ELECTRODIALYSIS ...Cost Analysis, Electrodialysis, Membranes-other, Polarization, Saline Conversion, ...**3.0285**

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HARD SURFACE LININGS--LOWER COST CANAL LINING PROGRAM ...Bituminous, Canals, Cement, Concrete, Linings-pavings, Sealant Materials, ...**8.0050**

General Weather Topics

Data Display Systems

NORTH SIERRA OROGRAPHIC, CONVECTIVE CLOUD STUDY - ATMOSPHERIC WATER RESOURCES PROGRAM ...Cloud Physics, Hydrology-general, Modification, Orographic Effects, Precipitation Instruments, ...**2.0731**

CLIMATE AND PHENOLOGICAL PATTERNS FOR AGRICULTURE IN THE WESTERN REGION ...Nevada, Patterns, ...**2.0730**

Meteorological Studies

Meteorological Averages

EVALUATION OF CLIMATIC PATTERNS AFFECTING IDAHO AGRICULTURE ...Agricultural Watersheds, Applied Climatology, Data Analysis - General, Evaporation, Forecasting, Idaho, Patterns, ...**2.0396**

CLIMATE AND PHENOLOGICAL PATTERNS FOR AGRICULTURE IN THE WESTERN REGION ...Applied Climatology, Other Water Conditions, Patterns, Phenology, Tables, Compilations, Catalogs, ...**3.0332**

Meteorological Extremes

THE ECONOMIC EFFECTS OF DROUGHT ON AN AGRICULTURAL ECONOMY ...Drought, Economic Impact, Great Plains Province, Weather, ...**2.0510**

A STUDY OF THE ECONOMIC IMPACT OF DROUGHT ON WATER SUPPLY SYSTEMS IN THE PASSAIC RIVER BASIN, NEW JERSEY ...Economic Impact, New Jersey, Public Utilities, River Basins, Water Quality-general, ...**2.0761**

PROPOSAL FOR COMPILATION OF CUMULATIVE DROUGHT BIBLIOGRAPHY ...Bibliography, Economics-general, Social Aspects, Weather, ...**2.0611**

A STUDY OF TECHNOLOGIES FOR REDUCING WINTER WEATHER COSTS ...Alaska, Benefit-cost Analysis, Forecasting-prediction, Great Lakes-general, Northeast, ...**2.0256**

EXTREME RAINFALL FOR THE MEKONG RIVER BASIN ...Dam Sites, Floods, Management, Southeast Asia, Water Loss Control, ...**2.0596**

THE EFFECTS OF EXTREME FLOODS AND PLACER MINING ON THE BASIC PRODUCTIVITY OF SUBARCTIC STREAMS ...Alaska, Benthic Fauna, Bottom Sampling, Floods, Placer, Productivity - Food Chain, ...**2.0022**

RAINFALL CHARACTERISTICS, DROUGHT INCIDENCE AND THE DEVELOPMENT OF A RAINFALL DEFICIENCY INDEX FOR THE AGRICULTURAL REGIONS OF PUERTO RICO ...Drought, Irrigation-general, Patterns, Puerto Rico, Rain, ...**2.0932**

THE IMPACT OF THE NORTHEASTERN DROUGHT ON THE PLANNING AND PROVISION OF MUNICIPAL WATER SUPPLIES ...Administrative Structures, Alternative Planning, Economic Impact, Northeast, Water Supply-general, ...**4.0136**

HYDROMETEOROLOGICAL ANALYSIS OF SEVERE RAINSTORMS ...Illinois, Patterns, Radar, Storms-general, Weather Charts-maps, ...**2.0414**

IRRIGATION ...Economics-general, Irrigation, Irrigation Engineering, Sprinkler Irrigation, Yield, ...**2.0673**

DROUGHT FREQUENCY, INTENSITY & DURATION - ITS CORRELATION TO STREAMFLOW AND ITS IMPACT UPON SYNTHETIC HYDROLOGY ...Climatography, Flow Characteristics -water, Patterns, Synthetic Hydrology-general, Water Loss-general, ...**2.0763**

METEOROLOGICAL DROUGHT ...Technique Development, Weather Forecasting, ...**2.0593**

HYDROLOGY AND GEOCHEMISTRY OF CLOSED BASIN LAKES ...Basin Shape, Evaporation, Geochemical Analysis, Lakes, Salt, Solution, ...**2.1137**

Meteorological Studies-general

EFFECTS OF WEATHER ON CROPS ...Available Water, Evapotranspiration, Moisture Tension, Projections and Estimations, Soil Moisture -non-specific, ...**2.0482**

WATER LOSS ...Amount, Depth, Requirements for Water, Water Level Fluctuation, Water Loss-general, ...**4.0228**

DETERMINATION OF SAFE LEVELS OF POLLUTION IN PUERTO RICO ...Bays, Contamination - Water, Pollution - Effects of , Puerto Rico, Recreation Sites, Water Properties-general, ...**2.0937**

PHYSICAL, METEOROLOGICAL, AND HYDROLOGIC ASPECTS OF EVAPOTRANSPIRATION ...Evapotranspiration, Soil-water-plant Relationships, Translocation, Water Balance-budget, Water Yield, ...**2.0951**

DISPATCHING SYSTEM FOR CONTROL OF COMBINED SEWER LOSSES ...Combined Sewer, Control Gate, Energy Losses-general, Hydraulics-general, Hydrology-general, ...**5.0609**

LAKE ERIE ENVIRONMENTAL STUDIES PROGRAM ...Biological, Biological-general, Chemical, Chemical-general, Deltas, Eutrophication, Lake Erie, Monitoring (long Term Studies), Physical-general, Sedimentology-general, ...**2.0783**

CONTROL AND PREVENTION OF CULVERT AND ROAD ICINGS ...Culvert, Drainage, Hydrology-general, Roadway-general, Snow and Ice Removal, ...**2.0750**

Micrometeorology

MICROMETEOROLOGICAL INVESTIGATIONS OF THE ENERGY BUDGET - EFFECT OF SUMMER WINDS ...Evapotranspiration, Heat Budget, Heat Flow, Semi - Arid, Wind-general, ...**2.0516**

MICROMETEOROLOGY OF SOYBEANS ...Environmental-disease Relation, Evapotranspiration, Furrow Irrigation, Irrigation, Soybeans, ...**2.0070**

SUBSYNOPTIC WEATHER SPECIFICATION ...Cloud Cover, Data Analysis Applications, Dew, Model Studies, Temperature, Weather Forecasting, ...**2.0592**

GREAT LAKES RESEARCH - ICE CHARACTERISTICS ...Aerial, Lake Superior, Origin, Petrofabrics, Radiation-terrestrial, Sea Ice, ...**2.0644**

UNDERSTANDING AND IMPROVING SOIL-PLANT-ATMOSPHERIC RELATIONSHIPS FOR MORE EFFICIENT UTILIZATION OF WATER ...Irrigation, Root Absorption, Soil-water-plant Relationships, ...**2.1057**

Model Studies

LAKE EFFECT STORM STUDY ...Formation, Lake Erie, Lake Ontario, Sea of Japan, Weather Forecasting, ...**2.0778**

ICE FORMATION BY CONTACT NUCLEATION ...Formation, Growth and Preparation, Nucleation, Nucleation Physics, Temperature, ...**3.0339**

SMALL-SCALE CIRCULATIONS OF THE SAN FRANCISCO BAY AREA ...Air Motion-general, Inversion, Land-sea Breezes, Orographic Effects, San Francisco Bay, ...**2.0154**

NUMERICAL SIMULATION OF THE MACROPHYSICAL AND MICROPHYSICAL PROCESSES OF MOIST CONVECTION ...Cloud Formation and Evolution, Clouds-precipitation, Convection, Formation, Thermodynamics, ...2.0239

COMPUTER SIMULATION AND EVALUATION OF CLIMATOLOGICAL MODELS ...Computers-general, Patterns, Statistics-general, ...7.0044

RESEARCH ON CHARACTERISTICS OF CONVECTIVE CLOUDS IN TEXAS ...Aircraft, Cloud Physics, Cumulus, Data Analysis - General, Texas, ...2.1023

PILOT STUDY OF THE PROBABILITY OF OCCURRENCE OF CLIMATOLOGICAL PHENOMENA IN THE ATLANTA AREA ...Applied Climatology, Georgia, Weather Forecasting, ...2.0351

GENERAL CIRCULATION - NUMERICAL MODELING OF PRECIPITATION ...Air Motion-general, Forecasting, Heat Exchange, Humidity, Weather Modification-general, ...2.0265

SUBSYNOPTIC WEATHER SPECIFICATION ...Cloud Cover, Data Analysis Applications, Dew, Micrometeorology, Temperature, Weather Forecasting, ...2.0592

NUMERICAL PREDICTION OF CLOUDINESS AND PRECIPITATION ...Applications, Forecasting, Prediction Models, ...2.0266

CLOUD AND PRECIPITATION FORECAST MODEL ...Cloud Cover, Condensation-general, Forecasting, Latent Heats, Weather Forecasting, ...2.0267

NUMERICAL PRECIPITATION MODEL ...Computers-general, Forecasting, Simulation Theory, Western, ...2.0588

LARGE SCALE DYNAMIC EFFECTS OF CLOUD SEEDING ...Clouds-precipitation, Patterns, Statistics-general, ...2.0171

A TEST OF CERTAIN EVALUATION DESIGNS FOR CLOUD-SEEDING EXPERIMENTS ...Clouds-precipitation, Forecasting, Mathematical Analysis, Oklahoma, Weather Charts-maps, ...2.0180

INVESTIGATION OF THE FEASIBILITY OF WARM-CLOUD MANAGEMENT ...Cloud Temperature, Clouds-precipitation, Modification, Other, ...2.0165

AIRFLOW AND DIFFUSION PARAMETERS IN CONNECTION WITH ATMOSPHERIC WATER RESOURCES PROGRAM ...Diffusion, Orographic Effects, Topographic Influences, Weather Modification-other, Wind Tunnels, ...2.0167

Planning-support

EVALUATION OF PRECIPITATION MANAGEMENT PROGRAMS BY PRECIPITATION RATE MEASUREMENTS ...Clouds-precipitation, Modification, ...2.0199

Weather Charts-maps

METEOROLOGICAL ANALYSIS OF PRECIPITATION EFFECTS OF SWISS HAIL SUPPRESSION EXPERIMENTS ...Clouds-precipitation, Modification, Patterns, Pressure-density, ...2.0108

INFLUENCE OF TOPOGRAPHIC FEATURES ON RAINFALL IN WEST VIRGINIA ...Forecasting, Mathematical Analysis, Patterns, Topographic Influences, West Virginia, ...2.1140

HYDROMETEOROLOGICAL ANALYSIS OF SEVERE RAINSTORMS ...Illinois, Meteorological Extremes, Patterns, Radar, Storms-general, ...2.0414

RAINFALL FREQUENCY RELATIONS FOR PENNSYLVANIA ...Amount, Design Flow-flood, Gages, Hydrographic, Pennsylvania, ...2.0926

PRECIPITATION-FREQUENCY MAPS FOR WESTERN UNITED STATES ...Climate, Geomorphology, Patterns, Western, ...7.0052

HYDROLOGIC STUDIES (STORM STUDIES) HAWAIIAN ISLANDS ...Hawaii, Hydrology-general, Storm Water, Storms-general, ...2.0366

A TEST OF CERTAIN EVALUATION DESIGNS FOR CLOUD-SEEDING EXPERIMENTS ...Clouds-precipitation, Forecasting, Mathematical Analysis, Model Studies, Oklahoma, ...2.0180

Weather Forecasting

(U) INSTABILITY PATTERNS IN THE TROPICS ...Radar, Tropic, ...2.0320

LAKE EFFECT STORM STUDY ...Formation, Lake Erie, Lake Ontario, Model Studies, Sea of Japan, ...2.0778

PROBABLE MAXIMUM PRECIPITATION FOR SMALL BASIN IN THE TENNESSEE RIVER DRAINAGE SYSTEM ...Amount, Drainage, Storms-general, Tennessee River, Topographic Influences, ...2.0594

PROBABLE MAXIMUM PRECIPITATION FOR SOUTHWEST STATES ...Amount, Design Flow-flood, Floods, Patterns, Snowmelt, Southwest, ...2.0597

WEATHER IN RELATION TO KANSAS AGRICULTURE ...Agricultural Studies -general, Information Retrieval Methods, Kansas, Plant Environment, Ns, ...2.0508

PILOT STUDY OF THE PROBABILITY OF OCCURRENCE OF CLIMATOLOGICAL PHENOMENA IN THE ATLANTA AREA ...Applied Climatology, Georgia, Model Studies, ...2.0351

METEOROLOGICAL DROUGHT ...Meteorological Extremes, Technique Development, ...2.0593

SUBSYNOPTIC WEATHER SPECIFICATION ...Cloud Cover, Data Analysis Applications, Dew, Micrometeorology, Model Studies, Temperature, ...2.0592

PROBABILITY TABLES FOR PRECIPITATION ...Moisture-other, Other Probability, Precipitation-other, Requirements for Water, Tables, Compilations, Catalogs, ...2.0604

CLOUD AND PRECIPITATION FORECAST MODEL ...Cloud Cover, Condensation-general, Forecasting, Latent Heats, Model Studies, ...2.0267

FIRE WEATHER FORECAST TECHNIQUES ...Fire Behavior - Identification, Fire Prevention, Regulation of Weather & Veg-, Technique Development, Thunderstorms, ...2.0587

SNOW AND ICE COVER INVESTIGATIONS ...Arctic, Frost, Sea Ice, Snowmelt, Snowpack, ...2.0747

Generators

Other Generators

COORDINATION OF PLANT FREQUENCY, D-C-TRANSMISSION AND SYSTEM CONTROL ...Ac-dc, Electric Power Plants, Evaluation Other, Power Conditioner, Power Transmission, ...8.0126

Genetics

Environment Effects on Genome

SALT TOLERANCE IN BLUE PANICGRASS, PANICUM ANTIDOTALE ...Halophytic, Panicum -other, Saline Soils, Selection & Breeding, ...3.0023

Mutagens

SURVEY OF CLOSTRIDIUM BOTULINUM TYPE E ...Bacterial Exotoxins, Clostridium Botulinum, Identification, Infra Red, ...5.0957

Gene Action

Disease & Anomalies

BREEDING AND EVALUATION OF IMPROVED VARIETIES OF PERENNIAL COOL-SEASON GRASSES ADAPTED TO SEMIARID AND ARID REGIONS ...Arid and Desert, Breeding, Breeding and Genetics, Semi - Arid, ...2.0574

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GENETIC AND CYTOGENIC STUDIES OF HORTICULTURAL CROPS-BREEDING XEROPHYTIC CUCURBITA ...Aerial, Arid and Desert, Arizona, Squash, Pumpkin, Sterility, ...3.0010

Metabolic-biochemical Genetics

WATER CONSERVATION THROUGH EFFICIENT USE BY CROP PLANTS ...Conservation-general , Moisture Deficiency, Natural Variation of Water USE, Requirements for Water, Selection & Breeding, ...2.0057

Population Studies (genetics)

Clones

INVASION OF THE AQUATIC HABITAT BY AMPHIBIOUS SPECIES OF POLYGONUM ...Amphibious Plants, Habitat Studies, of Aquatic Plants, Plant Taxonomy, Polygonaceae, ...2.1105

Population -other

EVOLUTION OF ALLOPATRIC POPULATIONS ...Captive Rearing, Ecological, Lake Trout, Brook Trout, Maine, Population Dynamics, ...5.0464

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WATER CONSERVATION THROUGH EFFICIENT USE BY CROP PLANTS ...Conservation-general, Metabolic-biochemical Genetics, Moisture Deficiency, Natural Variation of Water USE, Requirements for Water, ...2.0057

SALT TOLERANCE IN BLUE PANICGRASS, PANICUM ANTIDOTALE ...Environment Effects on Genome, Halophytic, Panicum -other, Saline Soils, ...3.0023

Genetics

HYBRID SUNFISH STUDIES ...Centrarchidae -other, Laboratory, Maturity & Growth Stages, Ponds, ...**6.0195**

GUAVA VARIETIES. SELECTION & PROPAGATION OF GUAVA VARIETIES & INVESTIG. OF COMMERCIAL & INDUST. POSSIBILITIES OF THE FRUIT (ABBREV) ...Irrigation, Myrtaceae, Puerto Rico, Trees, Varietal Evaluation, ...**5.1047**

Sterility

GENETIC AND CYTOGENIC STUDIES OF HORTICULTURAL CROPS-BREEDING XEROPHYTIC CUCURBITA ...Aerial, Arid and Desert, Arizona, Interspecific Genetic Relat. , Squash, Pumpkin, ...**3.0010**

Geochemical Analysis

GEOCHEMICAL STUDIES OF CONTINENTAL WATERS ...Authigenesis, Location, Pore Fluids, Radioisotopes, ...**1.0081**

COLUMBIA RIVER SEDIMENT STUDIES ...Columbia River, Radioactivity-general, Radiochemical Techniques, Sediments, Self-purification, ...**5.1249**

CLASSIFICATION OF DEEP SUBSURFACE WATERS BY CHEMICAL COMPOSITION AND GEOLOGY ...Chemical Analysis (water), Groundwater, High Pressure Research, Interstitial - Connate Water, Salinity, ...**2.0883**

GEOCHEMICAL BEHAVIOR OF IRON AND MANGANESE IN A RESERVOIR (LAKE LYNN, WEST VIRGINIA) FED BY STREAMS CONTAINING ACID MINE DRAINAGE ...Acidity, Iron, Manganese, Mine Drainage Control, West Virginia, ...**2.1139**

GEOCHEMISTRY AND ORIGIN OF SULFO-SALINE GROUND WATER, SALINE COUNTY, MISSOURI ...Atlases-maps, Chemical-general, Groundwater, Permeability, Salinity, Sulfide, ...**4.0152**

CHEMICAL CHARACTERISTICS OF WATERS IN FLOODED BITUMINOUS-COAL MINESHAFTS ...Acidity, Bituminous, Mine Drainage Control, Mine Hydrology, Pyrite Group, ...**5.1279**

TRACE ELEMENT CHEMISTRY OF A SMALL POND IN RELATION TO PRODUCTIVITY ...Environmental Ecology, Ponds, Population Dynamics, Trace Element Analysis, Zooplankton, ...**6.0232**

THE DEVELOPMENT OF GEOCHEMICAL AND GEOPHYSICAL TECHNIQUES AS AN AID TO DETERMINING AVAILABILITY OF GROUND WATER IN LIMESTONE TERRANES ...Available Water, Geophysical Analysis, Groundwater, Karst Topography, Water Sources -general, ...**2.0009**

DISSOLVED CONSTITUENTS OF NATURAL WATERS - CONTRIBUTIONS FROM MINERALIZED AREAS ...Chemical Reactions, Groundwater, Mineralization, Mineralogy-petrology, Ore Minerals, ...**2.0734**

WATER DATING TECHNIQUES AS APPLIED TO THE MISSOULA GROUND-WATER RESERVOIR, MONT. ...Carbon-14, Groundwater Movement, Montana, Unconsolidated Aquifers, ...**2.0715**

UTILIZATION OF OIL FIELD BRINES AS A POSSIBLE FERTILIZER SOURCE ...Atomic Absorption, Brines, Emission, Material Recovery Wastes, X-ray, ...**1.0056**

CHEMISTRY OF HYDROSOLIC METALS IN NATURAL WATER ...Aeration, Aluminum, Demineralization, Iron, Manganese, Solution Chemistry, ...**5.0119**

HYDROLOGY AND GEOCHEMISTRY OF CLOSED BASIN LAKES ...Basin Shape, Evaporation, Lakes, Meteorological Extremes, Salt, Solution, ...**2.1137**

HYDROLOGY OF SUBSURFACE WASTE DISPOSAL - NATIONAL REACTOR TESTING STATION, IDAHO ...Groundwater Movement, Nuclear Power, Radioactivity-general, Underground Waste Disposal, Water Cycle, ...**5.0319**

Geochemistry

Atmosphere

GEOCHEMICAL STUDIES WITH STABLE AND RADIOACTIVE ISOTOPES ...Mineral Groups, Nuclear - General, Radiochemical Techniques, Sedimentary Rocks, Uranium, ...**2.0134**

Gaseous Atmosphere

STUDY OF LIGHT ISOTOPES IN LACUSTRINE ENVIRONMENTS ...Lakes, Oxygen, ...**2.0242**

Crystal Chemistry

Properties and Structure

STUDY OF THE SULFIDE-TO-SULFATE REACTION MECHANISM ...Adsorption-other, Biological Cycles, Oxidation-general, Pyrite Group, Solution Chemistry, Sulfate, Sulfite, Sulfide, ...**5.0880**

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CLASSIFICATION OF DEEP SUBSURFACE WATERS BY CHEMICAL COMPOSITION AND GEOLOGY ...Chemical Analysis (water), Geochemical Analysis, Groundwater, Interstitial - Connate Water, Salinity, ...**2.0883**

Mineral Equilibra

MINERAL-WATER CHEMISTRY, GREAT LAKES ...Chemical Reactions, Great Lakes-general, Mineral Genesis, Model Studies, Phase Relationships, Solution Chemistry, ...**5.0552**

Phase Relationships

MINERAL-WATER CHEMISTRY, GREAT LAKES ...Chemical Reactions, Great Lakes-general, Mineral Equilibra, Mineral Genesis, Model Studies, Solution Chemistry, ...**5.0552**

Solution Chemistry

CARBON, OXYGEN AND SULFUR ISOTOPES AND THE ORIGIN AND SOURCES OF URANIUM MINERALIZATION ...Mineral Genesis, Ore Deposits, Radiochemical Techniques, Thermophysical Properties, Transfer Processes, Uraninite Group, ...**2.1083**

SOLUBILITY OF NATURAL GASES IN CONNATE WATER AND OF WATER IN NATURAL GASES ...Brines, High Pressure - 1-1000 Atm, Interstitial - Connate Water, Ions and Gases, Natural Gas, Solubility, ...**1.0080**

A LABORATORY STUDY OF THE SOLUBLE METALS IN ROCKS, SAPROLITE, AND SOIL FROM THE BROAD QUADRANGLE, GEORGIA ...Atomic Absorption, Laboratory Analysis, Lateritic, Solubility, Trace Element Analysis, ...**1.0037**

MINERAL-WATER CHEMISTRY, GREAT LAKES ...Chemical Reactions, Great Lakes-general, Mineral Equilibra, Mineral Genesis, Model Studies, Phase Relationships, ...**5.0552**

STUDY OF THE SULFIDE-TO-SULFATE REACTION MECHANISM ...Adsorption-other, Biological Cycles, Oxidation-general, Properties and Structure, Pyrite Group, Sulfate, Sulfite, Sulfide, ...**5.0880**

GEOCHEMICAL CONTROLS OF WATER QUALITY ...Chemical Analysis (water), Electroanalyses-other, Equilibrium-other, Properties of Minerals, Reaction-general, ...**2.0115**

CHEMISTRY OF HYDROSOLIC METALS IN NATURAL WATER ...Aeration, Aluminum, Demineralization, Geochemical Analysis, Iron, Manganese, ...**5.0119**

MINERAL-WATER INTERACTION IN SALINE ENVIRONMENTS ...Analysis and Detection, California, Evaporation, Interfacial, Solution, ...**2.1095**

SPATIAL DISTRIBUTION OF CHEMICAL CONSTITUENTS IN GROUND WATER ...Carbonates, Chemical-general, Groundwater, Model Studies, Sedimentary Petrogenesis, Statistical, ...**1.0120**

GEOHYDROLOGY OF THE POTOMAC-RARITAN-MAGOTHY AQUIFER SYSTEM ...Aquifers-general, Calcite Group, Clay Minerals-general, Groundwater, Mineralogy, ...**2.0768**

ENGINEERING GEOLOGIC BEHAVIOR OF FOUNDATIONS IN RESERVOIRS IN GYPSUM-LIMESTONE TERRAIN ...Engineering Structures-general, Foundations-general, Geology - Engineering, Gypsum, Limestone - General, ...**8.0074**

SOLUBILITIES OF THE SULFATES OF BARIUM AND STRONTIUM IN OILFIELD WATERS ...Barium, Brines, Fluid Properties, Radioisotopes, Strontium, Thermal Properties-other, ...**1.0097**

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CLAY MINERAL STABILITY AND WATER COMPOSITION ...Clay Minerals-general, Clays, Interstitial - Connate Water, Mineralization, Moisture Content, ...**1.0124**

Thermophysical Properties

CARBON, OXYGEN AND SULFUR ISOTOPES AND THE ORIGIN AND SOURCES OF URANIUM MINERALIZATION ...Mineral Genesis, Ore Deposits, Radiochemical Techniques, Solution Chemistry, Transfer Processes, Uraninite Group, ...**2.1083**

Exploration Methods

Hydrogeochemical Properties

HYDROGEOCHEMICAL INVESTIGATION OF SELECTED WATERSHEDS IN SOUTHWESTERN MONTANA ...Chemical-general, Environmental Effects-geologic, Montana, Rocks - Bedrock, Small Watersheds, ...**5.0698**

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Biological Cycles

STUDY OF THE SULFIDE-TO-SULFATE REACTION MECHANISM ...Adsorption-other, Oxidation-general, Properties and Structure, Pyrite Group, Solution Chemistry, Sulfate, Sulfite, Sulfide, ...**5.0880**

Element Ratios

GEOCHEMICAL STUDIES OF CONTINENTAL WATERS ...Authigenesis, Location, Pore Fluids, Radioisotopes, ...**1.0081**

STABLE CARBON AND OXYGEN ISOTOPE RATIO VARIATIONS IN THE FLOW TO CARBON AND OXYGEN THROUGH NORMAL AND POLLUTED AQUATIC SYSTEMS ...Analysis and Detection, Carbon, Organic-general, Oxygen, Pollutants - Path of , Sewerage Systems-other, ...**5.1183**

DISTRIBUTION OF ELEMENTS IN FLUVIAL AND BRACKISH ENVIRONMENTS ...Adsorption Capacity, Adsorption-general, Brackish Water, Chemical Reactions, Exchange Capacity, Solution, ...**2.0282**

Mineral Associations

HYDROLOGIC-MINERAL CYCLE INTERACTION IN SMALL UNDISTRUBED AND MANMANIPULATED ECOSYSTEMS ...Chemical Reactions, Environment, New Hampshire, Small Watersheds, Water Cycle, ...**2.0745**

GEOCHEMISTRY OF SAN FRANCISCO BAY ...Bays, Clays, Distribution, San Francisco Bay, Trace Element Analysis, ...**2.0121**

Mineral Genesis

CARBON, OXYGEN AND SULFUR ISOTOPES AND THE ORIGIN AND SOURCES OF URANIUM MINERALIZATION ...Ore Deposits, Radiochemical Techniques, Solution Chemistry, Thermophysical Properties, Transfer Processes, Uraninite Group, ...**2.1083**

MINERAL-WATER CHEMISTRY, GREAT LAKES ...Chemical Reactions, Great Lakes-general, Mineral Equilibra, Model Studies, Phase Relationships, Solution Chemistry, ...**5.0552**

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GEOCHEMICAL STUDIES WITH STABLE AND RADIOACTIVE ISOTOPES ...Atmosphere, Mineral Groups, Radiochemical Techniques, Sedimentary Rocks, Uranium, ...**2.0134**

Properties of Minerals

GEOCHEMICAL CONTROLS OF WATER QUALITY ...Chemical Analysis (water), Electroanalyses-other, Equilibrium-other, Reaction-general, Solution Chemistry, ...**2.0115**

Soil Chemistry

TRACE ELEMENTS IN RESIDUAL SOILS ...Clay Minerals-general, Lateritic, Mineralogy, Soil Chemical Properties, Trace Element Analysis, ...**2.0931**

Trace Element Analysis

THE BIOLOGY AND CHEMISTRY OF TRACE ELEMENTS IN MARINE AND ESTUARINE WATERS ...Chesapeake Bay, Estuaries, Phytoplankton, Productivity - Food Chain, Zooplankton, ...**2.0556**

PATHWAYS OF TRACE ELEMENTS IN ARCTIC LAKE ECOSYSTEMS ...Arctic, Gel Filtration, Lakes, Organic-general, Pollutants - Path of , ...**1.0004**

CHEMICAL STUDIES ON THE WATERS AND SOILS OF LAKES AND WETLANDS, WITH SPECIAL REFERENCE TO MINOR ELEMENTS ...Chemical, Chemical-general, Lakes, Minnesota, Wetlands, ...**2.0660**

FACTORS AFFECTING ZOOPLANKTON PRODUCTION IN FOUR ARIZONA LAKES ...Environmental Ecology, Lakes, Productivity - Food Chain, Water Bacteria, Zooplankton, ...**5.0047**

STRONTIUM ISOTOPE COMPOSITION AND TRACE ELEMENT CONCENTRATIONS IN LAKE HURON AND ITS PRINCIPAL TRIBUTARIES ...Chemical, Ions and Gases, Lake Huron, Rocks - Bedrock, Strontium, ...**2.0854**

TRACE ELEMENT CHEMISTRY OF A SMALL POND IN RELATION TO PRODUCTIVITY ...Environmental Ecology, Geochemical Analysis, Ponds, Population Dynamics, Zooplankton, ...**6.0232**

PRIMARY PRODUCTIVITY OF MINNESOTA LAKES ...Chemical-general, Lakes, Plankton (non-specific), Primary Productivity, Water Sampling, ...**5.0607**

A LABORATORY STUDY OF THE SOLUBLE METALS IN ROCKS, SAPROLITE, AND SOIL FROM THE BROAD QUADRANGLE, GEORGIA ...Atomic Absorption, Laboratory Analysis, Lateritic, Solubility, Solution Chemistry, ...**1.0037**

MODE OF OCCURRENCE OF MINOR ELEMENTS IN SEDIMENTS AND SOILS ...Chemical Analysis - Soils, Groundwater, Heavy Mineral Analysis, Mineralogy, Weathering Products, ...**1.0054**

TRACE ELEMENTS IN RESIDUAL SOILS ...Clay Minerals-general, Lateritic, Mineralogy, Soil Chemical Properties, Soil Chemistry, ...**2.0931**

THE ANALYSIS AND GEOCHEMISTRY OF TRACE ELEMENTS IN THE HYDROSPHERE ...Activation Analysis, Bays, Chemical Analysis (water), Chemical Reactions, Gamma, ...**1.0109**

TRACE ELEMENT CHEMISTRY OF STREAMS OF THE LOWER KANSAS RIVER BASIN ...Analysis and Detection, Atomic Absorption, Chemical Analysis (water), Trace Analyses-other, ...**1.0055**

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TEMPERATURE PROSPECTING FOR SHALLOW GLACIAL AND ALLUVIAL AQUIFERS ...Deposits, Temperature, Temperature Profiles, Unconsolidated Aquifers, ...**4.0095**

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ADVANCE WARNING OF GROUND-WATER POLLUTION HAZARDS, WITH SPECIAL REFERENCE TO AQUIFERS IN GLACIAL OUTWASH ...Electrical, Electromagnetic Probing, Groundwater, Physical Parameters, Unconsolidated Aquifers, ...**5.1235**

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HYDROGEOLOGY OF GLACIAL OUTWASH NEAR SIOUX FALLS, SOUTH DAKOTA ...Analog Computers, Available Water, Prediction Models, Projections and Estimations, South Dakota, ...**2.0975**

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REGIMEN OF THE MARTIN RIVER AND SIOUX GLACIERS, ALASKA ...Alaska, Streams, ...**2.0849**

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GEOMORPHIC STUDIES IN THE SIERRA NEVADA, CALIFORNIA ...Morphology-general, Regimen, Sediment Relationship, Sierra Nevada, Streams, ...**2.0119**

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THE USE OF GRAVITY SHAFTS FOR GROUND WATER RECHARGE, PHASE I OF A TWO PHASE STUDY ...Economic Efficiency, Recharge Pits - Wells, Turbidity, Unconsolidated Aquifers, ...**4.0189**

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INVESTIGATION OF PERMEABILITY OF FINE GRAINED GLACIAL SEDIMENTS IN RELATION TO WASTE DISPOSAL IN ILLINOIS ...Disposal, Permeability, Recharge Pits - Wells, Till, ...**2.0409**

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GLACIOLOGY AND METEOROLOGY OF ANVERS ISLAND, ANTARCTICA ...Antarctica, Data Analysis - General, Geologic Maps, Intensity, Thickness - Area, ...**2.0856**

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CONTINUATION OF GLACIOLOGICAL INVESTIGATIONS ON THE CASEMENT GLACIER, ALASKA ...Alaska, Floor Properties, General Synoptic Observations, Rheology - Flowage, ...**2.0858**

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REGIMEN OF THE MARTIN RIVER AND SIOUX GLACIERS, ALASKA ...Alaska, Streams, ...**2.0849**

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GLACIAL MELT WATER PREDICTION ...Energy, Forecasting-prediction, Glaciers, Water Yield, ...**2.0010**

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REVERSE OSMOSIS MEMBRANES CONTAINING GRAPHITIC OXIDE ...Desalination, Membranes-other, Pilot Plant, Reverse Osmosis, ...**3.0416**

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HYDROLOGIC CHARACTERIZATION OF SMALL WATERSHEDS ...Drainage, Internal Water Movement, Moisture Content, Slopes, Small Watersheds, ...**2.0434**

GRAVITY FLOW OF WATER IN SOILS AND AQUIFERS OF WESTERN KANSAS ...Aquifers-general, Kansas, Natural Recharge, Soil Environment, Storage of Water, ...**2.0502**

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GREAT LAKES, PORTS AND SHIPPING SYSTEM ...Economics-general, Information Analysis, Ports & Harbors, Water Transportation, ...**8.0171**

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A SYSTEMS ANALYSIS OF THE WESTERN BASIN OF LAKE ERIE ...Aquatic Ecology, Economic Impact, Pollution - Effects of , Systems Analysis, Water Quality Control-general, ...**6.0426**

VERTICAL CURRENT STRUCTURE IN THE GREAT LAKES ...Buoys, Currents -water, Forecasting-prediction, Model Studies, Wind-water Interaction, ...**2.0632**

MINERAL-WATER CHEMISTRY, GREAT LAKES ...Chemical Reactions, Mineral Equilibria, Mineral Genesis, Model Studies, Phase Relationships, Solution Chemistry, ...**5.0552**

BOTULINUM FOOD POISONING IN RELATION TO FISHERY PRODUCTS ...Antibiotics, Clostridium Botulinum, Fish, N.s. , Microbiological, Repression, ...**5.1305**

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GREAT LAKES RESEARCH - CHARACTERISTICS OF LAKE WATER ...Chemical-general, Currents -water, Ocean Meteorological Studies, Physical-general, Water Quality-general, ...**2.0648**

GREAT LAKES RESEARCH - EFFECTS OF STRUCTURES ON COASTAL SEDIMENTATION ...Beach, Bed Load, Coastal Engineering-other, Energy-dynamics, Engineering Structures-general, Velocity -water, ...**2.0650**

GREAT LAKES RESEARCH - COASTAL AREA SEDIMENTATION ...Beach, Development, General Transport Effects, Lakeshores-inlets, Model Studies, ...**2.0651**

GREAT LAKES RESEARCH - LAKE WAVES ...Waves, ...**2.0641**

GREAT LAKES RESEARCH - HARBOR CURRENTS ...Currents - water, Harbors, Model Studies, Pressure-density, Water Level Fluctuation, Wind-general, ...**2.0642**

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GREAT LAKES RESEARCH - RIVER ICE JAMS ...Ice Jam, Streams, Survey Studies, Water Movement-general, ...**2.0636**

GREAT LAKES RESEARCH - GREAT LAKES DEICING ...Alteration, Bibliography, Ice Properties-general, Origin, Sea Ice, ...**2.0646**

GREAT LAKES RESEARCH - MONITORING OF WATER CHARACTERISTICS ...Automatic Data Aquisition, Forecasting-prediction, Geophysical Analysis, Instrumentation-general, Temperature, ...**2.0649**

CHEMICAL CHARACTERISTICS OF THE GREAT LAKES ...Chemical Analysis (water), Nutrients, Productivity - Food Chain, Water Quality-general, ...**5.0542**

RESEARCH ON THE MACROBENTHOS OF THE GREAT LAKES ...Aquatic Ecology, Benthic Fauna, Earthworms, Food Supply, Water Quality-general, ...**6.0292**

MONITORING OF PESTICIDE LEVELS IN THE GREAT LAKES ...Insecticides -non-specific, Monitoring Systems, Pollutants-general, Water Sampling, ...**5.0544**

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LAKE ERIE DIKE ...Dike, Disposal-other, Models, Wave Action, Waves, ...**8.0219**

LAKE EFFECT STORM STUDY ...Formation, Lake Ontario, Model Studies, Sea of Japan, Weather Forecasting, ...**2.0778**

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CLADOPHORA AS RELATED TO POLLUTION IN WESTERN LAKE ERIE ...Algal Pollutant Sources, Bioindicators, Chemical Analysis, Cladophora, Mapping, ...**5.0883**

THE ECOLOGIC IMPACT OF THE INTERACTIONS AMONG MICROORGANISMS AND AQUATIC CONTAMINANTS IN LAKE ERIE ...Environment, Pollution - Effects of , Primary Productivity, Sediments, Water Bacteria, ...**6.0427**

DYNAMIC MODEL STUDY OF LAKE ERIE ...Hydraulics-general, Inflow, Model Studies, Synthetic Hydrology-general, ...**5.0766**

A PROGRAM FOR DEMONSTRATING COMBINED SEWER OVERFLOW CONTROL TECHNIQUE FOR WATER QUALITY IMPROVEMENTS AND BEACH PROTECTION ...Chlorination, Combined Sewer, Disinfection, Polyelectrolytes, Potable Water, Shoreline - Coastline, ...**5.0867**

NEUTRON ACTIVATION ANALYSIS OF IMPURITIES IN RAIN AND SNOW ...Activation Analysis, Calcium, Rain-general, Snowmelt, Storms-general, Sulfur, ...**5.0767**

RHEOTAXIS IN ALGAL METABOLISM AND PHOTOSYNTHESIS ...Algal Pollutant Sources, Cladophora, Motility and Migration, Photosynthesis, Respiration, ...**6.0377**

LAKE ERIE ENVIRONMENTAL STUDIES PROGRAM ...Biological, Biological-general, Chemical, Chemical-general, Deltas, Eutrophication, Meteorological Studies-general, Monitoring (long Term Studies), Physical-general, Sedimentology-general, ...**2.0783**

INVESTIGATIONS OF SHORE EROSION ALONG THE OHIO SHORELINE OF LAKE ERIE ...Aerial, Engineering Structures-general, Erosion-general, Gaging, Shoreline - Coastline, ...**8.0275**

MARINE SURFACE FORECASTING TECHNIQUES ...Forecasting-prediction, Ocean Meteorological Studies, Storms-general, Surface Environments, Tides, ...**2.0599**

GREAT LAKES RESEARCH - LAKE PRECIPITATION ...Amount, Forecasting, Great Lakes-general, Lake Michigan, Ocean Meteorological Studies, ...**2.0638**

GREAT LAKES RESEARCH - WATER-LEVEL DISTURBANCES ...Lake Michigan, Model Studies, Seiches, Tides, Water Level Fluctuation, ...**2.0640**

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ENVIRONMENTAL CHANGES IN LAKE ERIE ...Aquatic Ecology, Environmental Changes, Environmental Ecology, Ions and Gases, Nutrients, ...**5.0540**

CHEMISTRY OF THE HYPOLIMNION OF LAKE ERIE ...Chemical-general, Ions and Gases, Overturn, Oxygen, Stratification, ...**2.0625**

QUANTITATIVE AND QUALITATIVE CHARACTERISTICS OF MATERIALS CONTRIBUTING TO SEDIMENTATION IN LAKE ERIE ...Location, Organic, Organics, Rate of Deposition, Sedimentation, ...**2.0628**

DISTRIBUTION AND ABUNDANCE OF ZOOPLANKTON IN LAKE ERIE ...Aquatic Ecology, Computers-general, Environmental Ecology, Interbiotic Relat.(non-specif), Other Computers, Population Dynamics, ...**6.0294**

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DYNAMICS OF THE CIRCULATION IN THE GREAT LAKES ...Circulation General, Hydrodynamics, Lake Michigan, Model Studies, Wind-water Interaction, ...**2.0407**

STRONTIUM ISOTOPE COMPOSITION AND TRACE ELEMENT CONCENTRATIONS IN LAKE HURON AND ITS PRINCIPAL TRIBUTARIES ...Chemical, Ions and Gases, Rocks - Bedrock, Strontium, Trace Element Analysis, ...**2.0854**

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GEOLOGICAL STUDIES IN NORTHERN LAKE MICHIGAN ...Deposits-other, Lakes, Rocks - Bedrock, Submergent, Water Level Fluctuation, ...**2.0630**

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STUDY OF INFLUENCE OF STRATIFICATION ON CURRENT STRUCTURE ...Circulation General, Currents-other, Hydrodynamics, ...**2.0810**

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A COHERENT-AREA STUDY OF SOUTHERN LAKE MICHIGAN ...Bioindicators, Chemical Identification, Eutrophication, Sedimentology-general, Weather Modification-other, ...**5.0547**

A DETAILED STUDY OF LAKE MICHIGAN PLANKTON DIATOMS ...Phytoplankton, Planktonic - Floating, Plant Taxonomy, Range Or Territorial Distr. , ...**5.0554**

A STUDY OF THE QUALITY OF INDIANA SURFACE WATERS ...Indiana, Ions and Gases, Ohio River, Surface Water, Water Quality-general, ...**5.0389**

LAKE MICHIGAN WATER QUALITY MODEL ...Discharge-general, Hardness-minerals, Management, Mathematical Analysis, Water Quality-general, ...**6.0198**

GREAT LAKES RESEARCH - LAKE PRECIPITATION ...Amount, Forecasting, Great Lakes-general, Lake Erie, Ocean Meteorological Studies, ...**2.0638**

GREAT LAKES RESEARCH - ENERGY TRANSFER AT THE AIR-WATER INTERFACE ...Data Analysis - General, Heat and Radiation Transfer, Heat-transfer-other, Mass Transfer, Towers, Wind-water Interaction, ...**2.0639**

GREAT LAKES RESEARCH - WATER-LEVEL DISTURBANCES ...Lake Erie, Model Studies, Seiches, Tides, Water Level Fluctuation, ...**2.0640**

Lake Ontario

LAKE EFFECT STORM STUDY ...Formation, Lake Erie, Model Studies, Sea of Japan, Weather Forecasting, ...**2.0778**

LAKE EFFECT SNOW SITUATIONS, EASTERN LAKE ONTARIO AREA ...Atmospheric Pressure, Data Acquisition, General Synoptic Observations, Topographic Influences, ...**7.0084**

SEASONAL VARIATIONS OF SOME LIMNOLOGICAL FACTORS IN LITTLE SODUS BAY, NEW YORK ...Bays, Chemical-general, Eutrophication, New York, Productivity - Food Chain, ...**3.0355**

Lake Superior

USE OF THE COASTAL ZONE FOR THE U. S. COASTLINE OF LAKE ERIE AND LAKE SUPERIOR ...Lake Erie, Lakeshores-inlets, Land Use, Social Aspects, Welfare Economics, ...**6.0125**

A STUDY OF THE OPEN WATER DISTRIBUTION AND ABUNDANCE OF NET-PLANKTON AS AN INDEX OF EUTROPHICATION IN LAKE SUPERIOR ...Automatic Data Aquisition, Bioindicators, Plankton Sampling, Water Quality-general, Zooplankton, ...**5.0600**

GREAT LAKES RESEARCH - ICE CHARACTERISTICS ...Aerial, Micrometeorology, Origin, Petrofabrics, Radiation-terrestrial, Sea Ice, ...**2.0644**

LAKE SUPERIOR CHEMICAL CONTROL OF SEA LAMPREY ...Control of Nuisance Species, Flow Characteristics -water, Lampreys, Larvicides, Streams, ...**5.0577**

LAKE SUPERIOR EXPLORATIONS ...Commercial Fishing, Management -other, Nets, Smelts, Suckers, ...**6.0293**

EFFECTS OF HIGH TEMPERATURE, LOW OXYGEN, AND PH EXTREMES ON THE SURVIVAL OF AQUATIC INSECTS AND CRUSTACEA IMPORTANT AS TROUT FOOD ...Aquatic Ecology, Food Supply, Gases, Dissolved -water, High Temp. -85f Or Above, Ph, Acidity -water, ...**5.0593**

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MINERAL RECOVERY FROM CONCENTRATED BRINES ...Brines, Chloride, Desalination, Magnesium, Potassium, Regeneration-other, ...**5.1198**

THE BIOLOGY AND CONTROL OF TABANIDAE IN MARSHLANDS ALONG THE EASTERN SHORE OF THE GREAT SALT LAKE, UTAH ...Flies -horse,deer, Habitat Studies, Management, Survey Methods, Swamps-marshes, ...**6.0596**

SHORE-LINE ENGINEERING STUDIES ON GREAT SALT LAKE ...Hydraulic Structures, Hydrographic, Shoreline - Coastline, Shoreline Structures, Wave Action, ...**8.0293**

ENGINEERING CHARACTERISTICS OF THE BOTTOM SEDIMENTS OF GREAT SALT LAKE ...Engineering Structures-general, Soil - Bearing Capacity, Soil Exploration, Soil Test - Insitu, Vane, ...**8.0294**

CHEMICAL QUALITY OF BRINES ASSOCIATED WITH DEEP SEDIMENTS BENEATH GREAT SALT LAKE ...Brines, Chemical Analysis (water), Salt, Water Sampling, Water Wells, ...**5.1200**

SALT DISTRIBUTION ALONG LAKE BOTTOM AND WITHIN DEEP SEDIMENTS BENEATH GREAT SALT LAKE ...Chlorine, Quaternary Period, Salt, Sodium, ...**5.1201**

HYDROLOGY OF THE SUB-LAKE SEDIMENTS BENEATH GREAT SALT LAKE ...Artificial Recharge, Brines, Geology - Engineering, Interstitial - Connate Water, Permeability, ...**2.1082**

CONTROL OF INSECT VECTORS ON WATERFOWL MARSHES ...Cultural Control, Insecticides -non-specific, Land Use, Management, Swamps-marshes, ...**4.0263**

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DEEP ICE CORE STUDIES AND ANALYSES FROM GREENLAND AND ANTARCTICA ...Antarctica, Core Analysis, Dust - Particulate Matter, Extraterrestrial, Radioactive Dating-general, Velocity, ...**2.0754**

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HIGHWAY DRAINAGE STUDY ...Drainage, Maryland, ...**2.0579**

DIFFUSION OF ENTRAPPED GASES IN POROUS MEDIA ...Aquifers-general, Cavitation-other, Compressibility--gas-liq, Diffusion, Ions and Gases, Porous Media - Flow Through, ...**2.0209**

CLASSIFICATION OF DEEP SUBSURFACE WATERS BY CHEMICAL COMPOSITION AND GEOLOGY ...Chemical Analysis (water), Geochemical Analysis, High Pressure Research, Interstitial - Connate Water, Salinity, ...**2.0883**

SHALES AS FILTERS IN NATURAL WATERS ...Chemical-general, Dewatering, Filtration, Fine-grained Clastics, Interstitial - Connate Water, ...**2.0079**

THE EVALUATION OF APPLICATION OF C-14 DATING OF GROUND WATER ...Aquifers-general, Carbon-14, Disposal Methods-other, Radioactivity-general, Underground Waste Disposal, ...**5.0241**

THE EFFECT OF THE NATURAL SEALING OF POTHOLES UPON WATER MOVEMENT AND GROUNDWATER RESOURCES ...Internal Water Movement, Linings-pavings, Permeability, Potholes, Subsurface Flow, ...**2.0667**

EFFECT OF PESTICIDE RESIDUES AND OTHER ORGANOTOXICANTS ON THE QUALITY OF SURFACE AND GROUNDWATER RESOURCES ...Carbamates -non-specific, Movement, Leaching, Persistence in Soils, Removal of Residues, Water Quality Control-general, ...**5.0396**

GEOCHEMISTRY AND ORIGIN OF SULFO-SALINE GROUND WATER, SALINE COUNTY, MISSOURI ...Atlases-maps, Chemical-general, Geochemical Analysis, Permeability, Salinity, Sulfide, ...**4.0152**

INDUCED ELECTRICAL POLARIZATION AND GROUND WATER ...Artificial Recharge, Electric Logging, Geophysical Analysis, Groundwater Basins, Polarization, ...**7.0007**

THE EFFECT OF POTHOLE DRAINAGE UPON GROUNDWATER RESOURCES ...Drainage, Potholes, Radioisotopes, Unsaturated Flow, ...**4.0144**

AVAILABILITY, DISTRIBUTION, QUANTITY AND QUALITY OF WATER RESOURCES IN CARBONATE KARST TERRAIN ...Available Water, Carbonate Aquifers, Karst Topography, Runoff, Water Balance-budget, Water Quality-general, ...**4.0155**

POLLUTION EFFECTS ON GROUND WATER RECHARGE IN HAWAII ...Adsorption-absorption-other, Natural Recharge, Pollutants - Path of , Pollution - Effects of , Soil Environment, ...**5.0313**

EFFECTS OF GROUNDWATER SEEPAGE ON STREAM REGIMEN ...Baseflow, Flume Studies, North Dakota, Seepage, Suspension, ...**2.0832**

THE GROUND-WATER FLOW SYSTEM IN THE DELMARVA PENINSULA ...Aquifers-general, Delaware, Flow Characteristics - water, Model Studies, Water Balance-budget, ...**2.0254**

INVENTORY & EVALUATION OF THE GROUND-WATER RESOURCES OF SUMMIT VALLEY & UPPER SILVER BOW CREEK DRAINAGE AREA ...Montana, Survey Studies, Tables, Compilations, Catalogs, Urban Environments, Water Quality-general, ...**2.0711**

GROUND WATER SEEPAGE PATTERNS TO WELLS FOR UNCONFINED FLOW ...Approximations, Flow Characteristics - water, Seepage, ...**2.0478**

ADVANCE WARNING OF GROUND-WATER POLLUTION HAZARDS, WITH SPECIAL REFERENCE TO AQUIFERS IN GLACIAL OUTWASH ...Electrical, Electromagnetic Probing, Outwash Plains, Physical Parameters, Unconsolidated Aquifers, ...**5.1235**

SIMULATION OF WATER RESOURCE REGIMES ...Analog Computers, Estuaries, Model Studies, Surface Water, ...**7.0047**

INVESTIGATION OF WATER LOSSES TO SINKHOLES IN THE PAHASAPA LIMESTONE, AND THEIR RELATION TO RESURGENT SPRINGS BLACK HILLS, SOUTH DAKOTA ...Karst Topography, Leekage, South Dakota, Springs, Tracers-general, ...**2.0979**

THE DEVELOPMENT OF GEOCHEMICAL AND GEOPHYSICAL TECHNIQUES AS AN AID TO DETERMINING AVAILABILITY OF GROUND WATER IN LIMESTONE TERRANES ...Available Water, Geochemical Analysis, Geophysical Analysis, Karst Topography, Water Sources -general, ...**2.0009**

TRACE AND TRACER ELEMENTS IN GROUND WATER ...Agricultural Chemicals-general, Arizona, Industrial Wastes, Trace Elements, Tracers-general, ...**4.0010**

GEOPHYSICAL EXPLORATION FOR HAWAIIAN GROUND WATER - PHASE II ...Electric Logging, Electromagnetic Probing, Geophysical Analysis, Hawaii, Seismic Surveys, ...**2.0371**

A SYSTEM APPROACH FOR INTEGRATING GROUNDWATER AND SURFACE-WATER USE ...California, Conjunctive Use, Systems Analysis, Water Quality Control-general, Water Utilization -general, ...**6.0037**

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GEOHYDROLOGY OF SHALLOW AQUIFERS IN HENRY AND WEAKLEY COUNTIES, TENNESSE ...Aquifers-general, Observation Wells, Pollution Sources-general, Pumping, Tennessee, ...**2.0998**

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SEDIMENTATION AND HYDROLOGY-ROCK CREEK AND ANACOSTIA RIVER BASINS, MARYLAND ...Erosion-general, Land Use, Maryland, Sediment Yield, Urban Environments, ...**4.0130**

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GROUND WATER RECHARGE AND MANAGEMENT IN CALIFORNIA ...Groundwater Basins, Percolation, Recharge - general, Soil Environment, Storage of Water, ...**4.0033**

ECONOMICS OF WATER MANAGEMENT ON THE TEXAS HIGH PLAINS ...Aquifers-general, Economic Impact, Production & Processing, Texas, Water Allocation, Water Yield, Welfare Economics, ...**6.0137**

TRAVEL OF NITROGEN IN SOILS ...Animal Waste Removal-treatment, Movement, Availability, Nitrogen, Pollutants - Path of , Soil Tests, ...**1.0070**

SORPTION KINETICS IN FLOW THROUGH GRANULAR PARTICLES ...Adsorption-other, Ion Exchange-other, Porous Media - Flow Through, Rate Determination, Tertiary Treatment, Water Quality Control-general, ...**5.1191**

INVESTIGATION OF WATER SUPPLY PROBLEMS IN ARCTIC AND SUB-ARCTIC AREAS ...Arctic, Potable Water, Storage of Water, Surface Water, Water Supply-general, ...**3.0004**

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SYSTEMS ANALYSIS FOR GROUNDWATER MANAGEMENT ...Economic Efficiency, Management, Model Studies, Saline Water Intrusion, Systems Analysis, ...**5.0071**

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OPTIMIZATION OF WELLS AND RECHARGE FACILITIES IN CONJUNCTIVE USE OF GROUNDWATER RESERVOIRS ...Conjunctive Use, Optimization, Pumping, Recharge -general, Water Wells, ...**6.0054**

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EVALUATION OF GROUNDWATER RESOURCES, LIVERMORE VALLEY, CALIFORNIA ...Data Acquisition-general, Management, Model Studies, Subsurface Flow, Water Yield, ...**4.0025**

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HYDROLOGIC ANALYSIS OF GROUNDWATER BASINS BY DIGITAL COMPUTER SIMULATION ...Aquifers-general, Digital Computers, Groundwater Movement, Mathematical Analysis, Model Studies, ...**4.0043**

HYBRID COMPUTER SIMULATION OF GROUND-WATER BASINS ...Development of Models, Groundwater, Hybrid Computers, Model Studies, Water Quality Control-general, ...**2.0106**

A SALT BALANCE INVESTIGATION ON THE SANTA ANA RIVER BASIN ABOVE PRADO DA ...California, Forecasting-prediction, Salinity, Systems Analysis, Water Quality Control-general, ...**5.0098**

GROUND-WATER STUDIES - PILOT DRAINAGE BASIN STUDY ...Carbonate Aquifers, Groundwater Movement, Land Use, Natural Recharge, Runoff, Water Cycle, ...**2.0418**

WATER REQUIREMENTS FOR CROP PRODUCTION IN THE ROSWELL UNDERGROUND WATER BASIN ...Irrigation, Irrigation-general, Requirements for Water, Tillage, Cropping Systems, Water Costs, ...**3.0334**

SPECIFIC YIELD INVESTIGATION ...Aquifers-general, California, Moisture Content, Projections and Estimations, Water Yield, ...**2.0182**

MECHANICS OF GROUND-WATER FLOW ...Aquifers-general, Artificial Recharge, Earthquakes, Groundwater Movement, Water Table Fluctuation, ...**2.1093**

QUANTITATIVE WATER-BUDGET ANALYSIS OF WESTERN LONG ISLAND, NEW YORK ...Alternative Planning, Management, New York, Water Balance-budget, Water Resources Development, ...**2.0809**

GROUND-WATER HYDROLOGY AND DEVELOPMENT IN EAST-CENTRAL WASHINGTON ...Drawdown, Groundwater Mining, Subsurface Flow, Washington, Water Table Fluctuation, ...**2.1135**

SAN GORGONIO PASS GROUND-WATER STUDIES, CALIFORNIA ...Artificial Recharge, California, Groundwater Movement, Storage of Water, Water Table Fluctuation, ...**4.0037**

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WATER RESOURCES OF BRANCH-BLACKSTONE RIVER BASIN, RHODE ISLAND ...Gaging, Permeability, Rhode Island, Runoff, Water Yield, ...**2.0614**

GROUND WATER RECHARGE AND MANAGEMENT IN CALIFORNIA ...Groundwater, Percolation, Recharge -general, Soil Environment, Storage of Water, ...**4.0033**

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DETERMINATION OF EVAPOTRANSPIRATION FOR SHORT INTERVALS ON A BENCHMARK BASIN ...Evapotranspiration, Heat Budget, Israel, Moisture Content, Water Balance-budget, ...**2.0493**

AVAILABILITY, DISTRIBUTION, QUANTITY AND QUALITY OF WATER RESOURCES IN CARBONATE KARST TERRAIN ...Available Water, Carbonate Aquifers, Groundwater, Runoff, Water Balance-budget, Water Quality-general, ...**4.0155**

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WATER YIELD AND GROUNDWATER MOVEMENT IN THE EDWARDS PLATEAU AS AFFECTED BY GEOLOGY, CHANNEL AND VALLEY MATERIALS, AND FLOOD STRUCTURES ...Engineering Structures-general, Groundwater Movement, Rain, Texas, Water Table Fluctuation, Water Yield, ...**2.1031**

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ECOLOGY AND PHYSIOLOGY OF THERMORPHILIC BLUE-GREEN ALGAE ...Adaptation, Cyanophyta (non-specific & Ot), Habitat Studies, High Temp. - 85f Or Above, ...**2.0898**

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REDUCTION OF GROUND WATER INFILTRATION INTO SEWERS BY ZONE PUMPING ...Pump, Pumping, Sewerage Systems-general, Water Table Fluctuation, Water Wells, ...**5.0320**

USE OF LATEX AS A SOIL SEALANT TO CONTROL ACID MINE WASTE DRAINAGE ...Acidity, Elastomers Rubber, Linings-pavings, Mine Drainage Control, Sealant Materials, Seepage, ...**5.0996**

TEMPORARY LININGS FOR WATERWAYS AND EMBANKMENTS ...Cover Crops, Design Criteria, Embankments, Erosion Control, Florida, Hydrology-general, ...**3.0178**

POND SEALING ...Adsorption Capacity, Linings-pavings, Permeability, Ponds, ...**4.0223**

CONCRETE DITCH LINING AND PIPE FOR IRRIGATION SYSTEMS ...Irrigation, Linings-pavings, Open Channel, Pipes, Plain, ...**8.0272**

RIPRAP, REQUIREMENTS IN CHANNELS ...Drag, Lift, Models, Open Channel, Velocity, ...**8.0246**

STUDIES OF EQUATIONS FOR SEEPAGE LOSS FROM CANALS ...Canals, Loss, Open Channel, Permeability, Soil Test - Insitu, ...**8.0129**

STUDY OF TUNNEL LININGS AND REINFORCEMENT ...Channel Type-other, Data Analysis - General, Linings-pavings, Reinforced, ...**8.0104**

INVESTIGATION OF EROSION AND TRACTIVE FORCES ON CANALS--OPEN AND CLOSED CONDUIT RESEARCH PROGRAM ...Canals, Erosion-general, Linings-pavings, Soil Environment, Traction, ...**8.0035**

MEMBRANE LININGS-OPEN AND CLOSED CONDUIT RESEARCH PROGRAM ...Bituminous, Elastomers Rubber, Open Channel, Polyethylene, Polyvinyl Chloride, ...**8.0051**

STREAM CHANNEL STABILIZATION SEDIMENT CONTROL WORKS IN CHANNELS ...Channels, Erosion Control, Open Channel, Scouring, Sedimentation, ...**5.0930**

FACILITIES, METHODS AND DESIGN CRITERIA TO PUMP, CONVEY, CONTROL AND MEASURE WATER FOR AGRICULTURAL PURPOSES IN THE NORTHERN PLAINS ...Irrigation-general, Pumping, Runoff, Storage of Water, Water Distribution Systems, Water Transfer, ...**3.0141**

EVALUATION AND CONTROL OF SEEPAGE FROM WATER STORAGE AND CONVEYANCE STRUCTURES ...Models, Preventive Measures, Seepage, Storage of Water, Water Loss Control, ...**8.0002**

Models

LAKE ERIE DIKE ...Dike, Disposal-other, Lake Erie, Wave Action, Waves, ...**8.0219**

USE OF LARGE ROUGHNESS ELEMENTS FOR HYDRAULIC ENERGY DISSIPATION ...Channel Roughness, Culvert, Drainage, Energy Dissipators, Open Channel, ...**8.0295**

THE USE OF LIGHT-WEIGHT SPHERICAL PARTICLES FOR DISCHARGE MEASUREMENT IN OPEN CHANNELS ...Flume, Measurement, Open Channel, Turbulent, Velocity, ...**7.0069**

MODEL STUDIES FOR DEVELOPMENT AND CALIBRATION OF STREAMFLOW CONTROL DEVICES IN THE SOUTHERN BRANCH ...Channel Regulation-general, Computers-general, Discharge-general, Gaging, Synthetic Hydrology-general, ...**3.0189**

CALIFORNIA AQUEDUCT, NORTH SAN JOAQUIN DIVISION, FISH PROTECTIVE FACILITY ...Engineering Structures-general, Open Channel, Pipes, Transition Sections, Velocity, ...**8.0009**

HYDRAULICS OF STORM SEWER JUNCTIONS ...Design Criteria, Drainage, Drainage Systems, Storm Water, Urban Research, ...**5.0356**

DEVELOPMENT OF HYDRAULIC DESIGN CRITERIA ...Conduit, Design Criteria, Simulators, Spillways, Water Control Works-other, ...**8.0226**

HYDRAULIC PROTOTYPE TESTS ...Channel Regulation-other, Conduit, Simulators, Spillways, ...**8.0228**

EFFECTS OF SCALE AND OPERATING TECHNIQUE ON HARBOR MODELS ...Harbors, Synthetic Hydrology-general, ...**7.0065**

WAVE ACTION ON STRUCTURES ...Engineering Structures-general, Hydrodynamic Structures, Shoreline Structures, Stability, Wave Action, ...**8.0150**

STRUCTURAL DESIGN OF SHORE STRUCTURES ...Coastal Engineering-general, Engineering Structures-general, Hydrodynamic Structures, Shoreline Structures, Wave Action, ...**8.0151**

STABILIZATION OF SHORES BY GROINS AND JETTIES ...Development, Groin, Jetty, Sedimentation, Wave Action, ...**2.0263**

RIPRAP, REQUIREMENTS IN CHANNELS ...Drag, Lift, Lining, Open Channel, Velocity, ...**8.0246**

HYDRAULIC MODEL STUDIES OF A PUMP INLET MANIFOLD ...Axial Flow, Critical, Desalination, Distilling Units, Flash Distillation, High Pressure, ...**3.0120**

GATES, VALVES, AND ORIFICES ...Control Gate, Design Criteria, Orifice, Seals, Valves, ...**8.0037**

STUDY OF POLYCENTERED, PARABOLIC, AND OTHER SHAPES FOR ARCH DAMS ...Analysis Structural, Arch Dams, Design Criteria, ...**8.0090**

HYDRAULIC AND STRUCTURAL DESIGN - SPILLWAYS AND OUTLET WORKS ...Concrete-other, Hydraulic Structures, Spillways, Ultimate, ...**8.0139**

HYDRAULIC DESIGN OF STRUCTURES FOR WATER USE AND CONTROL IN THE SOUTHERN PLAINS ...Agricultural Watersheds, Design Criteria, Design Flow-flood, Hydraulic Structures, Water Loss Control, ...**8.0277**

EVALUATION AND CONTROL OF SEEPAGE FROM WATER STORAGE AND CONVEYANCE STRUCTURES ...Lining, Preventive Measures, Seepage, Storage of Water, Water Loss Control, ...**8.0002**

Power Development

FISH PASSAGE THROUGH TURBINES ...Fish -non-specific, Hydraulic, Management -other, Mortality Rates, Stamina, ...**8.0312**

INTAKES, ENTRANCES, AND TRANSITIONS ...Energy Losses-other, Penstock, Pipes, Transition Sections, Vortex, ...**8.0099**

SITE TESTS TO DETERMINE STRUCTURAL PROPERTIES OF ROCK FOUNDATIONS ...Dams-other, Engineering Structures-general, Foundations-general, Rock Mechanics, Tunnels, ...**8.0019**

ULTIMATE STRENGTH DESIGN ...Codes and Standards, Electric Power Plants, Reinforced, Structural, ...**8.0030**

DESIGN OF DOUBLE-CURVATURE MULTIPLE-ARCH DAMS FOR USE IN WIDE VALLEYS ...Analysis Structural, Arch Dams, Engineering Structures-general, Reinforced, Shells, ...**8.0095**

POWER PRODUCTION ...Electric Power Plants, Nuclear Power, Reservoir Systems, Spray Devices, Thermal Pollution, ...**5.0983**

Reservoir Systems

POWER PRODUCTION ...Electric Power Plants, Nuclear Power, Power Development, Spray Devices, Thermal Pollution, ...**5.0983**

Sedimentation

HYDRAULIC INVESTIGATION OF SOIL EROSION AND SEDIMENTATION IN HIGHWAY MEDIAN AND SIDE DITCHES ...Alabama, Drainage, Flow Characteristics -water, Scouring, Silting, ...**2.0004**

STUDY OF TRANSPORT, DEPOSITION AND SCOUR OF FINE PARTICLES THROUGH A POROUS MEDIUM ...Flow Characteristics -water, Permeability, Porosity, Porous Media - Flow Through, Silting, ...**2.0081**

CHANGES IN NATURAL CHANNELS RESULTING FROM CONTROL DEVICES IN THE UPPER REACHES OF THE BASINS ...Channels, Control Factors-general, Open Channel, Reservoirs, Structure Sites, ...**2.0685**

NON-EQUILIBRIUN TRANSPORT OF SUSPENDED SEDIMENT ...Flume, Length, Open Channel, Scouring, Suspension, ...**2.0696**

DEPOSITION OF FINE SEDIMENTS IN TURBULENT FLOWS ...Channel Roughness, Open Channel, Secondary Flows, Shearflow, Turbulent, ...**5.0764**

METHODS AND EQUIPMENT FOR SUBSURFACE DRAINAGE ...Drainage, Drainage Systems, ...**4.0193**

SCOUR AT RELIEF BRIDGES ...Bridges & Culverts, Culvert, Drainage, Scouring, Transition Sections, ...**8.0005**

PERFORMANCE CHARACTERISTICS OF LARGE SCALE HYDROMECHANICS LABORATORY EQUIPMENT ...Flume Studies, Inflow, Synthetic Hydrology-general, Turbulent Flow, ...**8.0195**

HYDRAULICS LABORATORY ...Channels, Flow of Dispersed Solids, Open Channel, Streams, Suspension, Turbulent, ...**8.0146**

STABILIZATION OF SHORES BY GROINS AND JETTIES ...Development, Groin, Jetty, Models, Wave Action, ...**2.0263**

GREAT LAKES RESEARCH - SPOIL DISPOSAL EFFECTS ...Dispersion -water, Great Lakes-general, Pollution - Effects of , Sediments, Spoil Banks, Water Properties-general, ...**5.0561**

MECHANICS OF FLOW STRUCTURE AND FLUID RESISTANCE ...Open Channel, Sediment Transport-general, Turbulent Flow, ...**2.0236**

CHANNELIZATION STUDIES ...Channel Geometry, Channels, Control and Protection, New Mexico, Silting, ...**8.0053**

MECHANICS OF SEDIMENT ENTRAINMENT, TRANSPORTATION AND DEPOSITION IN CHANNELS OF THE SOUTHERN BRANCH AND AT THE USDA SEDIMENTATION LABORATO ...Channels, Flume Studies, Sediment Transport-general, Velocity -water, Waves, ...**2.0677**

DEVELOPMENT OF STRUCTURAL MEASURES FOR SEDIMENT CONTROL AND FOR STREAM CHANNEL STABILIZATION IN THE SOUTHERN BRANCH ...Agricultural Watersheds, Channel Geometry, Engineering Structures-general, Open Channel, Shear-flow, Velocity, ...**5.0622**

STREAM CHANNEL STABILIZATION SEDIMENT CONTROL WORKS IN CHANNELS ...Channels, Erosion Control, Lining, Open Channel, Scouring, ...**5.0930**

Seepage

SMALL RESERVOIR SEALING ...Linings-pavings, Sealant Materials, ...**8.0288**

DRAINAGE DESIGNS AS INFLUENCED BY CONDITIONS IN THE VICINITY OF THE DRAIN LINE ...Drainage Systems, Erosion Control, Pipe, Tube, Pipes, Plastics - General, ...**8.0010**

USE OF LATEX AS A SOIL SEALANT TO CONTROL ACID MINE WASTE DRAINAGE ...Acidity, Elastomers Rubber, Lining, Linings-pavings, Mine Drainage Control, Sealant Materials, ...**5.0996**

DEVELOPING RESERVOIRS FOR SUPPLEMENTAL IRRIGATION ...Leekage, Linings-pavings, Loss, Reservoirs, Water Loss Control, ...**3.0302**

DESIGN OF OPEN CHANNELS TO PREVENT BANK FAILURE ...Piezometers, Subsurface Flow, ...**4.0253**

IMPROVEMENT OF WATER SUPPLY SOURCES AND STORAGE FACILITIES IN THE CORN BELT ...Corn Belt, Permeability, Ponds, Reservoirs, Water Loss Control, ...**8.0274**

Water Distribution Systems

ANALYSIS OF SMALL WATER MANAGEMENT STRUCTURES ...Administrative Structures, Hydraulic Structures, Management, Water Control Works-general, Water Transfer, ...**4.0260**

A MODEL FOR QUANTIFYING FLOW AUGMENTATION BENEFITS ...Flood Control, Flow Augmentation, Model Studies, Other Methods, River Basins, Systems Analysis, ...**6.0152**

INTERSTATE REGIONAL PLANNING FOR WATER SUPPLY AND WASTE DISPOSAL ...Delaware River, Disposal-general, Interstate, Planning, Water Quality Control-general, Water Supply-general, ...**5.0748**

THE ECONOMICS OF WATER TRANSFER - AN APPRAISAL OF INSTITUTIONS ...Administrative Structures, Systems Analysis, Water Costs, Water Transfer, Water Utilization -general, ...**6.0055**

MODEL STUDY OF CONTROL STRUCTURES FOR FOOTHILL FEEDER TUNNELS ...Aqueducts, Control Gate, Urban Environments, Water Transfer, ...**8.0217**

REVIEW OF ALGALCIDES ...Algacides -non-specific, Algal Pollutant Sources, Public Utilities, Residential, Survey Studies, ...**5.0358**

DEVELOPMENT OF AUTOMATED SUBIRRIGATION SYSTEM ...Automated Equipment, Irrigation Engineering, Moisture, Pipes, Plastics - General, Subsurface Irrigation, ...**3.0024**

INVESTIGATIONS OF ALGAE INHIBITING MATERIALS ...Cement, Concrete, Coatings-other, Fouling, Inhibitors, Liquids Or Sprays, Organic Wastes, ...**3.0106**

INVESTIGATION EVALUATION AND DESIGN OF OPEN AND CLOSED CONDUIT SYSTEMS AS IT RELATES CONVEYANCE AND DISTRIBUTION SYSTEMS ...Conduit, Hydraulic Equipment, Irrigation Engineering, Irrigation-general, Remote Sensing -other, Water Transfer, ...**8.0169**

FACILITIES, METHODS AND DESIGN CRITERIA TO PUMP, CONVEY, CONTROL AND MEASURE WATER FOR AGRICULTURAL PURPOSES IN THE NORTHERN PLAINS ...Irrigation-general, Lining, Pumping, Runoff, Storage of Water, Water Transfer, ...**3.0141**

Waterproof

SEALING OF CANALS AND RESERVOIRS WITH COLORADO CLAYS ...Clay, Colorado, Irrigation Engineering, Open Channel, Particle Size, Permeability, Reservoirs, ...**8.0144**

STRUCTURAL PROBLEMS ASSOCIATED WITH CONCRETE PIPE ...Concrete-general, Design Criteria, Pipes, Pressure-general, Soil - Buried Structures, ...**8.0033**

External Pressure on Structure

Control Gate

COLLECTION OF JUVENILE SALMON IN TURBINE INTAKES ...Columbia River, Electric Power Plants, Mortality Rates, Salmon & Trout - Non-specific, Turbine-other, ...**8.0299**

FEEDBACK CONTROL OF CANAL CHECK GATES ...Canals, Channel Regulation-other, Economic Efficiency, Water Demand, ...**4.0023**

SUBCRITICAL FLOW AT OPEN CHANNEL STRUCTURES ...Critical, Design Criteria, Measurement, Open Channel, Transition Sections, ...**4.0261**

DISPATCHING SYSTEM FOR CONTROL OF COMBINED SEWER LOSSES ...Combined Sewer, Energy Losses-general, Hydraulics-general, Hydrology-general, Meteorological Studies-general, ...**5.0609**

MODEL STUDY OF CONTROL STRUCTURES FOR FOOTHILL FEEDER TUNNELS ...Aqueducts, Urban Environments, Water Distribution Systems, Water Transfer, ...**8.0217**

HYDRAULIC INVESTIGATION OF TAINTER GATES AS FLOW MEASURING DEVICES ...Fluid Dynamics, Fluids, Measurement, ...**8.0167**

GENERAL SPILLWAY TESTS ...Design Criteria, Energy Dissipators, Ext Pressure on Struct-other, Spillways, Weir, ...**8.0242**

DETROIT TEST CONDUIT ...Conduit, Erosion Control, Flume Studies, Scouring, Transition Sections, ...**8.0282**

GATES, VALVES, AND ORIFICES ...Design Criteria, Models, Orifice, Seals, Valves, ...**8.0037**

DESIGN IMPROVEMENTS--GATES AND VALVES ...Channel Regulation-other, Dam, Canal, Galvanic, Seals, Valves, ...**8.0088**

AUTOMATION OF CANAL SYSTEMS ...Canals, Channel Regulation-other, Controls, Open Channel, Other Control Systems, ...**8.0138**

Dam

ARTIFICIAL FLOODS ...Computers-general, Dams-other, Floods, Flow Characteristics -water, ...**6.0076**

Ext Pressure on Struct-general

WAVE FORCES ON BREAKWATERS ...Breakwaters , Shoreline Structures, Wave Action, Waves, ...**8.0232**

Ext Pressure on Struct-other

GENERAL SPILLWAY TESTS ...Control Gate, Design Criteria, Energy Dissipators, Spillways, Weir, ...**8.0242**

Fluid Flow

Channel Geometry

INVESTIGATION OF SCOUR AT BRIDGES IN ALASKA ...Alaska, Bridges & Culverts, Drainage, Erosion Control, Scouring, Suspension, ...**2.0285**

SOIL EROSION STUDIES IN OKLAHOMA AND SOIL SEDIMENTATION STUDIES IN OKLAHOMA ...Culvert, Drainage, Erosion-general, Froude Number, Stabilization-general, ...**2.0877**

STOCHASTIC TREATMENT OF RIVER GEOMETRY ...Meanders, Morphology-general, Open Channel, Shape, Stochastic Processes, ...**2.0443**

HYDRAULIC RESISTANCE IN ALLUVIAL CHANNELS ...Alluvial Deposits, Energy-dynamics, Flow Characteristics -water, Flow of Dispersed Solids, Sediment Transport-general, ...**2.0448**

THE FLOW OF WATER IN FLUMES AND CANALS ...Canals, Flume, Open Channel, Open Channel Flow, Turbulent, ...**8.0222**

DISPERSION OF WATER POLLUTANTS IN CURVILINEAR FLOWS ...Fluid Mixing, Open Channel, Pollutants - Path of , Stratified, Turbulent, ...**5.0414**

LABORATORY TESTING OF HYDRAULIC FORMULATIONS FOR OPEN CHANNEL FLOW ...Channel Roughness, Open Channel, Routing, Systems of Equations, Transition Sections, Velocity, ...**2.0573**

EFFECT OF SURFACE IRRIGATION HYDRAULICS ON EFFICIENT APPLICATION OF WATE ...Channel Roughness, Flow Characteristics -water, Open Channel, Surface Flow, Surface Irrigation -general, ...**4.0239**

OPEN-CHANNEL TRANSITIONS IN SUPERCRITICAL FLOW ...Critical, Cross-section, Hydraulics-general, Open Channel, Open Channel Flow, ...**8.0283**

DETROIT TEST CHUTE ...Depth, Flow of Gas in Liquid, Flume Studies, Spillways, Velocity, ...**8.0281**

CHANNELIZATION STUDIES ...Channels, Control and Protection, New Mexico, Sedimentation, Silting, ...**8.0053**

TRANSIENT FLOW IN OPEN CHANNELS ...Hydraulic Gradient, Open Channel Flow, Pump-other, Siphon, Transient, ...**8.0039**

DEVELOPMENT AND EVALUATION OF MEANS AND MEASURES FOR CHANNEL STABILIZATION ...Channels, Design Criteria, Flow Characteristics -water, Mechanics, General, Scouring, Sediment Transport-general, ...**5.1022**

DEVELOPMENT OF STRUCTURAL MEASURES FOR SEDIMENT CONTROL AND FOR STREAM CHANNEL STABILIZATION IN THE SOUTHERN BRANCH ...Agricultural Watersheds, Engineering Structures-general, Open Channel, Sedimentation, Shear-flow, Velocity, ...**5.0622**

Channel Roughness

USE OF LARGE ROUGHNESS ELEMENTS FOR HYDRAULIC ENERGY DISSIPATION ...Culvert, Drainage, Energy Dissipators, Models, Open Channel, ...**8.0295**

INCIPIENT MOTION OF ROUGHNESS ELEMENTS IN TURBULENT OPEN CHANNEL FLOW ...Design Criteria, Drag, Lift, Open Channel, Turbulent, ...**2.1061**

AN ANALYTICAL AND EXPERIMENTAL STUDY OF BED FORMS UNDER WATER WAVES ...Friction, Geomorphology-topography, Model Studies, Water Tunnels Tables, Wave Action, Waves, ...**2.0347**

MEASUREMENT AND ANALYSIS OF NATURAL-TYPE SURFACES AFFECTING FLUID FLOW ...Computers-general, Fluid Flow-other, Frictional, Hydraulic Gradient, ...**2.0247**

DEPOSITION OF FINE SEDIMENTS IN TURBULENT FLOWS ...Open Channel, Secondary Flows, Sedimentation, Shear-flow, Turbulent, ...**5.0764**

HYDRAULICS OF SURFACE IRRIGATION ...Flow Characteristics -water, Irrigation, Irrigation Engineering, Mathematical Analysis, Soils -general, Surface Irrigation -general, ...**2.0215**

LABORATORY TESTING OF HYDRAULIC FORMULATIONS FOR OPEN CHANNEL FLOW ...Channel Geometry, Open Channel, Routing, Systems of Equations, Transition Sections, Velocity, ...**2.0573**

EFFECT OF SURFACE IRRIGATION HYDRAULICS ON EFFICIENT APPLICATION OF WATE ...Channel Geometry, Flow Characteristics -water, Open Channel, Surface Flow, Surface Irrigation -general, ...**4.0239**

THE CHARACTERIZATION OF OVERLAND FLOW ON VERY ROUGH SURFACES ...Channels, Data Analysis Applications, Flow Characteristics -water, Model Studies, Surface Flow, ...**8.0192**

OPEN CHANNEL ROUGHNESS CHARACTERIZATION ...Discharge-general, Flume, Flume Studies, Open Channel, Open Channel Flow, ...**2.1073**

MECHANICS OF FLUID RESISTANCE ...Close Channel, Friction, Skin Friction, Turbulent, Viscosity, ...**2.0362**

STUDIES OF CANAL HYDRAULICS ...Canals, Energy Losses-other, Hydraulics-general, Open Channel, Transition Sections, ...**8.0130**

THE HYDRAULICS AND MEASUREMENT OF CHANNEL, FLOOD PLAIN, AND OVERLAND FLOW IN THE SOUTHERN PLAINS ...Channels, Floodplains, Measurement, Open Channel, Unsteady, ...**8.0276**

Channel Type-other

STUDY OF TUNNEL LININGS AND REINFORCEMENT ...Data Analysis - General, Lining, Linings-pavings, Reinforced, ...**8.0104**

Conduit

UNSTEADY FLOW PARAMETERS IN HYDRAULIC DESIGN ...Incompressible, Pressure, Reservoirs, Transition Sections, Unsteady, ...**8.0200**

FLUID FRICTION IN THE PRESENCE ON NON-RIGID BOUNDARIES ...Friction, ...**5.0479**

TRANSPORT OF SOLID SUSPENSION IN CONDUITS ...Combined Sewer, Design Criteria, Flow of Dispersed Solids, Measurement, Transportation, ...**5.0988**

MODEL STUDY OF SEWER DROPSHAFT ...Design-other, Discharge-general, Flow Regulations, Runoff, Two-phase-other, ...**8.0218**

SIPHON TYPE TRICKLE TUBE FOR FARM PONDS AND RESERVOIRS ...Design Criteria, Farm Pond, Reservoirs, Siphon, Technique Development, Water Level Fluctuation, ...**8.0203**

DEVELOPMENT OF HYDRAULIC DESIGN CRITERIA ...Design Criteria, Models, Simulators, Spillways, Water Control Works-other, ...**8.0226**

HYDRAULIC PROTOTYPE TESTS ...Channel Regulation-other, Models, Simulators, Spillways, ...**8.0228**

DETROIT TEST CONDUIT ...Control Gate, Erosion Control, Flume Studies, Scouring, Transition Sections, ...**8.0282**

PIPELINE AND TUNNEL HYDRAULICS ...Friction, Hydraulics-general, Pipelines, Pipes, Texas, ...**8.0042**

INVESTIGATION EVALUATION AND DESIGN OF OPEN AND CLOSED CONDUIT SYSTEMS AS IT RELATES CONVEYANCE AND DISTRIBUTION SYSTEMS ...Hydraulic Equipment, Irrigation Engineering, Irrigation-general, Remote Sensing - other, Water Distribution Systems, Water Transfer, ...**8.0169**

Culvert

FLOOD FREQUENCY STUDY ...Bridges & Culverts, Floods, New Mexico, Peak Flow, Rio Grande, ...**2.0772**

USE OF LARGE ROUGHNESS ELEMENTS FOR HYDRAULIC ENERGY DISSIPATION ...Channel Roughness, Drainage, Energy Dissipators, Models, Open Channel, ...**8.0295**

WATERSHED SHAPE-FACTOR ...Design Criteria, Drainage, Engineering Structures-general, North Dakota, Peak Flow, ...**2.0277**

HYDRAULIC PERFORMANCE OF BRIDGES ...Bridges & Culverts, Design Criteria, Dike, Drainage, Engineering Structures-general, ...**8.0158**

HYDROLOGY STUDY ...Bridges & Culverts, Engineering Structures-general, Floods, Flow Characteristics -water, Small Watersheds, ...**2.0292**

INVESTIGATION AND ANALYSIS OF FLOODS FROM SMALL DRAINAGE AREAS IN SOUTH CAROLINA ...Design Flow-flood, Drainage, Floods, Small Watersheds, South Carolina, ...**2.0301**

INVESTIGATION AND ANALYSIS OF FLOOD HYDROGRAPHS FROM SMALL DRAINAGE BASINS IN SOUTH DAKOTA ...Bridges & Culverts, Drainage, Floods, Hydrographs, Rain-general, Small Watersheds, ...**2.0294**

ESTIMATING RUNOFF RATES FROM SMALL RURAL WATERSHEDS ...Drainage, Forecasting-prediction, Runoff, Small Watersheds, ...**2.0240**

SOIL EROSION STUDIES IN OKLAHOMA AND SOIL SEDIMENTATION STUDIES IN OKLAHOMA ...Channel Geometry, Drainage, Erosion-general, Froude Number, Stabilization-general, ...**2.0877**

ENGINEERING INVESTIGATION PERTAINING TO FLOOD PROTECTION OF BRIDGES AND CULVERTS ...Bridges & Culverts, Design Criteria, Drag, Drainage, Erosion Control, Floods, ...**8.0145**

PREVENTION AND CONTROL OF CULVERTS AND ROAD ICINGS ...Heating, Snow and Ice Removal, Standards & Criteria, ...**2.0025**

PERFORMANCE OF CIRCULAR CULVERTS ON STEEP GRADES ...Channels, Drainage, Engineering Structures-general, Erosion Control, Flow Characteristics -water, ...**8.0289**

SCOUR AT RELIEF BRIDGES ...Bridges & Culverts, Drainage, Scouring, Sedimentation, Transition Sections, ...**8.0005**

DEVELOPMENT OF HYDRAULIC DESIGN PROCEDURES FOR STRUCTURAL PLATE PIPE AND PIPE-ARCH CULVERTS USING RESISTANCE FACTORS FROM RECENT RESEARCH ...Drainage, Engineering Structures-general, Friction, Pipes, ...**8.0159**

DEVELOPMENT OF HYDRAULIC DESIGN PROCEDURES FOR CONCRETE BOX CULVERTS WITH STANDARD, IMPROVED AND SIDE-TAPERED INLETS ...Drainage, Economics-general, Engineering Structures-general, Structural, Transition Sections, ...**2.0304**

CONTROL AND PREVENTION OF CULVERT AND ROAD ICINGS ...Drainage, Hydrology-general, Meteorological Studies-general, Roadway-general, Snow and Ice Removal, ...**2.0750**

OPEN CHANNEL HYDRAULICS ...Irrigation, Open Channel, Transition Sections, Weir, ...**8.0127**

Energy Losses-general

DISPATCHING SYSTEM FOR CONTROL OF COMBINED SEWER LOSSES ...Combined Sewer, Control Gate, Hydraulics-general, Hydrology-general, Meteorological Studies-general, ...**5.0609**

DEVELOPMENT OF STANDARD DESIGNS FOR CANAL STRUCTURES ...Canals, Construction, Design Criteria, Model Studies, Open Channel, ...**8.0064**

Energy Losses-other

LOSS COEFFICIENT IN A CHANNEL BEND WITH NATURALLY DEFORMED BED ...Model Studies, Open Channel, Surface Phenomena, Transition Sections, Velocity, ...**2.0934**

OPEN CHANNEL TRANSITIONS ...Canals, Flow Characteristics - water, Open Channel, Surface Phenomena, Transition Sections, ...**8.0004**

INTAKES, ENTRANCES, AND TRANSITIONS ...Penstock, Pipes, Power Development, Transition Sections, Vortex, ...**8.0099**

STUDIES OF CANAL HYDRAULICS ...Canals, Channel Roughness, Hydraulics-general, Open Channel, Transition Sections, ...**8.0130**

Fluid Flow-general

HYDRAULIC STUDIES AND RESEARCH ON CALIFORNIA WATER FACILITIES ...Flow Characteristics -water, Irrigation, Irrigation-general, Model Studies, Synthetic Hydrology-general, ...**7.0010**

Fluid Flow-other

MEASUREMENT AND ANALYSIS OF NATURAL-TYPE SURFACES AFFECTING FLUID FLOW ...Channel Roughness, Computers-general, Frictional, Hydraulic Gradient, ...**2.0247**

Flume

THE USE OF LIGHT-WEIGHT SPHERICAL PARTICLES FOR DISCHARGE MEASUREMENT IN OPEN CHANNELS ...Measurement, Models, Open Channel, Turbulent, Velocity, ...**7.0069**

THE FLOW OF WATER IN FLUMES AND CANALS ...Canals, Channel Geometry, Open Channel, Open Channel Flow, Turbulent, ...**8.0222**

NON-EQUILIBRIUN TRANSPORT OF SUSPENDED SEDIMENT ...Length, Open Channel, Scouring, Sedimentation, Suspension, ...**2.0696**

FLOW MEASUREMENT OF IRRIGATION WATER ...Canals, Flow Characteristics -water, Fluids, Irrigation, Measurement, ...**3.0144**

OPEN CHANNEL ROUGHNESS CHARACTERIZATION ...Channel Roughness, Discharge-general, Flume Studies, Open Channel, Open Channel Flow, ...**2.1073**

EFFECTS OF SCALE AND OPERATING TECHNIQUE ON HARBOR MODELS ...Harbors, Synthetic Hydrology-general, ...**7.0065**

Friction

AN ANALYTICAL AND EXPERIMENTAL STUDY OF BED FORMS UNDER WATER WAVES ...Channel Roughness, Geomorphology-topography, Model Studies, Water Tunnels Tables, Wave Action, Waves, ...**2.0347**

METHODS TO REDUCE WATER POLLUTION CAUSED BY STORM WATER SEWER LOADING BY USING FLUID FLOW FRICTION REDUCERS ...Flow, Molecular Weight-other, Polyelectrolytes, Storm Sewer Quantity-other, Storm Water, ...**5.1185**

FLUID FRICTION IN THE PRESENCE ON NON-RIGID BOUNDARIES ...Conduit, ...**5.0479**

FLOW IN ECCENTRIC ANNULAR PIPES ...Configuration of Body, Pipes, Shape, Turbulent, ...**8.0182**

DEVELOPMENT OF HYDRAULIC DESIGN PROCEDURES FOR STRUCTURAL PLATE PIPE AND PIPE-ARCH CULVERTS USING RESISTANCE FACTORS FROM RECENT RESEARCH ...Culvert, Drainage, Engineering Structures-general, Pipes, ...**8.0159**

EFFECTS OF SCALE AND OPERATING TECHNIQUE ON HARBOR MODELS ...Harbors, Synthetic Hydrology-general, ...**7.0065**

MECHANICS OF FLUID RESISTANCE ...Channel Roughness, Close Channel, Skin Friction, Turbulent, Viscosity, ...**2.0362**

PIPELINE AND TUNNEL HYDRAULICS ...Conduit, Hydraulics-general, Pipelines, Pipes, Texas, ...**8.0042**

Hydraulic Gradient

MEASUREMENT AND ANALYSIS OF NATURAL-TYPE SURFACES AFFECTING FLUID FLOW ...Channel Roughness, Computers-general, Fluid Flow-other, Frictional, ...**2.0247**

PERFORMANCE OF DRAINAGE SYSTEMS ...Drainage Systems, Drawdown, Observation Wells, Permeability, Water Table Fluctuation, ...**4.0174**

FACTORS AFFECTING STABILITY OF ARTIFICIAL AND NATURAL CHANNELS ...Channels, Cohesive Soil-general, Open Channel, Soil Stability Analysis, Vane, ...**8.0034**

DRAINAGE SYSTEMS - PIPE AND FILTERS ...Drainage Engineering, Drainage Systems, Filters, Pipelines, Pipes, ...**8.0018**

TRANSIENT FLOW IN OPEN CHANNELS ...Channel Geometry, Open Channel Flow, Pump-other, Siphon, Transient, ...**8.0039**

Measurement

INVESTIGATION OF WATER RESOURCES IN ALASKA ...Gaging, Hydrology-general, Open Channel, Streams, ...**2.0269**

THE USE OF LIGHT-WEIGHT SPHERICAL PARTICLES FOR DISCHARGE MEASUREMENT IN OPEN CHANNELS ...Flume, Models, Open Channel, Turbulent, Velocity, ...**7.0069**

SUBCRITICAL FLOW AT OPEN CHANNEL STRUCTURES ...Control Gate, Critical, Design Criteria, Open Channel, Transition Sections, ...**4.0261**

TRANSPORT OF SOLID SUSPENSION IN CONDUITS ...Combined Sewer, Conduit, Design Criteria, Flow of Dispersed Solids, Tra..sportation, ...**5.0988**

HYDRAULICS OF SURFACE IRRIGATION ...Irrigation Engineering, Math Models, Porous Media - Flow Through, Surface Flow, Surface Irrigation -general, ...**2.0047**

FLOW MEASUREMENT OF IRRIGATION WATER ...Canals, Flow Characteristics -water, Fluids, Flume, Irrigation, ...**3.0144**

HYDRAULIC INVESTIGATION OF TAINTER GATES AS FLOW MEASURING DEVICES ...Control Gate, Fluid Dynamics, Fluids, ...**8.0167**

THE IMPACT OF SUBURBAN DEVELOPMENT ON THE WATER RESOURCES OF NEW JERSEY. ...Agricultural Watersheds, Flow Characteristics -water, Gaging, Surburban Areas, Water Balance-budget, Water Table Fluctuation, ...**6.0352**

WATER MEASUREMENT ...Discharge-general, Dyes and Coloring, Fluids, Technique Development, Water Quantity-general, ...**8.0128**

THE HYDRAULICS AND MEASUREMENT OF CHANNEL, FLOOD PLAIN, AND OVERLAND FLOW IN THE SOUTHERN PLAINS ...Channel Roughness, Channels, Floodplains, Open Channel, Unsteady, ...**8.0276**

Open Channel

USE OF LARGE ROUGHNESS ELEMENTS FOR HYDRAULIC ENERGY DISSIPATION ...Channel Roughness, Culvert, Drainage, Energy Dissipators, Models, ...**8.0295**

INVESTIGATION OF WATER RESOURCES IN ALASKA ...Gaging, Hydrology-general, Measurement, Streams, ...**2.0269**

PROGRAM FOR INVESTIGATION AND ANALYSIS OF FLOODS FROM SMALL DRAINAGE AREAS IN DELAWARE ...Drainage, Floods, Flow Characteristics -water, Forecasting-prediction, Small Watersheds, ...**2.0295**

INCIPIENT MOTION OF ROUGHNESS ELEMENTS IN TURBULENT OPEN CHANNEL FLOW ...Channel Roughness, Design Criteria, Drag, Lift, Turbulent, ...**2.1061**

STOCHASTIC TREATMENT OF RIVER GEOMETRY ...Channel Geometry, Meanders, Morphology-general, Shape, Stochastic Processes, ...**2.0443**

MECHANICS OF FLOW IN OPEN CHANNEL SYSTEMS ...Numerical Analysis-other, Shock Waves, Steady, Unsteady, Waves in Liquids, ...**2.0097**

THE USE OF LIGHT-WEIGHT SPHERICAL PARTICLES FOR DISCHARGE MEASUREMENT IN OPEN CHANNELS ...Flume, Measurement, Models, Turbulent, Velocity, ...**7.0069**

EXPERIMENTAL INVESTIGATION OF HYDRAULIC TRANSIENTS IN RIVER-RESERVOIR SYSTEMS ...Hydraulics-general, Model Studies, Reservoirs, Streams, Transition Sections, ...**2.0993**

SUBCRITICAL FLOW AT OPEN CHANNEL STRUCTURES ...Control Gate, Critical, Design Criteria, Measurement, Transition Sections, ...**4.0261**

LOSS COEFFICIENT IN A CHANNEL BEND WITH NATURALLY DEFORMED BED ...Energy Losses-other, Model Studies, Surface Phenomena, Transition Sections, Velocity, ...**2.0934**

THE FLOW OF WATER IN FLUMES AND CANALS ...Canals, Channel Geometry, Flume, Open Channel Flow, Turbulent, ...**8.0222**

CHANGES IN NATURAL CHANNELS RESULTING FROM CONTROL DEVICES IN THE UPPER REACHES OF THE BASINS ...Channels, Control Factors-general, Reservoirs, Sedimentation, Structure Sites, ...**2.0685**

NON-EQUILIBRIUN TRANSPORT OF SUSPENDED SEDIMENT ...Flume, Length, Scouring, Sedimentation, Suspension, ...**2.0696**

DEPOSITION OF FINE SEDIMENTS IN TURBULENT FLOWS ...Channel Roughness, Secondary Flows, Sedimentation, Shearflow, Turbulent, ...**5.0764**

DISPERSION OF WATER POLLUTANTS IN CURVILINEAR FLOWS ...Channel Geometry, Fluid Mixing, Pollutants - Path of, Stratified, Turbulent, ...**5.0414**

MATHEMATICAL MODELS OF HYDROLOGIC SYSTEMS ...Economics-general, Hydraulic Structures, Model Studies, Unsteady, Unsteady Flow, Water Quality-general, ...**6.0382**

OPTIMAL DESIGN OF SEWER AND DRAINAGE SYSTEMS ...Digital Computers, Process Design, Sewerage Systems-other, Unsteady, ...**5.0530**

LABORATORY TESTING OF HYDRAULIC FORMULATIONS FOR OPEN CHANNEL FLOW ...Channel Geometry, Channel Roughness, Routing, Systems of Equations, Transition Sections, Velocity, ...**2.0573**

EFFECT OF SURFACE IRRIGATION HYDRAULICS ON EFFICIENT APPLICATION OF WATE ...Channel Geometry, Channel Roughness, Flow Characteristics -water, Surface Flow, Surface Irrigation -general, ...**4.0239**

OPEN CHANNEL TRANSITIONS ...Canals, Energy Losses-other, Flow Characteristics -water, Surface Phenomena, Transition Sections, ...**8.0004**

NUMERICAL ANALYSIS OF TIME-DEPENDENT FREE SURFACE FLOWS ...Capillarity, Dimension-three, Finite Differences, Partial, Unsteady, ...**2.0441**

CALIFORNIA AQUEDUCT, NORTH SAN JOAQUIN DIVISION, FISH PROTECTIVE FACILITY ...Engineering Structures-general, Models, Pipes, Transition Sections, Velocity, ...**8.0009**

THE MECHANICS OF OPEN-CHANNEL FLOW SYSTEMS ...Flow Characteristics -water, Steady, Transient, Transition Sections, Unsteady, ...**8.0011**

SEALING OF CANALS AND RESERVOIRS WITH COLORADO CLAYS ...Clay, Colorado, Irrigation Engineering, Particle Size, Permeability, Reservoirs, Waterproof, ...**8.0144**

HYDRAULICS LABORATORY ...Channels, Flow of Dispersed Solids, Sedimentation, Streams, Suspension, Turbulent, ...**8.0146**

CONCRETE DITCH LINING AND PIPE FOR IRRIGATION SYSTEMS ...Irrigation, Lining, Linings-pavings, Pipes, Plain, ...**8.0272**

OPEN-CHANNEL TRANSITIONS IN SUPERCRITICAL FLOW ...Channel Geometry, Critical, Cross-section, Hydraulics-general, Open Channel Flow, ...**8.0283**

INCIPIENT MOTION OF LARGE ROUGHNESS ELEMENTS IN TURBULENT OPEN CHANNEL FLOW ...Erosion Control, Flow Characteristics -water, Open Channel Flow, Sediment Transport-other, Turbulent Flow, ...**2.1062**

OPEN CHANNEL ROUGHNESS CHARACTERIZATION ...Channel Roughness, Discharge-general, Flume, Flume Studies, Open Channel Flow, ...**2.1073**

COMMITTEE ON CHANNEL STABILIZATION ...Alluvial Deposits, Bedding Planes, Channels, Design Criteria, Stabilization-other, Streams, Temperature, ...**2.0686**

RIPRAP, REQUIREMENTS IN CHANNELS ...Drag, Lift, Lining, Models, Velocity, ...**8.0246**

MECHANICS OF FLOW STRUCTURE AND FLUID RESISTANCE ...Sediment Transport-general, Sedimentation, Turbulent Flow, ...**2.0236**

DEVELOPMENT OF STANDARD DESIGNS FOR CANAL STRUCTURES ...Canals, Construction, Design Criteria, Energy Losses-general, Model Studies, ...**8.0064**

OPEN CHANNEL HYDRAULICS ...Culvert, Irrigation, Transition Sections, Weir, ...**8.0127**

STUDIES OF EQUATIONS FOR SEEPAGE LOSS FROM CANALS ...Canals, Lining, Loss, Permeability, Soil Test - Insitu, ...**8.0129**

DESIGN CRITERIA FOR OPEN CHANNELS ...Design Criteria, Hydraulics-general, Irrigation Engineering, Open Channel Flow, Surface Irrigation -general, ...**8.0136**

FACTORS AFFECTING STABILITY OF ARTIFICIAL AND NATURAL CHANNELS ...Channels, Cohesive Soil-general, Hydraulic Gradient, Soil Stability Analysis, Vane, ...**8.0034**

STUDIES OF CANAL HYDRAULICS ...Canals, Channel Roughness, Energy Losses-other, Hydraulics-general, Transition Sections, ...**8.0130**

STABILITY OF EARTH SLOPES ...Dams, Earthquakes, Pore Water, Slopes, Soil Stability Analysis, ...**8.0071**

AUTOMATION OF CANAL SYSTEMS ...Canals, Channel Regulation-other, Control Gate, Controls, Other Control Systems, ...**8.0138**

EXPLOSIVE EXCAVATION IN THE DEVELOPMENT OF WATER RESOURCES ...Earth & Rockfill Dams, Excavation, Nuclear Power, Reservoirs, Water Resources Development, ...**8.0041**

MEMBRANE LININGS-OPEN AND CLOSED CONDUIT RESEARCH PROGRAM ...Bituminous, Elastomers Rubber, Lining, Polyethylene, Polyvinyl Chloride, ...**8.0051**

PREVENTING OR CONTROLLING ACCELERATED EROSION OF UNSTABLE FOREST SOILS ...Erosion-general, Mountains-alpine, Movement, Availability, Slopes, Soil Science -other, Soil Stability Analysis, ...**5.0316**

EFFECTS OF VARIOUS FOREST TYPES AND STAND TREATMENTS ON GROUNDWATER RECHARGE AND STREAMBANK EROSION IN AREAS OF DEEP GLACIAL DRIFT ...Erosion Control, Erosion-general, Forest Watersheds, Natural Recharge, Stream Banks, ...**5.0573**

DEVELOPMENT OF STRUCTURAL MEASURES FOR SEDIMENT CONTROL AND FOR STREAM CHANNEL STABILIZATION IN THE SOUTHERN BRANCH ...Agricultural Watersheds, Channel Geometry, Engineering Structures-general, Sedimentation, Shear-flow, Velocity, ...**5.0622**

STREAM CHANNEL STABILIZATION SEDIMENT CONTROL WORKS IN CHANNELS ...Channels, Erosion Control, Lining, Scouring, Sedimentation, ...**5.0930**

THE HYDRAULICS AND MEASUREMENT OF CHANNEL, FLOOD PLAIN, AND OVERLAND FLOW IN THE SOUTHERN PLAINS ...Channel Roughness, Channels, Floodplains, Measurement, Unsteady, ...**8.0276**

Orifice

THE HYDRAULICS OF SPATIALLY VARIED STEADY FLOW IN AN IRRIGATION DISTRIBUTION CHANNEL WITH FURROW OUTLETS ...Channels, Engineering Structures-general, Flow Characteristics -water, Furrow Irrigation, Weir, ...**3.0398**

SUBIRRIGATION ...Irrigation Engineering, Subsurface Irrigation, Water Application Methods, ...**4.0121**

GATES, VALVES, AND ORIFICES ...Control Gate, Design Criteria, Models, Seals, Valves, ...**8.0037**

Pipes

UNSTEADY FREE SURFACE FLOW IN LONG STORM DRAIN ...Drainage, Eigenvalues, Engineering Structures-general, Other Methods, Steady, Transition Sections, Unsteady, ...**8.0142**

TRANSIENT FLOW THROUGH CLOSED CONDUITS ...Acoustic Effects, Eigenvalues, Error Analysis, Interpolation, Transient, Valves, ...**2.0634**

PASSAGE OF ADULT SALMONIDS THROUGH PIPES ...Construction Land Use Effects, Management -other, Salmon - coho,chinook,sockeye.., ...**8.0301**

UNSTEADY FLOW OF DILUTE AQUEOUS HIGH POLYMER SOLUTIONS IN PIPES ...Additives, Fluid Flow-other, Mathematics Matching Code, Size, Unsteady, ...**8.0164**

THEORETICAL AND EXPERIMENTAL STUDY OF SUPERCRITICAL FLOW IN CIRCULAR DRAINS AND OF THE FORMATION OF HYDRAULIC JUMP IN THE SAME ...Critical, Drainage Systems, Engineering Structures-general, Flow of Gas in Liquid, Survey Studies, ...**2.0935**

DRAINAGE DESIGNS AS INFLUENCED BY CONDITIONS IN THE VICINITY OF THE DRAIN LINE ...Drainage Systems, Erosion Control, Pipe, Tube, Plastics - General, Seepage, ...**8.0010**

PIPELINE FLOW OF SOLIDS-LIQUID SUSPENSIONS ...Flow, Flow of Dispersed Solids, Sludge-other, Transition Sections, Viscosity, ...**5.0799**

LABORATORY STUDIES OF CONSERVATION AND DRAINAGE STRUCTURES ...Drainage, Erosion Control, Scouring, Transition Sections, Velocity, ...**3.0217**

FLOW IN ECCENTRIC ANNULAR PIPES ...Configuration of Body, Friction, Shape, Turbulent, ...**8.0182**

DEVELOPMENT OF AUTOMATED SUBIRRIGATION SYSTEM ...Automated Equipment, Irrigation Engineering, Moisture, Plastics - General, Subsurface Irrigation, Water Distribution Systems, ...**3.0024**

CALIFORNIA AQUEDUCT, NORTH SAN JOAQUIN DIVISION, FISH PROTECTIVE FACILITY ...Engineering Structures-general, Models, Open Channel, Transition Sections, Velocity, ...**8.0009**

DURABILITY OF CONCRETE DRAIN TILE AND IRRIGATION PIPE ...Drainage, Plain, Specifications, Strength, Techniques, ...**8.0221**

CONCRETE DITCH LINING AND PIPE FOR IRRIGATION SYSTEMS ...Irrigation, Lining, Linings-pavings, Open Channel, Plain, ...**8.0272**

DEVELOPMENT OF HYDRAULIC DESIGN PROCEDURES FOR STRUCTURAL PLATE PIPE AND PIPE-ARCH CULVERTS USING RESISTANCE FACTORS FROM RECENT RESEARCH ...Culvert, Drainage, Engineering Structures-general, Friction, ...**8.0159**

DISTRIBUTION OF LIQUIDS IN POLAR CAMPS ...Flow, Maintenance, Permafrost-frozen, Polar, Sewage, ...**5.0134**

INTAKES, ENTRANCES, AND TRANSITIONS ...Energy Losses-other, Penstock, Power Development, Transition Sections, Vortex, ...**8.0099**

PIPELINE AND TUNNEL HYDRAULICS ...Conduit, Friction, Hydraulics-general, Pipelines, Texas, ...**8.0042**

SOIL PRESSURES ON FLEXIBLE STEEL PIPE ...Model Studies, Pressure-general, Soil-structure Interaction, Triaxial, ...**8.0072**

DRAINAGE SYSTEMS - PIPE AND FILTERS ...Drainage Engineering, Drainage Systems, Filters, Hydraulic Gradient, Pipelines, ...**8.0018**

STRUCTURAL PROBLEMS ASSOCIATED WITH CONCRETE PIPE ...Concrete-general, Design Criteria, Pressure-general, Soil - Buried Structures, Waterproof, ...**8.0033**

Siphon

SIPHON TYPE TRICKLE TUBE FOR FARM PONDS AND RESERVOIRS ...Conduit, Design Criteria, Farm Pond, Reservoirs, Technique Development, Water Level Fluctuation, ...**8.0203**

TRANSIENT FLOW IN OPEN CHANNELS ...Channel Geometry, Hydraulic Gradient, Open Channel Flow, Pump-other, Transient, ...**8.0039**

Transition Sections

UNSTEADY FREE SURFACE FLOW IN LONG STORM DRAIN ...Drainage, Eigenvalues, Engineering Structures-general, Other Methods, Pipes, Steady, Unsteady, ...**8.0142**

UNSTEADY FLOW PARAMETERS IN HYDRAULIC DESIGN ...Conduit, Incompressible, Pressure, Reservoirs, Unsteady, ...**8.0200**

EXPERIMENTAL INVESTIGATION OF HYDRAULIC TRANSIENTS IN RIVER-RESERVOIR SYSTEMS ...Hydraulics-general, Model Studies, Open Channel, Reservoirs, Streams, ...**2.0993**

SUBCRITICAL FLOW AT OPEN CHANNEL STRUCTURES ...Control Gate, Critical, Design Criteria, Measurement, Open Channel, ...**4.0261**

LOSS COEFFICIENT IN A CHANNEL BEND WITH NATURALLY DEFORMED BED ...Energy Losses-other, Model Studies, Open Channel, Surface Phenomena, Velocity, ...**2.0934**

PIPELINE FLOW OF SOLIDS-LIQUID SUSPENSIONS ...Flow, Flow of Dispersed Solids, Pipes, Sludge-other, Viscosity, ...**5.0799**

LABORATORY STUDIES OF CONSERVATION AND DRAINAGE STRUCTURES ...Drainage, Erosion Control, Pipes, Scouring, Velocity, ...**3.0217**

LABORATORY TESTING OF HYDRAULIC FORMULATIONS FOR OPEN CHANNEL FLOW ...Channel Geometry, Channel Roughness, Open Channel, Routing, Systems of Equations, Velocity, ...**2.0573**

OPEN CHANNEL TRANSITIONS ...Canals, Energy Losses-other, Flow Characteristics -water, Open Channel, Surface Phenomena, ...**8.0004**

SCOUR AT RELIEF BRIDGES ...Bridges & Culverts, Culvert, Drainage, Scouring, Sedimentation, ...**8.0005**

CALIFORNIA AQUEDUCT, NORTH SAN JOAQUIN DIVISION, FISH PROTECTIVE FACILITY ...Engineering Structures-general, Models, Open Channel, Pipes, Velocity, ...**8.0009**

THE MECHANICS OF OPEN-CHANNEL FLOW SYSTEMS ...Flow Characteristics -water, Open Channel, Steady, Transient, Unsteady, ...**8.0011**

DEVELOPMENT OF HYDRAULIC DESIGN PROCEDURES FOR CONCRETE BOX CULVERTS WITH STANDARD, IMPROVED AND SIDE-TAPERED INLETS ...Culvert, Drainage, Economics-general, Engineering Structures-general, Structural, ...**2.0304**

DETROIT TEST CONDUIT ...Conduit, Control Gate, Erosion Control, Flume Studies, Scouring, ...**8.0282**

INTAKES, ENTRANCES, AND TRANSITIONS ...Energy Losses-other, Penstock, Pipes, Power Development, Vortex, ...**8.0099**

OPEN CHANNEL HYDRAULICS ...Culvert, Irrigation, Open Channel, Weir, ...**8.0127**

STUDIES OF CANAL HYDRAULICS ...Canals, Channel Roughness, Energy Losses-other, Hydraulics-general, Open Channel, ...**8.0130**

Tunnel

MODEL STUDY OF UNDERGROUND OPENINGS ...Dams-general, Foundations-general, Geology - Engineering, Model Studies, Rock Mechanics, Structural Analysis-general, ...**8.0067**

Wave Action

LAKE ERIE DIKE ...Dike, Disposal-other, Lake Erie, Models, Waves, ...**8.0219**

WAVE FORCES ON SUBMERGED STRUCTURES ...Drag, Hydraulic Structures, Lift, Shoreline Structures, Waves, ...**2.0629**

AN ANALYTICAL AND EXPERIMENTAL STUDY OF BED FORMS UNDER WATER WAVES ...Channel Roughness, Friction, Geomorphology-topography, Model Studies, Water Tunnels Tables, Waves, ...**2.0347**

CIVIL ENGINEERING STRUCTURES IN THE OCEANS ...Engineering Studies-other, Foundations-general, Hydraulic Structures, Hydrodynamics, Mechanical Properties, Soil Dynamics, ...**8.0165**

SHORE-LINE ENGINEERING STUDIES ON GREAT SALT LAKE ...Great Salt Lake, Hydraulic Structures, Hydrographic, Shoreline - Coastline, Shoreline Structures, ...**8.0293**

WAVE FORCES ON BREAKWATERS ...Breakwaters, Ext Pressure on Struct-general, Shoreline Structures, Waves, ...**8.0232**

STABILITY OF RUBBLE-MOUND BREAKWATERS ...Breakwaters, Design Criteria, Engineering Structures-general, Hydrodynamics, Shoreline Structures, Waves, ...**8.0230**

EFFECTS OF SCALE AND OPERATING TECHNIQUE ON HARBOR MODELS ...Harbors, Synthetic Hydrology-general, ...**7.0065**

WAVE ACTION ON STRUCTURES ...Engineering Structures-general, Hydrodynamic Structures, Models, Shoreline Structures, Stability, ...**8.0150**

STRUCTURAL DESIGN OF SHORE STRUCTURES ...Coastal Engineering-general, Engineering Structures-general, Hydrodynamic Structures, Models, Shoreline Structures, ...**8.0151**

STABILIZATION OF SHORES BY GROINS AND JETTIES ...Development, Groin, Jetty, Models, Sedimentation, ...**2.0263**

RUBBLE-MOUND PROTOTYPE STUDIES ...Breakwaters, Jetty, Shoreline Structures, Water Motion Recorders, Waves, ...**8.0156**

DESIGN OF RUBBLE WAVE ABSORBERS ...Breakwaters, Energy Dissipators, Waves, ...**7.0066**

SPECIAL STUDIES FOR CIVIL WORKS SOILS PROBLEMS ...Design Criteria, Earth & Rockfill Dams, Erosion Control, Field Soils Compaction, Slopes, ...**8.0255**

EVALUATION OF ROCK RIPRAP AND DEVELOPMENT OF SUBSTITUTES ...Aggregrates - Crushed Rock, Engineering Structures-general, Erosion Control, Petrography, Slopes, Soil Cement, ...**8.0081**

Weir

THE HYDRAULICS OF SPATIALLY VARIED STEADY FLOW IN AN IRRIGATION DISTRIBUTION CHANNEL WITH FURROW OUTLETS ...Channels, Engineering Structures-general, Flow Characteristics -water, Furrow Irrigation, Orifice, ...**3.0398**

OPEN CHANNEL HYDRAULICS ...Culvert, Irrigation, Open Channel, Transition Sections, ...**8.0127**

Hydraulic Engineering-other

A GENERALIZED COMPUTER LANGUAGE FOR HYDROLOGIC AND HYDRAULIC ANALYSIS ...Data Analysis - General, Digital Computers, Facilities, Problem Oriented Languages, ...**8.0213**

HYDRAULICS OF WELLS ...Aquifers-other, Drawdown, Model Studies, Unsteady Flow, Water Wells, ...**7.0077**

DEVELOPMENT OF HYDROLOGIC EQUIPMENT ...Design Instrumentation-other, Hydrology-general, Instrumental Services, Instrumentation-general, Other Telemetry, ...**7.0064**

HYDROLOGY TRAINING AND METHODOLOGY ...Computers-general, Education and Training, Hydrology-general, Meetings, ...**9.0001**

Internal Pressure on Structure

Penstock

INTAKES, ENTRANCES, AND TRANSITIONS ...Energy Losses-other, Pipes, Power Development, Transition Sections, Vortex, ...**8.0099**

Water Control Works

Arch Dams

ARCH DAM ANALYSES BASED ON THE MATHEMATICAL THEORY OF ELASTICITY ...Analysis Structural, Development of Models, Elasticity, Engineering Structures-general, Foundations-general, ...**8.0089**

STUDY OF POLYCENTERED, PARABOLIC, AND OTHER SHAPES FOR ARCH DAMS ...Analysis Structural, Design Criteria, Models, ...**8.0090**

ABUTMENT PADS FOR ARCH DAMS ...Concrete-other, Engineering Structures-general, Foundations-other, Joints, Mathematics Matching Code, ...**8.0091**

EFFECTS OF CRACKING IN ARCH DAMS ...Analysis Structural, Computers-general, Engineering Structures-general, Fracture Mechanics, Tensile, ...**8.0092**

DESIGN OF DOUBLE-CURVATURE MULTIPLE-ARCH DAMS FOR USE IN WIDE VALLEYS ...Analysis Structural, Engineering Structures-general, Power Development, Reinforced, Shells, ...**8.0095**

EARTHQUAKE THEORY AS APPLIED TO DAMS AND APPURTENANT STRUCTURES ...California, Dynamic-other, Earthquakes, Engineering Structures-general, ...**8.0096**

Channel Regulation-general

MODEL STUDIES FOR DEVELOPMENT AND CALIBRATION OF STREAMFLOW CONTROL DEVICES IN THE SOUTHERN BRANCH ...Computers-general, Discharge-general, Gaging, Models, Synthetic Hydrology-general, ...**3.0189**

Channel Regulation-other

FEEDBACK CONTROL OF CANAL CHECK GATES ...Canals, Control Gate, Economic Efficiency, Water Demand, ...**4.0023**

OPERATIONS RESEARCH IN WATER QUALITY MANAGEMENT ...Control and Protection, Engineering Structures-general, Management, Operations Research, Water Quality Control-general, ...**5.0526**

DEVELOPMENT OF AN OPERATIONS CONTROL PLAN ...Controls, Engineering Studies-other, Pump-other, Reservoirs, ...**6.0072**

HYDRAULIC PROTOTYPE TESTS ...Conduit, Models, Simulators, Spillways, ...**8.0228**

DESIGN IMPROVEMENTS--GATES AND VALVES ...Control Gate, Dam, Canal, Galvanic, Seals, Valves, ...**8.0088**

AUTOMATION OF CANAL SYSTEMS ...Canals, Control Gate, Controls, Open Channel, Other Control Systems, ...**8.0138**

Dams-general

ENGINEERING GEOLOGY ...Core Analysis, Foundations-general, Geology - Engineering, Highway Sites, Reservoirs, ...**8.0174**

PROTOTYPE ANALYSES - STRUCTURAL BEHAVIOR ...Concrete-general, Construction, Distances, Instrumentation, ...**8.0014**

MODEL STUDY OF UNDERGROUND OPENINGS ...Foundations-general, Geology - Engineering, Model Studies, Rock Mechanics, Structural Analysis-general, Tunnel, ...**8.0067**

Dams-other

STREAM RESTORATION AND CONTROLLED FLOWS ...Lake Trout, Brook Trout, Logging, Transport, Equipment, Maine, Salmon & Trout - Non-specific, Stream Rehabilitation, ...**4.0129**

INVESTIGATION OF SOIL FREEZING ...Density, Frost and Permafrost, Lining, Moisture Content, Void Ratio and Porosity, ...**8.0285**

GROUTING RESEARCH - DAM FOUNDATIONS ...Foundations-other, ...**8.0225**

ARTIFICIAL FLOODS ...Computers-general, Dam, Floods, Flow Characteristics -water, ...**6.0076**

SITE TESTS TO DETERMINE STRUCTURAL PROPERTIES OF ROCK FOUNDATIONS ...Engineering Structures-general, Foundations-general, Power Development, Rock Mechanics, Tunnels, ...**8.0019**

EVALUATION OF CONCRETE PROPERTIES OF CORES FROM OLD STRUCTURES ...Cement, Concrete, Engineering Structures-general, Mechanical Properties-general, Time, ...**8.0063**

DETERMINATION OF IN SITU STRESSES BY STRAIN-RELIEF METHOD ...Reinforced, Stress Recorders, ...**8.0021**

MASSIVE-HEAD BUTTRESS DAMS ...Foundations-general, Gravity Dams, Stresses-general, Uplift, ...**8.0094**

Design Criteria

WATERSHED SHAPE-FACTOR ...Culvert, Drainage, Engineering Structures-general, North Dakota, Peak Flow, ...**2.0277**

HYDRAULIC PERFORMANCE OF BRIDGES ...Bridges & Culverts, Culvert, Dike, Drainage, Engineering Structures-general, ...**8.0158**

DESIGN TO CONTROL EROSION IN ROADSIDE DRAINAGE CHANNELS ...Drainage, Erosion-general, Lining, Soil Erosion, ...**2.0657**

ENGINEERING INVESTIGATION PERTAINING TO FLOOD PROTECTION OF BRIDGES AND CULVERTS ...Bridges & Culverts, Culvert, Drag, Drainage, Erosion Control, Floods, ...**8.0145**

INCIPIENT MOTION OF ROUGHNESS ELEMENTS IN TURBULENT OPEN CHANNEL FLOW ...Channel Roughness, Drag, Lift, Open Channel, Turbulent, ...**2.1061**

DEVELOPMENT OF AUTOMATED SUBIRRIGATION SYSTEM ...Arkansas, Automated Equipment, Irrigation Engineering, Pipelines, Spray Devices, Subsurface Irrigation, ...**3.0025**

PILOT STUDY OF SMALL WATERSHED FLOOD HYDROLOGY IN HAWAII, PHASE II ...Discharge-general, Drainage Systems, Floods, Hawaii, Urban Environments, ...**2.0381**

SUBCRITICAL FLOW AT OPEN CHANNEL STRUCTURES ...Control Gate, Critical, Measurement, Open Channel, Transition Sections, ...**4.0261**

TRANSPORT OF SOLID SUSPENSION IN CONDUITS ...Combined Sewer, Conduit, Flow of Dispersed Solids, Measurement, Transportation, ...**5.0988**

TEMPORARY LININGS FOR WATERWAYS AND EMBANKMENTS ...Cover Crops, Embankments, Erosion Control, Florida, Hydrology-general, Lining, ...**3.0178**

FACTORS INFLUENCING THE FLOW OF SUBSOIL WATER IN THE IMMEDIATE PROXIMITY OF AND INTO DRAINAGE FACILITIES ...Drainage Systems, Flow Characteristics -water, Model Studies, Other, Seepage, ...**4.0088**

FACTORS INFLUENCING THE FLOW OF SUBSOIL WATER IN THE IMMEDIATE PROXIMITY OF AND INTO DRAINAGE FACILITIES ...Drainage Systems, Filters, Other, Permeability, Seepage, ...**4.0200**

PREPARATION OF A HIGHWAY DRAINAGE POLICY STATEMENT AND PRACTIVE MANUAL FOR THE STATE OF ILLINOIS ...Drainage, Drainage Systems, Handbooks, Illinois, Roads and Highways, Water Law-general, ...**6.0205**

HYDRAULICS OF STORM SEWER JUNCTIONS ...Drainage, Drainage Systems, Models, Storm Water, Urban Research, ...**5.0356**

SIPHON TYPE TRICKLE TUBE FOR FARM PONDS AND RESERVOIRS ...Conduit, Farm Pond, Reservoirs, Siphon, Technique Development, Water Level Fluctuation, ...**8.0203**

COMPILATION OF EARTH DAM CRITERIA FOR DESIGN USE ...Abstracts, Dams, Earth & Rockfill Dams, Engineering Structures-general, ...**8.0254**

GENERAL SPILLWAY TESTS ...Control Gate, Energy Dissipators, Ext Pressure on Struct-other, Spillways, Weir, ...**8.0242**

DEVELOPMENT OF HYDRAULIC DESIGN CRITERIA ...Conduit, Models, Simulators, Spillways, Water Control Works-other, ...**8.0226**

STABILITY OF RUBBLE-MOUND BREAKWATERS ...Breakwaters, Engineering Structures-general, Hydrodynamics, Shoreline Structures, Wave Action, Waves, ...**8.0230**

LOCK FILLING AND EMPTYING SYSTEM ...Locks, Water Transportation, ...**8.0244**

HARBOR DESIGN STUDIES ...Harbors, Navigation, Waves, ...**8.0231**

RIPRAP-PROTECTION FOR HYDRAULIC STRUCTURES ...Dike, Engineering Structures-general, Sea Wall, Water Control Works-other, ...**8.0245**

COMMITTEE ON CHANNEL STABILIZATION ...Alluvial Deposits, Bedding Planes, Channels, Open Channel, Stabilization-other, Streams, Temperature, ...**2.0686**

DEVELOPMENT OF CRITERIA FOR ARTIFICIAL BEACHES ...Beach, Beaches, Coastal Engineering-other, Shoreline Structures, Statistics-general, ...**8.0155**

SPECIAL STUDIES FOR CIVIL WORKS SOILS PROBLEMS ...Earth & Rockfill Dams, Erosion Control, Field Soils Compaction, Slopes, Wave Action, ...**8.0255**

GATES, VALVES, AND ORIFICES ...Control Gate, Models, Orifice, Seals, Valves, ...**8.0037**

DEVELOPMENT OF STANDARD DESIGNS FOR CANAL STRUCTURES ...Canals, Construction, Energy Losses-general, Model Studies, Open Channel, ...**8.0064**

EARTH AND ROCKFILL DAM DESIGN PRACTICES ...Dams, Earth & Rockfill Dams, Earthquakes, Engineering Structures-general, Soil Stability Analysis, ...**8.0137**

DESIGN CRITERIA FOR OPEN CHANNELS ...Hydraulics-general, Irrigation Engineering, Open Channel, Open Channel Flow, Surface Irrigation -general, ...**8.0136**

STUDY OF POLYCENTERED, PARABOLIC, AND OTHER SHAPES FOR ARCH DAMS ...Analysis Structural, Arch Dams, Models, ...**8.0090**

STRUCTURAL PROBLEMS ASSOCIATED WITH CONCRETE PIPE ...Concrete-general, Pipes, Pressure-general, Soil - Buried Structures, Waterproof, ...**8.0033**

DESIGN CRITERIA FOR LIVESTOCK FARMSTEAD WATER SYSTEMS ...Automatic Data Aquisition, Storage of Water, Water Demand, Water Transfer, Water Utilization -animal, ...**6.0257**

DEVELOPMENT AND EVALUATION OF MEANS AND MEASURES FOR CHANNEL STABILIZATION ...Channel Geometry, Channels, Flow Characteristics -water, Mechanics, General, Scouring, Sediment Transport-general, ...**5.1022**

HYDRAULIC DESIGN OF STRUCTURES FOR WATER USE AND CONTROL IN THE CORN BELT ...Construction, Corn Belt, Model Studies, Routing, Water Control Works-general, ...**8.0216**

HYDRAULIC DESIGN OF STRUCTURES FOR WATER USE AND CONTROL IN THE SOUTHERN PLAINS ...Agricultural Watersheds, Design Flow-flood, Hydraulic Structures, Models, Water Loss Control, ...**8.0277**

DRAINAGE FACILITIES, METHODS, AND DESIGN CRITERIA FOR PROTECTION AND IMPROVEMENT OF AGRICULTURAL CROPS AND SOILS IN THE NORTHERN PLAINS ...Drainage, Drainage Systems, Flow Characteristics -water, Simulation, ...**4.0064**

RESERVOIR SEDIMENTATION STUDIES IN CORN BELT STATES ...General Deposition, Reservoirs, Reservoirs and Impoundments, Sediment Yield, Sediments, ...**2.0868**

Dike

LAKE ERIE DIKE ...Disposal-other, Lake Erie, Models, Wave Action, Waves, ...**8.0219**

HYDRAULIC PERFORMANCE OF BRIDGES ...Bridges & Culverts, Culvert, Design Criteria, Drainage, Engineering Structures-general, ...**8.0158**

RIPRAP-PROTECTION FOR HYDRAULIC STRUCTURES ...Design Criteria, Engineering Structures-general, Sea Wall, Water Control Works-other, ...**8.0245**

Drainage Systems

EROSION CONTROL CRITERIA FOR DRAINAGE STRUCTURES ...Drainage, Erosion-general, ...**2.0681**

INVESTIGATION AND ANALYSIS OF FLOODS FROM SMALL DRAINAGE AREAS IN OHIO ...Floods, Ohio, Small Watersheds, ...**2.0275**

SMALL WATERSHED STUDY ...Design-other, Drainage, Hydraulic Structures, ...**2.0297**

PILOT STUDY OF SMALL WATERSHED FLOOD HYDROLOGY IN HAWAII, PHASE II ...Design Criteria, Discharge-general, Floods, Hawaii, Urban Environments, ...**2.0381**

PHYSICAL, CHEMICAL AND MICROBIOLOGICAL FACTORS AFFECTING THE DISCHARGE OF WATER INTO DRAIN TILE ...Drainage, Drainage Engineering, Water Properties-general, ...**2.0145**

THEORETICAL AND EXPERIMENTAL STUDY OF SUPERCRITICAL FLOW IN CIRCULAR DRAINS AND OF THE FORMATION OF HYDRAULIC JUMP IN THE SAME ...Critical, Engineering Structures-general, Flow of Gas in Liquid, Pipes, Survey Studies, ...**2.0935**

FLOW OF WATER INTO TILE DRAINS ON STRATIFIED SOILS ...Laplace Transform, Percolation, Seepage, ...**2.0486**

DRAINAGE DESIGNS AS INFLUENCED BY CONDITIONS IN THE VICINITY OF THE DRAIN LINE ...Erosion Control, Pipe, Tube, Pipes, Plastics - General, Seepage, ...**8.0010**

ENGINEERING PHASES OF SURFACE DRAINAGE ...Deltas, Drainage, Drainage Engineering, ...**4.0019**

FACTORS INFLUENCING THE FLOW OF SUBSOIL WATER IN THE IMMEDIATE PROXIMITY OF, AND INTO DRAINAGE FACILITIES ...Capillarity, Grain Size and Distribution, Methods, Model Studies, Seepage, ...**2.0212**

FACTORS INFLUENCING THE FLOW OF SUBSOIL WATER IN THE IMMEDIATE PROXIMITY OF AND INTO DRAINAGE FACILITIES ...Design Criteria, Flow Characteristics -water, Model Studies, Other, Seepage, ...**4.0088**

PERFORMANCE OF DRAINAGE SYSTEMS ...Drawdown, Hydraulic Gradient, Observation Wells, Permeability, Water Table Fluctuation, ...**4.0174**

EVALUATION OF SOIL AND WATER CONSERVATION DESIGN ...Conservation, Conservation & Management Eng, Conservation-general, Soil Preparation & Renovation, ...**2.0800**

METHODS AND EQUIPMENT FOR SUBSURFACE DRAINAGE ...Drainage, Sedimentation, ...**4.0193**

FACTORS INFLUENCING THE FLOW OF SUBSOIL WATER IN THE IMMEDIATE PROXIMITY OF AND INTO DRAINAGE FACILITIES ...Design Criteria, Filters, Other, Permeability, Seepage, ...**4.0200**

PREPARATION OF A HIGHWAY DRAINAGE POLICY STATEMENT AND PRACTIVE MANUAL FOR THE STATE OF ILLINOIS ...Design Criteria, Drainage, Handbooks, Illinois, Roads and Highways, Water Law-general, ...**6.0205**

HYDRAULICS OF STORM SEWER JUNCTIONS ...Design Criteria, Drainage, Models, Storm Water, Urban Research, ...**5.0356**

DRAINAGE OF STRATIFIED FOILS ...Drainage, Drainage Engineering, Soil-water-plant Relationships, ...**5.0939**

DRAINAGE SYSTEMS - PIPE AND FILTERS ...Drainage Engineering, Filters, Hydraulic Gradient, Pipelines, Pipes, ...**8.0018**

IMPROVEMENT AND MODERNIZATION OF SURFACE AND SUBSURFACE DRAINAGE PRACTICES AND FACILITIES IN THE CORN BELT ...Corn Belt, Drainage, Pipe, Tube, Plastics - General, ...**4.0191**

DRAINAGE FACILITIES, METHODS, AND DESIGN CRITERIA FOR PROTECTION AND IMPROVEMENT OF AGRICULTURAL CROPS AND SOILS IN THE NORTHERN PLAINS ...Design Criteria, Drainage, Flow Characteristics -water, Simulation, ...**4.0064**

DRAINAGE SYSTEMS FOR THE GREAT BASIN ...Artesian Flow, Drainage, Great Basin, Groundwater Movement, Permeability, ...**4.0164**

Earth & Rockfill Dams

THE EFFECT OF HIGH CONFINING PRESSURE ON THE DEFORMATION OF SOIL ...Dams, Deformation, Foundations-general, Pressure-other, Shear Strength, ...**8.0013**

COMPILATION OF EARTH DAM CRITERIA FOR DESIGN USE ...Abstracts, Dams, Design Criteria, Engineering Structures-general, ...**8.0254**

SHEAR STRENGTH OF ROCK FILL ...Consolidation, Engineering Structures-general, Granular-general, Shear Strength, Triaxial, ...**8.0016**

TECHNICAL SUPPORT, INVESTIGATIONS OF ARCTIC CONSTRUCTION ...Arctic, Cold - Climates, Construction, Thermal Properties-general, ...**8.0266**

SPECIAL STUDIES FOR CIVIL WORKS SOILS PROBLEMS ...Design Criteria, Erosion Control, Field Soils Compaction, Slopes, Wave Action, ...**8.0255**

EARTH AND ROCKFILL DAM DESIGN PRACTICES ...Dams, Design Criteria, Earthquakes, Engineering Structures-general, Soil Stability Analysis, ...**8.0137**

EXPLOSIVE EXCAVATION IN THE DEVELOPMENT OF WATER RESOURCES ...Excavation, Nuclear Power, Open Channel, Reservoirs, Water Resources Development, ...**8.0041**

Gravity Dams

PROTOTYPE ANALYSIS-STRUCTURAL BEHAVIOR ...Mass, Ohio River, Piezometers, Seepage, Uplift, ...**8.0149**

REINFORCEMENT OF OPENINGS IN MASSIVE CONCRETE STRUCTURES ...Analysis Structural, Fracture Mechanics, Reinforced, Stress Concentration, Thermal, ...**8.0093**

MASSIVE-HEAD BUTTRESS DAMS ...Dams-other, Foundations-general, Stresses-general, Uplift, ...**8.0094**

Groin

HYDRODYNAMIC CHARACTERISTICS OF FLOW CONCENTRATION GROINS ...Aeration, Engineering Structures-general, Floods, Flow Characteristics -water, Streams, ...**8.0268**

COASTAL WORKS EVALUATION FOR CHECKING, IMPROVING AND DEVELOPING DESIGN RELATIONSHIPS AND CONSTRUCTION TECHNIQUE ...Breakwaters, Construction, Development, Jetty, Shoreline Structures, ...**8.0148**

STABILIZATION OF SHORES BY GROINS AND JETTIES ...Development, Jetty, Models, Sedimentation, Wave Action, ...**2.0263**

Jetty

COASTAL WORKS EVALUATION FOR CHECKING, IMPROVING AND DEVELOPING DESIGN RELATIONSHIPS AND CONSTRUCTION TECHNIQUE ...Breakwaters, Construction, Development, Groin, Shoreline Structures, ...**8.0148**

STABILIZATION OF SHORES BY GROINS AND JETTIES ...Development, Groin, Models, Sedimentation, Wave Action, ...**2.0263**

RUBBLE-MOUND PROTOTYPE STUDIES ...Breakwaters, Shoreline Structures, Water Motion Recorders, Wave Action, Waves, ...**8.0156**

Locks

PROTOTYPE ANALYSES - LOCK BEHAVIOR INVESTIGATION ...Concrete-general, Deflection, Hydraulic Structures, Internal, Pressure-general, ...**8.0256**

LOCK FILLING AND EMPTYING SYSTEM ...Design Criteria, Water Transportation, ...**8.0244**

Reservoirs

RECREATIONAL IMPACT OF FEDERAL MULTI-PURPOSE RESERVOIRS ...Highway Classification-other, Planning, Projected Demand, Recreation Sites, Reservoirs and Impoundments, Touring, Transportation Needs, ...**6.0219**

UNSTEADY FLOW PARAMETERS IN HYDRAULIC DESIGN ...Conduit, Incompressible, Pressure, Transition Sections, Unsteady, ...**8.0200**

EXPERIMENTAL INVESTIGATION OF HYDRAULIC TRANSIENTS IN RIVER-RESERVOIR SYSTEMS ...Hydraulics-general, Model Studies, Open Channel, Streams, Transition Sections, ...**2.0993**

CHANGES IN NATURAL CHANNELS RESULTING FROM CONTROL DEVICES IN THE UPPER REACHES OF THE BASINS ...Channels, Control Factors-general, Open Channel, Sedimentation, Structure Sites, ...**2.0685**

EFFECTS OF LIMNOLOGICAL FACTORS ON WATER TREATMENT ...Iowa, Other, Public Utilities, Reservoirs and Impoundments, Water Quality-general, ...**5.0415**

DEVELOPING RESERVOIRS FOR SUPPLEMENTAL IRRIGATION ...Leekage, Linings-pavings, Loss, Seepage, Water Loss Control, ...**3.0302**

DEVELOPMENT OF AN OPERATIONS CONTROL PLAN ...Channel Regulation-other, Controls, Engineering Studies-other, Pump-other, ...**6.0072**

SEALING OF CANALS AND RESERVOIRS WITH COLORADO CLAYS ...Clay, Colorado, Irrigation Engineering, Open Channel, Particle Size, Permeability, Waterproof, ...**8.0144**

ENGINEERING GEOLOGY ...Core Analysis, Dams-general, Foundations-general, Geology - Engineering, Highway Sites, ...**8.0174**

SIPHON TYPE TRICKLE TUBE FOR FARM PONDS AND RESERVOIRS ...Conduit, Design Criteria, Farm Pond, Siphon, Technique Development, Water Level Fluctuation, ...**8.0203**

OPTIMIZATION TECHNIQUES FOR HYDROLOGIC ENGINEERING ...Floods, Hydrographs, Hydrology-general, Optimization, Reservoirs and Impoundments, Routing, ...**6.0075**

EXPLOSIVE EXCAVATION IN THE DEVELOPMENT OF WATER RESOURCES ...Earth & Rockfill Dams, Excavation, Nuclear Power, Open Channel, Water Resources Development, ...**8.0041**

IMPROVEMENT OF WATER SUPPLY SOURCES AND STORAGE FACILITIES IN THE CORN BELT ...Corn Belt, Permeability, Ponds, Seepage, Water Loss Control, ...**8.0274**

RESERVOIR SEDIMENTATION STUDIES IN CORN BELT STATES ...Design Criteria, General Deposition, Reservoirs and Impoundments, Sediment Yield, Sediments, ...**2.0868**

Sea Wall

RIPRAP-PROTECTION FOR HYDRAULIC STRUCTURES ...Design Criteria, Dike, Engineering Structures-general, Water Control Works-other, ...**8.0245**

Spillways

EVALUATION OF SELECTED COMPUTER PROGRAMS IN HYDROLOGY ...Hydrology-general, Model Studies, Routing, Runoff, Storm Water, ...**2.0659**

GENERAL SPILLWAY TESTS ...Control Gate, Design Criteria, Energy Dissipators, Ext Pressure on Struct-other, Weir, ...**8.0242**

DEVELOPMENT OF HYDRAULIC DESIGN CRITERIA ...Conduit, Design Criteria, Models, Simulators, Water Control Works-other, ...**8.0226**

HYDRAULIC PROTOTYPE TESTS ...Channel Regulation-other, Conduit, Models, Simulators, ...**8.0228**

DETROIT TEST CHUTE ...Channel Geometry, Depth, Flow of Gas in Liquid, Flume Studies, Velocity, ...**8.0281**

VIBRATION OF LOW-CREST SPILLWAYS ...Hydrodynamic Structures, Non-linear, ...**7.0068**

HYDRAULIC AND STRUCTURAL DESIGN - SPILLWAYS AND OUTLET WORKS ...Concrete-other, Hydraulic Structures, Models, Ultimate, ...**8.0139**

Water Control Works-general

ANALYSIS OF SMALL WATER MANAGEMENT STRUCTURES ...Administrative Structures, Hydraulic Structures, Management, Water Distribution Systems, Water Transfer, ...**4.0260**

HYDRAULIC DESIGN OF STRUCTURES FOR WATER USE AND CONTROL IN THE CORN BELT ...Construction, Corn Belt, Design Criteria, Model Studies, Routing, ...**8.0216**

Water Control Works-other

ECONOMICS OF FLOOD CONTROL STRUCTURES IN THE LOWER MINNESOTA RIVER WATERSHED DISTRICT ...Economics-general, Floodproofing, Floods, Minnesota, Water Loss Control, ...**6.0305**

DEVELOPMENT OF HYDRAULIC DESIGN CRITERIA ...Conduit, Design Criteria, Models, Simulators, Spillways, ...**8.0226**

RIPRAP-PROTECTION FOR HYDRAULIC STRUCTURES ...Design Criteria, Dike, Engineering Structures-general, Sea Wall, ...**8.0245**

Weir

GENERAL SPILLWAY TESTS ...Control Gate, Design Criteria, Energy Dissipators, Ext Pressure on Struct-other, Spillways, ...**8.0242**

Hydraulics-general

TRANSPORT PROCESSES OF PARTICLES IN DILUTE SUSPENSIONS IN TURBULENT WATER FLOW ...Colloidal Phenomena, Flow Characteristics -water, Sedimentation, Transport, Turbulent Flow, ...**5.0370**

TIDAL EFFECTS ON GROUND WATER HYDRAULICS IN HAWAII ...Analog Computers, Groundwater, Hawaii, Model Studies, Tides, ...**2.0378**

ROTATIONAL STABILITY OF DILUTE POLYMER SOLUTIONS ...Fluid Flow-other, Mass Transfer, Organic, Polymer Type-other, Solution, Transport, ...**1.0027**

HYDRAULIC GEOMETRY OF STREAMS ...Flow Characteristics - water, Ions and Gases, Low Flow, Physiography-general, River Basins, ...**2.0444**

EXPERIMENTAL INVESTIGATION OF HYDRAULIC TRANSIENTS IN RIVER-RESERVOIR SYSTEMS ...Model Studies, Open Channel, Reservoirs, Streams, Transition Sections, ...**2.0993**

DEVELOPMENT OF A MATHEMATICAL MODEL FOR THE SIMULATION OF FLAT-LAND WATERSHED HYDRAULICS ...Development of Models, Mathematical Analysis, Model Studies, Technique Development, Wetlands, ...**4.0102**

A WATER QUALITY COMPUTER MODEL OF COOK INLET (PHASE ONE - THE HYDRAULIC MODEL) ...Alaska, Computers-general, Estuaries, Model Studies, Water Quality-general, ...**7.0002**

DYNAMIC MODEL STUDY OF LAKE ERIE ...Inflow, Lake Erie, Model Studies, Synthetic Hydrology-general, ...**5.0766**

STATUS OF THERMAL POLLUTION AND RESEARCH NEEDS ...Bibliography, Pollution - Effects of , Thermal Pollution, Water Quality Control-general, ...**5.1139**

CENTER FOR RESEARCH AND TRAINING IN HYDRAULIC AND HYDROLOGIC ASPECTS OF WATER POLLUTION CONTROL ...Document & Literature Info, Training Grants, Fellowships, Water Quality Control-general, ...**5.1137**

DISPATCHING SYSTEM FOR CONTROL OF COMBINED SEWER LOSSES ...Combined Sewer, Control Gate, Energy Losses-general, Hydrology-general, Meteorological Studies-general, ...**5.0609**

OPEN-CHANNEL TRANSITIONS IN SUPERCRITICAL FLOW ...Channel Geometry, Critical, Cross-section, Open Channel, Open Channel Flow, ...**8.0283**

TIDAL FLOWS IN RIVERS AND HARBORS ...Committee-support, Harbors, Streams, Tides, ...**2.0688**

REGIONAL HYDROLOGIC SYSTEM ANALYSES (HYDRODYNAMICS) ...Groundwater Movement, Permeability, Systems Analysis, ...**2.1092**

TRANSPORT PROPERTIES OF NATURAL CLAYS ...Clay, Clays, Percolation, Permeability, Sampling, ...**2.1102**

GRAIN SIZE DISTRIBUTION AND BEDLOAD TRANSPORT ...Bed Load, Channels, Discharge-general, Flume Studies, Grain Size, ...**2.1101**

FLOW SURFACE PROTECTION ...Aeration, Cavitation-other, Engineering Structures-general, ...**8.0038**

PIPELINE AND TUNNEL HYDRAULICS ...Conduit, Friction, Pipelines, Pipes, Texas, ...**8.0042**

INSTRUMENTATION, DATA ACQUISITION, AND COMPUTER TECHNIQUES ...Analog Computers, Automatic Data Aquisition, Data Analysis Applications, Digital Computers, ...**7.0019**

DESIGN CRITERIA FOR OPEN CHANNELS ...Design Criteria, Irrigation Engineering, Open Channel, Open Channel Flow, Surface Irrigation -general, ...**8.0136**

STUDIES OF CANAL HYDRAULICS ...Canals, Channel Roughness, Energy Losses-other, Open Channel, Transition Sections, ...**8.0130**

STREAM FLOW REGIMES ON A SEMIARID RANGELAND WATERSHED ...Agricultural Watersheds, Channels, Hydrographs, Runoff, Storms-general, ...**4.0178**

Hydrocarbons

BIOCHEMICAL OXIDATION OF HYDROCARBONS IN NATURAL WATERS ...Bacteria (non-specific), Chemostat, Degradation, Organic Matter, Seasonal, ...**1.0110**

Hydrology-general

INVESTIGATION OF WATER RESOURCES IN ALASKA ...Gaging, Measurement, Open Channel, Streams, ...**2.0269**

HYDROLOGY RESEARCH PROJECT ...Data Acquisition-general, Data Analysis - General, Drainage, Small Watersheds, Structural, ...**2.0281**

STATISTICAL, METEOROLOGICAL AND DEPTH-AREA ANALYSIS OF RAINFALL ...Data Analysis Applications, Forecasting, Middle-east-general, Patterns, ...**2.0492**

HYDROLOGY PROGRAM ADMINISTRATION AND SUPPORT ...Aerial, Aircraft, E M Radiation-general, Satellites, Water Resources - General, ...**6.0141**

DOUBTFUL HYDROGRAPHIC DATA ...Aircraft, Data Analysis - General, Satellites, Technique Development, ...**6.0278**

COORDINATION AND LIAISON AT MANNED SPACECRAFT CENTER, HOUSTON ...Aeromagnetic, Aircraft, Geography-physical, Infrared Radiation, Ultra - Violet Radiation, ...**6.0146**

NUCLEAR TECHNIQUES IN SOILS HYDROLOGY, SNOW GAGING, AND RELATED APPLICATIONS ...Gaging, General, Radioisotopes, Soil Environment, Soil-water-plant Relationships, ...**1.0007**

EXTREME HYDROLOGIC EVENTS & THEIR EFFECTS ON NUCLEAR FACILITIES ...Floods, Natural Recharge, Radioactivity-general, Runoff, Water Table Fluctuation, ...**2.0273**

STOCHASTIC STRUCTURE OF HYDROLOGIC SERIES ...Patterns, Runoff, Stochastic Processes, ...**6.0109**

SUPPORT OF THE COMMITTEE ON WATER ...Committee-support, Management, Teaching and Research, ...**9.0003**

PARTIAL SUPPORT OF THE U. S. NATIONAL COMMITTEE FOR THE INTERNATIONAL HYDROLOGICAL DECADE ...Committee-support, ...**9.0005**

NORTH SIERRA OROGRAPHIC, CONVECTIVE CLOUD STUDY - ATMOSPHERIC WATER RESOURCES PROGRAM ...Cloud Physics, Data Display Systems, Modification, Orographic Effects, Precipitation Instruments, ...**2.0731**

STRATTON SAGEBRUSH HYDROLOGY STUDY ...Cover Crops, Range, Runoff, Sediment Yield, Soil Environment, ...**2.0221**

HYDROLOGIC INVESTIGATION OF WATERSHEDS IN OHIO ...Discharge-general, Ohio, Simulation, Small Watersheds, ...**2.0861**

INFLUENCE OF GEOHYDROLOGY ON LANDSCAPE AND SOIL FORMATION ...Morphology-general, Physiography-general, Soil Genesis, Weathering-general, ...**5.0409**

GENERALIZED ANALYSIS OF SMALL WATERSHED RESPONSES ...Discharge-general, Forecasting-prediction, Inflow, Small Watersheds, ...**2.0084**

HYDROLOGICAL DATA ACQUISITION THROUGH REMOTE RECONNAISSANCE SYSTEMS ...Aerial, Data Acquisition-other, Infrared Radiation, Mapping, Moisture Content, Reflectance, ...**7.0075**

GEOPHYSICAL INVESTIGATIONS IN ALLUVIAL BASINS IN SOUTHERN ARIZONA ...Arizona, Electric Logging, Gravity Surveys, Seismic Refraction, ...**2.0062**

HYDROLOGIC ASPECTS OF WATER LAWS IN MINNESOTA ...Administrative Structures, Water Cycle, Water Rights-general, Water Transfer, ...**6.0306**

A METHOD OF DETERMINING AND MAPPING THE HYDROLOGIC RESPONSE OF UNGAGED WATERSHEDS IN THE SOUTHEAST ...Atlases-maps, Land Use, Morphology-general, Small Watersheds, Southeast, ...**7.0025**

APPLICATION OF AN ELECTRONIC ANALOG COMPUTER TO THE SIMULATION OF THE TOTAL HYDROLOGIC-ECONOMIC FLOW SYSTEM ...Analog Computers, Economics-general, Model Studies, River Basins, ...**6.0585**

EVALUATION OF HYDROLOGIC EFFECTS OF URBANIZATION ...Land Use, Regression Analysis, Runoff, Small Watersheds, Storm Water, Urban Environments, ...**4.0231**

SYSTEMS APPROACH TO FLOW PREDICTION IN WATER RESOURCE PLANNING ...Fourier Transform, Monte Carlo Methods, Non-autonomous, Prediction Models, Regression Analysis, Spectral Analysis, ...**2.0915**

COMPUTER SIMULATION OF THE HYDROLOGIC SYSTEM OF A MOUNTAIN WATERSHED ...Digital Computers, Groundwater, Model Studies, Mountains-alpine, Surface Water, Watersheds-other, ...**2.0707**

FEASIBILITY STUDY OF ELECTRICAL GEOPHYSICAL METHODS IN THE DETERMINATION OF SUBSURFACE HYDROGEOLOGIC ENVIRONMENTS IN SOUTH CAROLINA ...Electric Logging, Electronics - Applied, Induction, Piedmont Province, Porosity-permeability, Water Table Fluctuation, ...**2.0950**

THE INFLUENCE OF WETLANDS ON QUANTITY AND QUALITY OF STREAM FLOW ...Available Water, Evapotranspiration, Low Flow, Streams, Wetlands, ...**4.0170**

EFFICIENCY OF DATA COLLECTION SYSTEMS IN HYDROLOGY AND WATER RESOURCES FOR PREDICTION AND CONTROL ...Control and Protection, Economic Efficiency, Hybrid Computers, Systems Analysis, ...**7.0004**

WATER RESOURCES IN SOURDOUGH AND MIDDLE CREEK WATERSHEDS - A COMPARATIVE STUDY OF QUALITY AND HYDROLOGY ...Conservation-general, Land Use, Montana, Water Quality Control-general, Watersheds-general, ...**5.0695**

EVALUATION OF SELECTED COMPUTER PROGRAMS IN HYDROLOGY ...Model Studies, Routing, Runoff, Spillways, Storm Water, ...**2.0659**

GEOCHEMISTRY AND HYDROLOGY OF A SMALL BASIN IN THE UPPER BUFFALO RIVER WATERSHED, TENNESSEE ...Small Watersheds, Tennessee, Water Cycle, Water Properties-general, Weathering Products, ...**2.0999**

HYDROLOGIC AND PHOTOGEOLOGIC DETERMINATION OF RAINFALL, RUNOFF, AND GROUNDWATER RELATIONSHIPS IN A DOLOMITE AREA ...Amount, Dolomite, Groundwater, Photogrammetry, Runoff, ...**2.0702**

SEQUENTIAL USE WITHIN A HYDROLOGIC COMPLEX ...Management, Model Studies, Other Data Analysis, Systems Analysis, Water Quality-general, ...**5.1189**

DISPATCHING SYSTEM FOR CONTROL OF COMBINED SEWER LOSSES ...Combined Sewer, Control Gate, Energy Losses-general, Hydraulics-general, Meteorological Studies-general, ...**5.0609**

EFFECTS OF FIRE ON HYDROLOGY AND EROSION ...Erosion-general, Fire Damage, Recovery, Forest Watersheds, Middle Rocky Mts, ...**2.0226**

TEMPORARY LININGS FOR WATERWAYS AND EMBANKMENTS ...Cover Crops, Design Criteria, Embankments, Erosion Control, Florida, Lining, ...**3.0178**

THE INTERRELATIONSHIP BETWEEN WATERSHED FACTORS THAT AFFECT RUNOFF RATES AND VOLUME YIELDS IN THE SOUTHERN COASTAL PLAINS ...Agricultural Watersheds, Georgia, Morphology-general, Runoff, Water Yield, ...**3.0193**

HYDROLOGY OF SMALL AGRICULTURAL WATERSHEDS ...Missouri, Reservoirs and Impoundments, Runoff, Small Watersheds, Water Loss-general, ...**4.0151**

HYDROLOGIC CHARACTERIZATION OF SMALL WATERSHEDS ...Mathematical Analysis, Model Studies, Runoff, Small Watersheds, Stochastic Models, ...**4.0197**

HYDROLOGY OF WATERSHEDS ON SHALE SOILS ...Fine-grained Clastics, Moisture Content, Moisture Tension, Runoff, Small Watersheds, Soil Properties - Other, ...**4.0273**

HYDROLOGIC ANALYSIS BY ANALOG COMPUTERS ...Analog Computers, Groundwater, Hydrographs, Reservoirs and Impoundments, Routing, Surface Water, ...**2.0429**

HYDROLOGY AND WATER QUALITY OF SURFACE MINING FOR COAL IN PIKE COUNTY, INDIANA ...Coal-general, Indiana, Strip Mines, Water Quality-general, ...**5.0384**

ANALYSIS AND SYNTHESIS OF HYDROLOGIC SYSTEMS ...Computers-general, Flow Characteristics -water, Open Channel Flow, Patterns, Technique Development, ...**2.0615**

HYDROLOGIC MEASUREMENT SYSTEMS ...Amount, Data Networks, Error Analysis, Gages, Instrumentation-general, Rain-general, Technique Development, Urban Environments, ...**7.0056**

THE NANGARHAR CANAL PROJECT OF EASTERN AFGHANISTAN ...Afghanistan, Canals, Electric Power Plants, Irrigation-general, Water Resources Development, ...**4.0179**

DEVELOPMENT OF GROUND WATER CONTROL METHODS FOR THE HEAVY SOILS OF THE LAJAS VALLEY ...Aquifers-general, Groundwater, Piezometry, Puerto Rico, Soil Environment, ...**4.0209**

EXPERIMENTAL INVESTIGATION OF HYDROLOGICAL PARAMETERS OF AQUIFERS THROUGH ELECTRICAL RESISTIVITY MEASUREMENTS ...Aquifers-general, Borehole Geophysics, Electric Logging, Other Models, Porosity-permeability, ...**7.0028**

GEOLOGY AND HYDROLOGY OF THE PRESIDIO BOLSON, TEXAS AND ADJACENT MEXICO ...Bolsons, Groundwater, Local Stratigraphy, Sedimentary Basins, Water Yield, ...**2.1011**

HYDROGEOLOGY OF SOLID WASTE DISPOSAL SITES ...Chemical A nalysis (water), Groundwater Movement, Illinois, Sanitary Landfills, ...**5.0347**

GEOLOGY OF VALLEY FILL DEPOSITS IN THE MIDDLE ILLINOIS RIVER VALLEY ...Clastic Aquifers, Deposits, Sedimentary History, Valley, Buried, ...**7.0036**

PERMEABILITY OF UNCONSOLIDATED AQUIFER MATERIALS ...Aquifers-general, Data Analysis Applications, Permeability, Unconsolidated Aquifers, Valleys and Canyons, ...**7.0038**

MATHEMATICAL SIMULATION OF HYDROLOGIC EVENTS ON UNGAGED WATERSHEDS ...Hydrographs, Mathematical Analysis, Model Studies, Research - Development, Runoff, Watersheds-general, ...**2.0462**

AQUIFER STUDIES IN MARYLAND - SEDIMENTARY ROCKS IN THE COASTAL PLAIN ...Aquifers-general, Geologic Sections, Management, Specific Rock Unit, Subsurface, Water Allocation, ...**2.0561**

GEOLOGY AND GROUND WATER RESOURCES OF WARD COUNTY ...Aquifers-general, Geology-general, Groundwater, North Dakota, Water Quality-general, ...**2.0841**

SIMULATION MODEL FOR THE STUDY OF THE HYDROLOGY OF THE WISCONSIN RIVER ...Flow Characteristics -water, Reservoirs and Impoundments, River Basins, Simulation, Wisconsin, ...**2.1155**

NORTH FORK CITICO CREEK WATERSHED RESEARCH ...Construction, Forest Watersheds, Land Use, Multiple-purpose Projects, ...**4.0220**

DEVELOPMENT OF HYDROLOGIC ANALYSIS TECHNIQUES ...Computers-general, Data Analysis - General, Land Use, Model Studies, Technique Development, ...**2.0988**

AUTOMATIC VHF RADIO HYDROLOGIC DATA REPORTING SYSTEM ...Automatic Data Aquisition, Data Transmission Systems, General Synoptic Observations, Radio, Very High Frequency, ...**7.0096**

DEVELOPMENT OF HYDROLOGIC EQUIPMENT ...Design Instrumentation-other, Hydraulic Engineering-other, Instrumental Services, Instrumentation-general, Other Telemetry, ...**7.0064**

HYDROLOGY TRAINING AND METHODOLOGY ...Computers-general, Education and Training, Hydraulic Engineering-other, Meetings, ...**9.0001**

HYDROLOGIC SIMULATION - DAILY STREAMFLOW ...Antecedent Moisture, Design Flow-flood, Floods, Forecasting-prediction, Reservoirs and Impoundments, ...**6.0073**

OPTIMIZATION TECHNIQUES FOR HYDROLOGIC ENGINEERING ...Floods, Hydrographs, Optimization, Reservoirs, Reservoirs and Impoundments, Routing, ...**6.0075**

GENERALIZED HYDROLOGIC DESIGN CRITERIA ...Amount, Reservoirs and Impoundments, Technique Development, Water Resources Development, ...**6.0079**

HYDROLOGIC RELATIONS IN HAWAII ...Amount, Data Networks, Floodproofing, Hawaii, Runoff, ...**2.0365**

HYDROLOGIC STUDIES (STORM STUDIES) ...Flood Control, Floodproofing, Patterns, Storms-general, Tables, Compilations, Catalogs, ...**2.0549**

CONTROL AND PREVENTION OF CULVERT AND ROAD ICINGS ...Culvert, Drainage, Meteorological Studies-general, Roadway-general, Snow and Ice Removal, ...**2.0750**

FROZEN GROUND INVESTIGATIONS, BARROW, ALASKA ...Alaska, Frost and Permafrost, Ice Content, Permafrost-frozen, Runoff, Small Watersheds, ...**2.0748**

HYDROLOGIC STUDY OF A SMALL ALASKAN WATERSHED ...Alaska, General, General Synoptic Observations, Small Watersheds, Water Sampling, ...**2.0749**

HYDROLOGIC STUDIES (STORM STUDIES) HAWAIIAN ISLANDS ...Hawaii, Storm Water, Storms-general, Weather Charts-maps, ...**2.0366**

SAFFORD VALLEY, ARIZONA GEOPHYSICAL STUDIES ...Arizona, Geophysical Analysis, Groundwater, ...**2.0276**

POTENTIAL APPLICATIONS OF NUCLEAR EXPLOSIVES IN WATER RESOURCE DEVELOPMENT ...Economics-general, Nuclear Excavation, Nuclear Explosion, Water Law-general, Water Resources Development, ...**3.0067**

HYDROLOGIC STUDIES LEADING TO SITE UTILIZATION ...Adsorption Capacity, Groundwater, Nuclear Explosion, Pollutants - Path of , Radioactivity-underground Test, Sediment Transport-other, ...**3.0134**

RESEARCH IN LIMNOLOGY - INTERRELATIONS OF HYDROLOGY AND AQUATIC ECOLOGY ...Biological-general, Chemical-general, Destratification, Organic Matter, Physical-general, ...**2.0128**

HYDROLOGIC EFFECT OF VEGETATION MODIFICATION ...Model Studies, Modified Water Use, Water Development, Water Movement, Velocity, Water Yield, ...**3.0009**

HYDROLOGY OF THE COLUMBIA RIVER BASALT ...Columbia Plateaus, Igneous Rocks, Infiltration, Runoff, Specific Rock Unit, Tectonics-general, ...**2.0905**

SYSTEMS STUDY - MARYLAND PROJECT ...Alternative Planning, Management, Maryland, Planning, Water Resources Development, ...**6.0603**

ANALYTICAL MODEL OF THE LAND PHASE OF THE HYDROLOGIC CYCLE ...Model Studies, Water Cycle, ...**2.0117**

AERIAL MEASUREMENT OF HYDROLOGIC PHENOMENA ...Aerial, Data Acquisition-general, Geophysical Analysis, Humidity Instruments, Infrared Radiation, ...**7.0003**

HYDROLOGY OF HUNGRY HORSE RESERVOIR, MONTANA ...Flow Characteristics -water, Forecasting-prediction, Multiple-purpose Projects, Reservoirs and Impoundments, Total Volume, ...**2.0705**

HYDROLOGIC INFLUENCES OF STRIP MINING, BEAVER CREEK, KENTUCKY ...Appalachia, Coal-general, Mining Activities, Pollution - Effects of , Strip Mines, ...**5.0890**

HYDROLOGY OF THE CRYSTALLINE ROCK SYSTEM IN SOUTHEASTERN STATES ...Crystalline, Groundwater, Groundwater Movement, Water Quality-general, Water Wells, Water Yield, ...**2.0825**

HYDROLOGY OF ARKANSAS RIVER VALLEY, CANON CITY TO STATE LINE ...Arkansas River, Flow Characteristics -water, Groundwater, Irrigation-general, Management, Water Transfer, ...**2.0202**

HYDROLOGY OF THE SAVANNAH RIVER PLANT, SOUTH CAROLINA --BEDROCK WASTE STORAGE EXPLORATION - HYDROLOGY OF COASTAL PLAIN SEDIMENTS (ABBREV) ...Clastic Aquifers, Coastal Plain, Crystalline Aquifers, Seepage, Underground Waste Disposal, ...**5.1108**

WATER RESOURCES OF THE LOWER WISCONSIN RIVER VALLEY, WISCONSIN ...Available Water, Projections and Estimations, Water Quality-general, Water Supply-general, Wisconsin, ...**2.1149**

HYDROLOGIC EFFECTS OF SMALL RESERVOIR ON NEDERLO CREEK, WISCONSIN ...Discharge-general, Reservoirs and Impoundments, Runoff, Water Cycle, Wisconsin, ...**2.1148**

WATER RESOURCES STUDY, DUVAL COUNTY, FLORIDA ...Carbonate Aquifers, Florida, Surface Water, Total Volume, Water Quality-general, ...**2.0330**

HYDROLOGY OF UPPER OLD TAMPA BAY, FLORIDA ...Bays, Groundwater Movement, Lakes, Permeability, Water Harvesting, Water Quality-general, ...**2.0331**

INTENSIVE COOPERATIVE INVESTIGATIONS OF SELECTED POTHOLES ON MISSOURI COTEAU IN DICKEY, WARD AND STUTSMAN COUNTIES, NORTH DAKOTA ...Natural Recharge, Potholes, Water Fowl, N.s. , Water Level Fluctuation, Water Loss-general, ...**6.0419**

ANALYTICAL HYDROGRAPHY IN WATERSHED ENGINEERING ...Agricultural Watersheds, Conservation & Management Eng, Conservation-general, Water Yield, ...**4.0131**

PRECIPITATION CHARACTERISTICS INFLUENCING HYDROLOGIC PERFORMANCE OF AGRICULTURAL WATERSHEDS IN THE PACIFIC NORTHWEST ...Agricultural Watersheds, Patterns, Runoff, Sediment Yield, Snow-other, ...**2.0386**

CLIMATE, SOIL AND VEGETATION INFLUENCES ON HYDROLOGY OF RANGELANDS IN THE SOUTHWEST ...Floods, Runoff, Sediment Yield, Water Yield, ...**4.0007**

THE SIMULATION OF HYDROLOGIC EVENTS IN ARID REGIONS ...Analog Computers, Arid and Desert, Management, Model Studies, Surface Water, ...**2.1075**

LABORATORY CATCHMENT INVESTIGATIONS RELATING TO HYDROLOGIC SYSTEMS ANALYSIS ...Gaging, Model Studies, Morphology-general, Systems Analysis, ...**6.0574**

Hydroxyl

MULTILAYER FILTRATION ...Filter-other, Flocculation, Other, Sand, Waste Water Treatment-general, ...**5.1187**

Hysteresis

A SYSTEMATIC TREATMENT OF THE PROBLEM OF INFILTRATION ...Infiltration, Model Studies, Moisture Content, Patterns, Soil Profile, ...**2.0219**

PREDICTION OF WATER MOVEMENT IN UNSATURATED SOILS ...Internal Water Movement, Permeability, Saturated-unsaturated, Soil Environment, ...**2.0094**

PREDICTION OF WATER MOVEMENT IN UNSATURATED SOILS ...Electrical Properties, Internal Water Movement, Moisture Content, Nuclear Moisture Meters, Saturated-unsaturated, Temperature, ...**2.1119**

Ice Studies

Alteration

APPLIED PHYSICS AND MECHANICS ...Mechanical, Movement, Sea Ice, ...**8.0265**

GREAT LAKES RESEARCH - ICE COVER DISTRIBUTION ...Aerial, Aerospatial, Great Lakes-general, Petrofabrics, Sea Ice, ...**2.0645**

GREAT LAKES RESEARCH - GREAT LAKES DEICING ...Bibliography, Great Lakes-general, Ice Properties-general, Origin, Sea Ice, ...**2.0646**

Ice Jam

FORM, PROCESSES AND DEPOSITS OF THE KNIK RIVER, ALASKA ...Braided Stream, Deposition-other, Floods, Sediment Transport-other, Sorting, ...**2.0782**

MECHANICS OF ICE ...Mechanical, Snow and Ice Removal, St. lawrence River, Waterways, ...**8.0264**

GREAT LAKES RESEARCH - RIVER ICE JAMS ...Great Lakes-general, Streams, Survey Studies, Water Movement-general, ...**2.0636**

Origin

GREAT LAKES RESEARCH - GREAT LAKES DEICING ...Bibliography, Great Lakes-general, Harbors, Navigation, Sea Ice, ...**2.0643**

GREAT LAKES RESEARCH - ICE CHARACTERISTICS ...Aerial, Lake Superior, Micrometeorology, Petrofabrics, Radiation-terrestrial, Sea Ice, ...**2.0644**

GREAT LAKES RESEARCH - GREAT LAKES DEICING ...Alteration, Bibliography, Great Lakes-general, Ice Properties-general, Sea Ice, ...**2.0646**

Petrofabrics

COLD REGIONS PHYSICAL SCIENCE ...Arctic, Cloud Physics, Electron, Ice Fog, ...**2.0757**

GREAT LAKES RESEARCH - ICE CHARACTERISTICS ...Aerial, Lake Superior, Micrometeorology, Origin, Radiation-terrestrial, Sea Ice, ...**2.0644**

GREAT LAKES RESEARCH - ICE COVER DISTRIBUTION ...Aerial, Aerospatial, Alteration, Great Lakes-general, Sea Ice, ...**2.0645**

Properties

Ice Properties-general

A STUDY OF THE FREEZING CYCLE IN AN ALASKAN STREAM ...Alaska, General, Sampling, Streams, ...**2.0018**

GREAT LAKES RESEARCH - GREAT LAKES DEICING ...Alteration, Bibliography, Great Lakes-general, Origin, Sea Ice, ...**2.0646**

Mechanical

APPLIED PHYSICS AND MECHANICS ...Alteration, Movement, Sea Ice, ...**8.0265**

MECHANICS OF ICE ...Ice Jam, Snow and Ice Removal, St. lawrence River, Waterways, ...**8.0264**

Thermal

APPLIED PHYSICS AND MECHANICS ...Alteration, Mechanical, Movement, Sea Ice, ...**8.0265**

Icebergs

RADAR DATA ACQUISITION OVER OCEANOGRAPHIC TEST SITES ...Data Acquisition Systems, Electronics - Applied, Optical, Radar, Surface Environments, Waves, ...**6.0274**

Iceland

STUDY OF GEOLOGIC STRUCTURAL CONTROL ON THE FLOW AND DISCHARGE OF GEOTHERMAL WATERS ...Atlases-maps, Groundwater, Groundwater Movement, Regional Structure, Thermal Features-other, ...**2.0794**

Idaho

BEHAVIOR AND HABITAT INTERACTION OF BROOK TROUT AND CUTTHROAT TROUT ...Behavioral Ecology, Cutthroat Trout, Habitat Studies, Lake Trout, Brook Trout, Regression Analysis, ...**5.0324**

REYNOLDS CREEK WATERSHED STUDY ...Management and Fertility, Runoff, Sediment Yield, Water Yield, Watersheds-general, ...**2.0571**

CHARACTERISTICS OF MAJOR FOREST AND RANGE WATERSHED TYPES IN IDAHO ...Erosion-general, Forest Watersheds, Land Use, Runoff, Water Yield, ...**6.0176**

LIMNOLOGICAL STUDIES OF LENTIC WATERS IN IDAHO ...Alpine, Lakes, Phytoplankton, Primary Productivity, Productivity - Food Chain, Reservoirs and Impoundments, ...**2.0398**

BIOLOGICAL PRODUCTIVITY OF THE COEUR D'ALENE RIVER AS RELATED TO WATER QUALITY ...Data Analysis - General, Primary Productivity, Productivity - Food Chain, Streams, Water Quality-general, ...**5.0326**

EVALUATION OF CLIMATIC PATTERNS AFFECTING IDAHO AGRICULTURE ...Agricultural Watersheds, Applied Climatology, Data Analysis - General, Evaporation, Forecasting, Meteorological Averages, Patterns, ...**2.0396**

ECONOMICS OF WATER TRANSFER - AN APPRAISAL OF INSTITUTIONS ...Administrative Structures, Economic Efficiency, Water Law-general, Water Rights-general, Water Transfer, ...**6.0178**

DISTRIBUTION AND ECOLOGY OF AQUATIC INSECTS OF IDAHO ...Aquatic Ecology, Bottom Sampling, Chemical-general, Insects -non-specific, Physical-general, ...**2.0393**

NORTHERN IDAHO ALFALFA PROBLEM ...Alfalfa, Internal Water Movement, Other Enviromental Conditions, Soil Conditions, Soil-water-plant Relationships, ...**2.0397**

GEOTHERMAL RESOURCES OF IDAHO ...Chemical-general, Hot Springs, Survey Studies, Temperature, Water - Hot Water, ...**3.0206**

AN INVESTIGATION OF FACTORS INFLUENCING WATER QUALITY IN SOUTH FORK, COEUR DALENE RIVER ...Pollutants-general, Pollution Sources-general, Streams, Water Quality-general, ...**5.0328**

EUTROPHICATION RESEARCH AMERICAN FALLS RESERVOIR STUDY ...Chemical Analysis (water), Eutrophication, Nutrients, Reservoirs and Impoundments, Water Quality Control-general, ...**5.0317**

RUNOFF AND SEDIMENT MOVEMENT ON UNIT SOURCE WATERSHEDS OF THE PACIFIC INFLUENCED BY CLIMATE, SOILS, VEGETATION AND TOPOGRAPHY ...Physiography-general, Runoff, Sediment Yield, Water Yield, Watersheds-general, ...**2.0387**

WATER ACCUMULATION, FLOOD-WAVE MOVEMENT AND WATER YIELD FROM COMPLEX WATERSHEDS OF THE PACIFIC NORTHWEST ...Channels, Floods, Forecasting-prediction, Hydrographs, Peak Flow, Storage of Water, Water Yield, Watersheds-general, ...**3.0202**

SNOW ACCUMULATION AND MELT ON STUDY AREAS ...Energy-general, Mountains-alpine, Patterns, Photogrammetry, Snowmelt, ...**2.0388**

APPLICATIONS OF ANALOG COMPUTER SIMULATION TECHNIQUES FOR RUNOFF PREDICTIONS WITHIN THE REYNOLDS CREEK WATERSHED ...Analog Computers, Forecasting-prediction, Model Studies, Runoff, Simulation Theory, ...**7.0106**

Illinois

DEVELOPMENT OF DRAINAGE ASSESSMENT PROCEDURES BASED ON PHYSICAL FEATURES IN ILLINOIS ...Benefit-cost Analysis, Drainage, Drainage Engineering, Mathematical Analysis, Terrain Analysis, ...**6.0207**

INTERGOVERNMENTAL RELATIONSHIPS IN THE ADMINISTRATION OF WATER RESOURCES ...Administrative Structures, Water Law-general, Water Quality Control-general, Water Resources Development, ...**6.0210**

ECONOMIC ANALYSIS OF WATER USE IN ILLINOIS AGRICULTURE ...Corn, Economics-general, Irrigation-general, ...**6.0213**

WATER QUALITY CRITERIA FOR SELECTED RECREATION USES ...Mathematical Analysis, Pollution-water, Recreation Sites, User Characteristics -other, Water Quality-general, ...**5.0381**

ADVANCED METHODOLOGIES FOR WATER RESOURCES PLANNING ...Mathematical Programming, Optimization Technique, Planning, Stochastic Models, ...**6.0202**

EFFECT OF CHLORINATION ON CILIATE PROTOZOA AND THEIR ROLE AS A BARRIER TO STREAM POLLUTION ...Biological-general, Chlorination, Population Dynamics, Protozoa -other, Streams, ...**5.0379**

RELATION OF FLOODPLAIN POOLS TO THE BIOLOGICAL PRODUCTION OF THE KASKASKIA RIVER AND ITS MAIN-

STEM RESERVOIRS ...Food Supply, Habitat Studies, Productivity e Food Chain, Reservoirs and Impoundments, Streams, ...**2.0411**

LAWRENCE AVENUE UNDERFLOW SYSTEM ...Combined Sewer, Inlet, Outlet, Pump, Storage-retention-facilities, ...**4.0091**

BIOLOGICAL SURVEY OF STREAMS OF COLES COUNTY, ILLINOIS ...Aquatic Ecology, Contamination - Water, Environmental Ecology, Fish -non-specific, Streams, ...**5.0333**

RUNOFF FROM SMALL AGRICULTURAL AREAS IN ILLINOIS ...Agricultural Watersheds, Conservation, Conservation & Management Eng, Runoff, ...**3.0220**

ECONOMICS AND LEGAL FACTORS IN PROVIDING, USING AND MANAGING WATER RESOURCES IN AGRICULTURE ...Conflicts, Interstate, Legal Review, North Central, Water Demand, ...**6.0211**

HYDROLOGIC CHARACTERIZATION OF SMALL WATERSHEDS ...Aerial, Area, Mathematical Analysis, Slopes, Small Watersheds, ...**6.0206**

INVESTIGATIONS OF THE REMOVAL OF IRON FROM GROUNDWATER SUPPLIES IN ILLINOIS ...Demineralization, Filtration, Groundwater, Iron, Precipitation, ...**5.0375**

CHLORINATION OF WASTE WATER EFFLUENTS ...Activated, Bacteria, Chlorination, Effluent-standards, Sewage Bacteria, ...**5.0367**

PREPARATION OF A HIGHWAY DRAINAGE POLICY STATEMENT AND PRACTIVE MANUAL FOR THE STATE OF ILLINOIS ...Design Criteria, Drainage, Drainage Systems, Handbooks, Roads and Highways, Water Law-general, ...**6.0205**

SOUTHERN ILLINOIS REGIONAL ECONOMIC DATA SYSTEM ...Data Networks, Economics-general, Impact, Industrial-general, Regional Areas, ...**7.0030**

A PARASITOLOGICAL STUDY OF FISHES FROM THE PINE HILLS AREA ...Aquatic Ecology, Fish -non-specific, Helminths, Low Temp. -but Above 32f, Springs, ...**6.0180**

COMPARATIVE STUDIES OF COMMUNITIES IN ILLINOIS ...Administrative Structures, Local Government, Social Aspects, Urban Environments, ...**6.0189**

AN ECONOMIC ANALYSIS OF SOUTHERN ILLINOIS ...Base Studies, Economics-general, Finance, Trends,projections, ...**6.0179**

DAILY HEAT BUDGETS IN ENVIRONMENTAL FLUIDS ...Heat Budget, Heat Flow, Ohio, Temperature Or Heat Budgets, ...**2.0405**

ILLINOIS AND ITS INTERSTATE COMPACTS ...Administrative Structures, Control and Protection, Interstate, Legal Review, Urban Environments, ...**6.0185**

ALGAE IN ILLINOIS WATERS ...Algae- General, Plant Taxonomy, Water Sampling, ...**6.0184**

HYDROMETEOROLOGICAL ANALYSIS OF SEVERE RAINSTORMS ...Meteorological Extremes, Patterns, Radar, Storms-general, Weather Charts-maps, ...**2.0414**

AN ECONOMIC AND LEGAL APPRAISAL OF THE USE OF WATER FOR IRRIGATION AND OTHER PURPOSES ON ILLINOIS FARMS ...Agriculture, Irrigation-general, Legal Review, Legislative Processes, Water Law-general, ...**6.0214**

STATE GRAVITY SURVEY ...Gravity, Gravity Surveys, Seismic Reflection, Structural Analysis, Structure Location, ...**7.0035**

TOPOGRAPHIC EFFECTS ON PRECIPITATION ...Applied Climatology, Precipitation Instruments, Topographic Influences, ...**2.0412**

RADIOACTIVITY IN RAINFALL ...General Synoptic Observations, Radioactivity, Rain-general, ...**2.0415**

HYDROGEOLOGY OF SOLID WASTE DISPOSAL SITES ...Chemical Analysis (water), Groundwater Movement, Hydrology-general, Sanitary Landfills, ...**5.0347**

ELECTRICAL EARTH RESISTIVITY SURVEYS ...Clastic Aquifers, Electric Logging, Electrodes, Geophysical Analysis, Groundwater, ...**7.0033**

STATISTICAL ANALYSIS OF WATER CONSUMPTION ...Consumptive Use, Data Analysis Applications, Urban Environments, Water Sources -general, Water Utilization -general, ...**7.0037**

ENVIRONMENTAL GEOLOGY OF MCHENRY COUNTY, ILLINOIS ...Aquifers-general, Land Use, Potential of Deposit, Subsurface, Terrain Analysis, ...**6.0192**

THEORETICAL ANALYSIS OF REGIONAL GROUND-WATER FLOW IN THE HAVANA AREA ...Groundwater Movement, Mathematical Analysis, Model Studies, Subsurface Flow, Water Table Fluctuation, ...**2.0410**

ENVIRONMENTAL GEOLOGY OF THE SPRINGFIELD-DECATUR AREA ...Appraisals-general, Geology-general, Groundwater, Land Use, Urban Environments, ...**6.0193**

FISH POPULATION MANIPULATION AT RIDGE LAKE ...Control of Nuisance Species, Depth,water Level, Fluctuation, Lakes, Population Dynamics, Water Level Fluctuation, ...**6.0194**

CHEMICAL CONTROL OF AQUATIC VEGETATION ...Evaluation, Lakes, of Aquatic Plants, Pre-emergents (plants), ...**5.0349**

DEPTH DISTRIBUTION OF FISH IN LAKE GLENDALE ...Bluegills, Bream, Food Supply, Lakes, Largemouth Bass, Vertical Distribution, ...**6.0197**

ALGAL GROWTH POTENTIAL OF ILLINOIS WATERS ...Algae-General, Bioindicators, Growth (non-specific & Ot.), Growth and Differentiation, Other, ...**6.0199**

FLOOD INUNDATION MAPPING, NORTHEASTERN ILLINOIS ...Atlases-maps, Data Networks, Discharge-general, Floods, Gaging, ...**4.0093**

Illinois River

A STUDY OF A POLLUTED RIVER, THE ILLINOIS ...Aquatic Ecology, Bioindicators, Contamination - Water, Fish -non-specific, Mollusks -non-specific & Other, ...**2.0408**

PIT METHOD OF ARTIFICIAL GROUND-WATER RECHARGE ...Aquifers-general, Artificial Recharge, Induced Infiltration, Permeability, Recharge Pits - Wells, ...**4.0099**

ILLINOIS RIVER STUDY ...Ions and Gases, Low Flow, Self-purification, Streams & Rivers, Waste Water Treatment-general, ...**5.0351**

LIMNOLOGICAL STUDY OF PEORIA LAKE ...Biological-general, Chemical-general, Turbidity, ...**5.0354**

Immunology Methods

APPLICATION OF IMMUNOCHEMICAL TECHNIQUES TO THE DETECTION AND IDENTIFICATION OF CHEMICAL AND BIOLOGICAL POLLUTANTS ...Biological Pollutants -general, Chemical Identification, Mineralization, Technique Development, ...**5.0260**

India

STUDY OF LIQUEFACTION OF SATURATED SANDS ...Earthquakes, Sand, Saturated-unsaturated, Soil Dynamics, Soil Liquefaction, ...**8.0184**

LIQUEFACTION STUDIES OF TENUGHAT DAM SAND ...Earthquakes, Pore Water, Sand, Soil Dynamics, Soil Liquefaction, Soil Settlements, ...**8.0185**

LIQUEFACTION STUDIES OF UKAI DAM SAND ...Dams, Earthquakes, Sand, Soil Dynamics, Soil Liquefaction, ...**8.0186**

Indiana

THE EFFECT OF URBANIZATION ON RUNOFF IN SMALL WATERSHEDS ...Land Use, Model Studies, Runoff, Small Watersheds, Urban Environments, ...**2.0458**

WATER RESOURCES RESEARCH, MANPOWER AND TRAINING NEEDS FOR INDIANA ...Management, Personnel, Requirement and Resources, Training Grants, Fellowships, ...**9.0007**

IMPROVED METHODS FOR ESTIMATING MANPOWER NEEDS FOR WATER RESOURCES DEVELOPMENT ...Management, Personnel, Requirement and Resources, Water Resources Development, ...**6.0218**

ASSEMBLY AND ANALYSIS OF HYDROLOGIC AND GEOMORPHOLOGIC DATA FOR SMALL WATERSHEDS IN INDIANA ...Data Analysis - General, Geomorphology-general, Hydrographs, Small Watersheds, Streams, ...**2.0459**

DEVELOPMENT OF LAND USE EQUATIONS FOR THE SLOPING SOILS OF INDIANA ...Development of Models, Erosion-general, Land Use, Slopes, Tillage, Cropping Systems, ...**2.0464**

ESTIMATING SOIL MOISTURE FROM METEOROLOGICAL MEASUREMENTS ...Cover Crops, Evapotranspiration, General Synoptic Observations, Moisture-other, Soil Types, ...**2.0474**

A STUDY OF THE QUALITY OF INDIANA SURFACE WATERS ...Ions and Gases, Lake Michigan, Ohio River, Surface Water, Water Quality-general, ...**5.0389**

WATER POLLUTION STUDY OF THE WABASH RIVER ...Data Acquisition-general, Low Flow, Model Studies, Oxygen, Water Quality-general, ...**5.0390**

HYDROLOGY AND WATER QUALITY OF SURFACE MINING FOR COAL IN PIKE COUNTY, INDIANA ...Coal-general, Hydrology-general, Strip Mines, Water Quality-general, ...**5.0384**

HYDROLOGY STUDY IN U. S. GYPSUM MINE, SHOALS, INDIANA ...Artesian Flow, Carbonate Aquifers, Hydrated Acid and Norm, Mine Drainage Control, Mine Hydrology, ...**5.0386**

Indiana

MICROBIOLOGICAL ASPECTS OF ACID MINE-DRAINAGE ...Acidity, Autotrophic, Iron Bacteria, Mining Industry, Sulfur Bacteria, ...5.0385

THERMAL AND BIOLOGICAL CHARACTERISTICS OF LAKES ...Algae- General, Evaporation, Lakes, Stratification, Temperature, ...2.0452

EVAPORATION LOSSES FROM LAKES IN INDIANA ...Evaporation, Lakes, Reservoirs and Impoundments, Water Balance-budget, ...2.0454

CHANNEL MEANDER STUDIES ...Channels, Discharge-general, Grain Size, Meanders, Suspension, ...2.0453

LOW FLOW CHARACTERISTICS OF INDIANA STREAMS ...Discharge-general, Flow Characteristics -water, Gaging, Low Flow, ...2.0455

WATER RESOURCES, COLUMBUS, INDIANA AREA ...Alternative Planning, Clastic Aquifers, Groundwater, Model Studies, Water Development, ...2.0456

Induced Infiltration

USING SOIL FILTRATION TO REDUCE POLLUTION POTENTIAL OF LAGOON EFFLUENT ENTERING GROUND WATER SYSTEM ...Animal Wastes - Feed Lots, Filtration, Lagoon, Soil, Soil Conditions, ...5.0402

PIT METHOD OF ARTIFICIAL GROUND-WATER RECHARGE ...Aquifers-general, Artificial Recharge, Illinois River, Permeability, Recharge Pits - Wells, ...4.0099

GEOHYDROLOGIC SYSTEM ANALYSIS WITH AN ELECTRIC ANALOG COMPUTER ...Analog, Analog Computers, Aquifers-general, Digital Computers, Groundwater, Network Synthesis, Systems Analysis, ...2.0417

SPRINGFIELD AREA INFILTRATION STUDY, OHIO ...Artificial Recharge, Clastic Aquifers, Flow Characteristics -water, Ohio, Water Yield, ...4.0196

Industrial Operation

Cost Analysis

STUDIES ON THE FREEZING PROCESS FOR DESALTING SALINE WATERS ...Freezing, Other, Porosity, Thermodynamic Relation, Washing, ...3.0365

OPTIMAL DESALINATION BY GEOMETRIC PROGRAMMING AND MATHEMATICAL DECOMPOSITION ...Decompositions, Desalination, Mathematical Analysis, Optimal Statistics, Other Programming, ...3.0077

MEMBRANES FOR REVERSE OSMOSIS DESALINATION BY DIRECT CASTING ON POROUS SUPPORTS ...Cellulosics, Film, Natural Occurring, Reverse Osmosis, Saline Conversion, ...3.0309

COUNTERWASHERS FOR FREEZE-DISTILLATION DESALINATION ...Fluid Flow-other, Freezing, Packed Bed, Screening, Washing, ...3.0279

DESIGN, CONSTRUCT AND EVALUATE A 1,000 GALLON PER DAY REVERSE OSMOSIS UNIT OF RECTANGULAR CONFIGURATION ...Desalination, Membranes-other, Other, Reverse Osmosis, ...3.0028

DEVELOPMENT OF A 50,000 GALLON PER DAY NELLEN STACK ELECTRODIALYSIS MODULE ...Brackish Water, Desalination, Electrodialysis, Membranes-other, Waste Treatment-economics, ...3.0150

THE DESIGN, CONSTRUCTION AND TESTING OF A 10,000 GPD TRANSPORT DEPLETION DESALINATION PILOT PLANT ...Desalination, Ion Selective, Other, Pilot Plant, ...3.0148

A STUDY OF HYDRODYNAMIC ASPECTS OF REVERSE OSMOSIS %HYPERFILTRATION..Desalination, Fluid Flow-other, Reverse Osmosis, Turbulent, Water Purification Plants, ...5.1144

EVALUATION OF BRINE DESULFATING PROCESS AS APPLIED TO FEEDWATER FOR DESALINATION PLANTS ...Desalination, Economics-general, Pilot Plants, Sulfate, Sulfite, ...3.0409

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REMOVAL OF ORGANIC AND EUTROPHYING POLLUTANTS BY COMBINED CHEMICAL AND BIOLOGICAL TREATMENT ...Biological Treatment-general, Chemical Treatment, Denitrification, Eutrophication, Organics, ...**5.0399**

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INDUSTRIAL REUSE OF PROCESS WATER ...Biological Treatment-general, Pond, Sewage Lagoons, Water Reuse, ...**5.0480**

RECOVERY & REUSE OF LIME AS A COAGULANT IN TERTIARY TREAT & NITROGEN REMOVAL FROM TERTIARY TREATED EFFLUENT ...Coagulation, Concentration, Denitrification, Disposal, Tertiary Treatment, ...**5.0160**

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IMPROVE POLLUTION CONTROL BY REUSE OF PAPER MACHINE PROCESS WATERS ...Effluent-standards, Pulp and Paper Wastes, Recycle, Waste Treatment-economics, Water Reuse, ...**5.0807**

STEAM STRIPPING OF KRAFT PULP MILL EFFLUENT STREAMS ...Effluent-standards, Effluents-waste Water, Organic Matter, Pulp and Paper Wastes, Pulp, Paper , and Logging, Waste Water Treatment-general, ...**5.1263**

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A STUDY OF A PROCESS FOR PHOSPHATE REMOVAL FROM WATER SUPPLIES USING LANTHANUM PRECIPITATION ...Lanthanum, Phosphate, Phosphite, Process Design, Waste Treatment-economics, Waste Water Treatment-other, ...**5.0074**

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ALUMINA COLUMNS FOR THE SELECTIVE REMOVAL OF PHOSPHORUS FROM WASTEWATERS AND THE ULTIMATE DISPOSAL OF PHOSPHORUS AS CALCIUM PHOSPHATE ...Aluminum, Phosphate, Phosphite, Process Design, Regeneration-other, Selective-removal, ...**5.1243**

AN INVESTIGATION OF TECHNIQUES FOR THE REMOVAL OF CHROMIUM AND CYANIDES FROM ELECTROPLATING WASTES ...Chromium, Electroplated, Extraction, Flotation, Industrial Processes-other, Recovery, Scrap and Wastes, ...**5.0725**

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USE OF COAL AS ADSORBENT FOR TREATING WASTE WATER ...Adsorption-absorption-other, Anaerobic, Coal-general, Domestic, Secondary Treatment, ...**5.1017**

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PULP AND PAPER WASTE CONTROL AND TREATMENT ...Conservation-general, Disposal Wastes, in Plant Treatment Wastes, Pulp and Paper Wastes, Water Reuse, ...**5.0980**

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SLIME CONTROL ASSOCIATED WITH PULP MILL EFFLUENTS ...Bacterial Pollutant Sources, Industrial Wastes, Nutrition, Sphaerotilus, ...**5.0977**

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COMPLETE TREATMENT OF TANNERY INDUSTRIAL WASTE FOR CHROME TANNING, ALUM TANNING AND VEGETABLE TANNING ...Aerobic, Anaerobic, Neutralization, Process Design, Waste Water Pre-treatment, ...**5.0436**

AEROBIC BIOLOGICAL TREATMENT, SLUDGE DEWATERING AND DISPOSAL AND EFFLUENT REUSE FOR A SIDE LEATHER TANNERY ...Aerobic, Disposal, Drying-dewatering, Filtration, Lagoon, ...**5.0608**

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TEXTILE WASTE TREATMENT PRACTICE ...Loading, Waste Treatment-economics, Waste Water Treatment-general, Water Costs, ...**5.0005**

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DETERMINATION OF DEGRADED DYES AND AUXILIARY CHEMICALS IN EFFLUENTS FROM TEXTILE DYEING PROCESSES ...Chromatography-other, Dye Wastes, Lagoon, Spectroscopy-other, Waste Water Treatment-general, ...**5.0297**

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ECONOMIC AND LEGAL FACTORS IN PROVIDING, USING AND MANAGING WATER RESOURCES IN AGRICULTURE ...Administrative Structures, Benefit-cost Analysis, Water Allocation, Water Law-general, Water Quality Control-general, Water Resources Development, ...**6.0229**

ECONOMIC AND LEGAL FACTORS IN PROVIDING, USING, AND MANAGING WATER RESOURCES IN AGRICULTURE ...Economic Impact, Economics-general, Kansas, Management, Water Law-general, ...**6.0233**

USE OF GROUND WATER IN EXCESS OF RECHARGE ...Administrative Structures, Economic Efficiency, Water - Alternative Uses, Water Rights-general, Water Transfer, ...**3.0310**

ECONOMIC AND LEGAL FACTORS IN PROVIDING, USING, AND MANAGING WATER RESOURCES IN AGRICULTURE ...Economics-general, Management, Water Costs, Water Law-general, ...**6.0429**

A SURVEY OF THE SEASONALLY-INUNDATED MARGINS OF LAKE VOLTA (GHANA) ...Floods, Ghana, Soil Types, Topographical -other, ...**4.0084**

GROUND WATER RESEARCH ...Artificial Recharge, California, Dispersion -water, Groundwater, Groundwater Movement, ...**2.0135**

CALIFORNIA-ARIZONA ECONOMIC INTERDEPENDENCE AND THE COLORADO RIVER CONFLICT WITH PARTICULAR REFERENCE TO AGRICULTURE ...Agriculture, Colorado River, Economic Impact, Income, Input - Output Analysis, Water Allocation, ...**6.0050**

IMPACTS OF DROUTH ON LOCAL ECONOMIES IN KANSAS ...Drought, Economic Impact, History, Kansas, ...**2.0517**

ECONOMICS OF AGRICULTURAL WATER USE NORTH OF CANADIAN RIVER ...Application, Cost Analysis, Regression Analysis, Texas, Water Costs, ...**6.0559**

DRAINAGE FARM SERVICE ...Drainage Engineering, Land Use, Research Facilities, Utah, ...**4.0254**

ECONOMIC INVENTORY OF AGRICULTURAL WATER USE IN THE UNITED STATES ...Economics-general, Survey Studies, Water Demand, Water Resources Development, Water Utilization -general, ...**6.0600**

VALUE PRODUCTIVITY OF WATER IN AGRICULTURE ...Economic Efficiency, Irrigation-general, Minnesota, Technological Development, Water Demand, ...**6.0308**

ECONOMICS OF ALTERNATIVE ROUTINES FOR DELIVERING IRRIGATION WATER ...Economic Efficiency, Irrigation-general, Legal Review, Model Studies, Water - Alternative Uses, ...**6.0101**

Atomic Plants

SIMULATION MODELING OF THERMAL EFFECTS ON SELECTED RIVER SYSTEMS ...Digital Computers, Forecasting-prediction, Model Studies, Self-purification, Thermal Pollution, ...**4.0270**

PROBABLE EFFECTS ON MARINE ENVIRONMENTS OF DISPERSING BRINE EFFLUENTS FROM LARGE DESALINATION PLANTS IN THE GULF OF CALIFORNIA ...Brines, Desalination, Gulf of California, Marine Environments-general, Pollution - Effects of , ...**3.0020**

A COMPREHENSIVE ANALYSIS OF THE TULAROSA BASIN SALINE WATER RESOURCES - THEIR AVAILABILITY AND POTENTIAL ECONOMIC DEVELOPMENT ...Brines, Desalination, Electric Power Plants, Impact, New Mexico, ...**7.0076**

USE OF REACTOR COOLING WATER FROM NUCLEAR POWER PLANTS FOR IRRIGATION OF AGRICULTURAL CROPS ...High Temp. - 85f Or Above, Irrigation-general, Photosynthesis, Respiration, Transpiration and Evap, ...**3.0400**

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EFFECT OF REACTOR EFFLUENT ON QUALITY OF COLUMBIA RIVER WATER ...Columbia River, Digital Computers, Filtration, Pollution - Effects of , Radioactivity-general, ...**5.1246**

REDUCTION OF RADIOISOTOPES IN HANFORD REACTOR EFFLUENTS ...Effluents-waste Water, Neutron Activation, Nuclear Reactors, Radioactivity-general, ...**5.1253**

RADIONUCLIDES IN THE SAVANNAH RIVER ESTUARY AND ADJACENT COASTAL WATERS ...Estuaries, Pollutants - Path of , Radioactivity, Radioactivity-general, Tracers, ...**5.1098**

DESALINIZATION AND INTERREGIONAL STUDIES ...Benefit-cost Analysis, Desalination, Marketing, Radioactive Isotope, Water Costs, ...**6.0099**

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THE EFFECTS OF ENGINEERING PROJECTS ON THE ECOLOGY OF JONES BAY ...Aquatic Ecology, Bays, Engineering Structures-general, Texas, Water Properties-general, ...**6.0543**

THE EFFECTS OF ENGINEERING PROJECTS ON THE ECOLOGY OF MOSES LAKE ...Aquatic Ecology, Engineering Structures-general, Lakes, Texas, Water Properties-general, ...**6.0544**

NORTH FORK CITICO CREEK WATERSHED RESEARCH ...Forest Watersheds, Hydrology-general, Land Use, Multiple-purpose Projects, ...**4.0220**

FLOOD FLOWS AND SEDIMENT YIELD OF COLMA CREEK BASIN, CALIFORNIA ...California, Floods, Projections and Estimations, Sediment Yield, Urban Environments, Water Yield, ...**4.0038**

Electric Power Plants

THERMAL POLLUTION AND ITS IMPLICATIONS FOR THE COAL INDUSTRY-A SURVEY OF THE STATE OF KNOWLEDGE ...Data Acquisition-general, Pollution - Effects of , Survey Studies, Thermal Pollution, ...**5.0208**

FISHERIES-TURBINE RESEARCH COMPENDIUM COMPILATION ...Fish -non-specific, Migration, Mortality Rates, Turbine-other, ...**8.0310**

COLLECTION OF JUVENILE SALMON IN TURBINE INTAKES ...Columbia River, Control Gate, Mortality Rates, Salmon & Trout - Non-specific, Turbine-other, ...**8.0299**

REDUCTION OF RIVER HEAT POLLUTION BY TURBULENCE STIMULATION ...Destratification, Engineering Structures-general, Roughness, Stream Rehabilitation, Thermal Pollution, Turbulent Flow, ...**5.0214**

THE DISTRIBUTION OF TRACE ELEMENTS IN IMPOUNDMENTS ...Arkansas, Reservoirs and Impoundments, Trace Elements, Water Quality Control-general, Water Sampling, ...**2.0068**

A COMPREHENSIVE ANALYSIS OF THE TULAROSA BASIN SALINE WATER RESOURCES - THEIR AVAILABILITY AND POTENTIAL ECONOMIC DEVELOPMENT ...Atomic Plants, Brines, Desalination, Impact, New Mexico, ...**7.0076**

A THREE-DIMENSIONAL APPROACH TO THE EXCHANGE OF HEAT AND WATER VAPOR BETWEEN A LARGE WATER BODY AND THE ATMOSPHERE ...Boundary Layer Studies, Diffusion, Evaporation, Heat Exchange, ...**2.0793**

THERMAL AND INDUSTRIAL POLLUTION - DELAWARE RIVER ...Automatic Data Aquisition, Delaware River, Industrial Wastes, Physical Parameters, Pulp, Paper , and Logging, Thermal Pollution, ...**5.0989**

EFFECT OF HEATED WATER DISCHARGE FROM IPALCO'S PETERSBURG PLANT ON THE WATERS OF WHITE RIVER, INDIANA ...Biological-general, Chemical-general, Physical-general, Pollution - Effects of , Thermal Pollution, White River, ...**5.0383**

THE NANGARHAR CANAL PROJECT OF EASTERN AFGHANISTAN ...Afghanistan, Canals, Hydrology-general, Irrigation-general, Water Resources Development, ...**4.0179**

A UNIFIED APPROACH TO WATER, FOOD AND POWER IN A COASTAL DESERT COMMUNITY ...Arid and Desert, Desalination, Deserts, Diesel, Distilling Units, Greenhouses, Use of Impaired Water, ...**3.0015**

THE PREDICTION OF WATER QUALITY ASPECTS OF THE WENATCHEE RIVER ...Heat Flow, Recreation Sites, Streams, Thermal Pollution, Washington, ...**5.1234**

ECONOMIC ANALYSIS OF THE SANTEE-COOPER PROJECT - A RETROSPECTIVE STUDY UTILIZING CURRENT EVALUATION STANDARDS ...Benefit-cost Analysis, Economic Impact, Project Post-evaluation, Reservoirs and Impoundments, ...**6.0491**

WATER DISPATCHING OPERATIONS BY ELECTRONIC COMPUTER ...Daily, Design Flow-flood, Dynamic Control System, Inflow, Power Generation, Reservoirs and Impoundments, ...**2.0984**

TURBINE RATING FRAME INTERFERENCE STUDY ...Gaging, Inflow, Tennessee River, Turbine-other, ...**8.0287**

TEMPERATURE DISTRIBUTION IN THE VICINITY OF WASTE HEAT DISCHARGES ...Mathematical Analysis, Mixing, Stratification, Temperature, Thermal Pollution, ...**5.1120**

EFFECTS OF HEATED WATER IN A TIDAL ESTUARY ...Bays, Chesapeake Bay, Pollution Effects, Thermal Pollution, Urban Environments, Water Properties-general, ...**4.0078**

PRECAST CONCRETE FORMS ...Economics-general, Engineering Structures-general, Hydraulic Structures, Pre-cast, ...**8.0141**

DESIGN OF UNDERGROUND POWERPLANTS ...Borehole Geophysics, Digital Computers, Mechanics of Structures-other, Power Plant, Rock Mechanics, ...**8.0031**

UNDERGROUND TRANSMISSION AND EQUIPMENT DIELECTRICS-rSOLID, LIQUID, AND INERT GAS ...Cables and Transmission Lines, Evaluation Other, Field Testing, Insulators, Power Transmission, ...**8.0123**

ELECTRICAL MACHINERY TEMPERATURE CONTROL ...Motors and Appliances, Other Control Systems, Power Regulator, Temperature, ...**8.0125**

STRUCTURAL RESPONSE, DYNAMIC LOADS ...Computers-general, Dynamic-other, Earthquakes, Industrial Structures, Other Computers, Rock Mechanics, ...**8.0032**

ULTIMATE STRENGTH DESIGN ...Codes and Standards, Power Development, Reinforced, Structural, ...**8.0030**

POWER TRANSMISSION STRUCTURES, NEW TYPES ...Electrical Engineering-general, Power Transmission, Public Utilities, Structural, Transmission Lines, ...**8.0120**

CIRCUIT BREAKER RESEARCH ...Circuit Breaker, Electrical Engineering-general, Evaluation Other, Power Transmission, Switching, ...**8.0052**

COORDINATION OF PLANT FREQUENCY, D-C-TRANSMISSION AND SYSTEM CONTROL ...Ac-dc, Evaluation Other, Other Generators, Power Conditioner, Power Transmission, ...**8.0126**

POWER PRODUCTION ...Nuclear Power, Power Development, Reservoir Systems, Spray Devices, Thermal Pollution, ...**5.0983**

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ECONOMIC AND ENGINEERING ASPECTS OF WATER IN DELAWARES AGRI-BUSINESS INDUSTRY ...Agri Business, Disposal Wastes, Irrigation-general, Optimization, Projections and Estimations, Water Resources Development, ...**6.0120**

TREATMENT OF LIQUID WASTE FROM FOOD PROCESSING PLANTS ...Disposal Wastes, Recycle, Salting Out, Waste Water Treatment-general, Water Reuse, ...**5.0497**

MICROBIOLOGY OF SEWAGE LAGOONS - EFFECTS OF INDUSTRIAL WASTES ON COLIFORM AND OTHER ENTERIC ORGANISMS ...Bacteria, Biochemical Oxygen Demand, Industrial Waste-other, Lagoon, Sewage Bacteria, Sewage Lagoons, ...**5.0837**

EFFECTS OF SUGAR REFINING LAGOON EFFLUENTS ON BIOLOGICAL, PHYSICAL, AND CHEMICAL PROPERTIES OF FARGO CLAY ...Clay, Effluents-waste Water, Industrial Processes-other, North Dakota, Soil Contamination -other, Soil Properties - Other, ...**5.0834**

WATER UTILIZATION AND WASTE CONTROL IN THE POULTRY PROCESSING INDUSTRY ...Animal Waste Removal-treatment, Economics-general, Industrial Wastes, Poultry - N S, Waste Water Treatment-general, Water Utilization -general, ...**5.0819**

ECONOMIC AND ENGINEERING ASPECTS OF WATER IN DELAWARE'S AGRI-BUSINESS INDUSTRY ...Industrial Wastes, ...**6.0121**

TREATMENT OF ALKALINE WASTES FROM POTATO PROCESSING ...Activated, Canning Wastes, Concentration, Plant Waste Removal, Treatment, Streams & Rivers, Waste Water Treatment-general, ...**5.0465**

AEROBIC TREATMENT OF PACKINGHOUSE WASTES ...Aerobic, Industrial Processes-other, Pilot Plant, Pilot Plants, Waste Water Treatment-general, ...**5.0418**

USE OF FUNGI IMPERFECTI IN WASTE CONTROL ...Canning Wastes, Effluents-waste Water, Filtration, Fungal Pollutant Sources, Industrial Wastes, Organics, ...**5.0595**

REMOVAL OF ORGANICS AND NUTRIENTS FROM CITRUS PROCESSING PLANT WASTES ...Activated, Aeration, Citrus, Organics, Pond, Waste Water Treatment-general, ...**5.0266**

ANAEROBIC - AEROBIC SUGAR BEET WASTE TREATMENT ...Aerobic, Algae, Anaerobic, Industrial Processes-other, Plant Waste Removal, Treatment, Taste and Odor, ...**5.0193**

OPERATION OF POTATO PROCESSING PLANTS TO REDUCE WASTE AND STREAM POLLUTION ...in Plant Treatment Wastes, Industrial Wastes, Streams, Waste Water Treatment-general, ...**5.0058**

PILOT PLANT DEVELOPMENT OF THE ION-EXCHANGE PROCESS FOR RECOVERY OF AMINO COMPOUNDS FROM POTATO STARCH FACTORY EFFLUENTS ...Agricultural Chemicals-other, Air Pollution -other, Amino Acids -non-specific, Plant Waste Removal, Treatment, Vegetables, ...**5.0990**

WASTE DISPOSAL FROM FOOD PROCESSING PLANTS IN SOUTH CAROLINA ...Disposal Wastes, Percolation, Self-purification, Soil Environment, ...**5.1104**

Industrial-general

COOPERATIVE GULF OF MEXICO INVENTORY AND STUDY (AREA DESCRIPTION) ...Atlases-maps, Estuaries, Gulf of Mexico, Mississippi River, Water Properties-general, ...**7.0061**

FLUSHING PATTERN OF CERTAIN TIDAL STREAMS IN DELAWARE ...Aquatic Ecology, Circulation -water, Delaware, Discharge-general, Tidal Streams, ...**2.0250**

INPUT-OUTPUT ANALYSIS OF WATER USE FOR NEBRASKA INDUSTRIES - WATER RESOURCE PLANNING - WATER DEMAND ...Multiple-purpose Projects, Nebraska, Water Demand, ...**6.0336**

A CONTINUATION OF THE STUDY TO DETERMINE THE COSTS OF WATER IN INDUSTRIAL USES ...Benefit-cost Analysis, Computers-general, Model Studies, Water Costs, Water Demand, ...**6.0468**

MULTISTRUCTURAL DEMAND MODELS FOR WATER REQUIREMENT FORECASTING ...Model Studies, Projections and Estimations, Social Aspects, Water Demand, ...**6.0442**

AN ENGINEERING-ECONOMIC STUDY OF THE INDUSTRIAL GROWTH POTENTIAL OF THE UPPER PASSAIC RIVER BASIN ...Economic Impact, River Basins, Social Aspects, Water Law-general, Water Standards, ...**6.0347**

A DEMONSTRATION OF JOINT-MUNICIPAL-INDUSTRIAL WASTE TREATMENT IN THE ONONDAGA LAKE WATERSHED ...Chemical Treatment, Combined Sewer, Local Government, Waste Water Treatment-general, Watersheds-general, ...**5.0792**

SOUTHERN ILLINOIS REGIONAL ECONOMIC DATA SYSTEM ...Data Networks, Economics-general, Illinois, Impact, Regional Areas, ...**7.0030**

THE RELOCATION OF INDUSTRY AND THE LOCATION OF NEW INDUSTRY AS AFFECTED BY THE AVAILABILITY OF WATER SITES ...Available Water, Mississippi River, ...**4.0090**

INVESTIGATION OF LINKAGES OF WATERFRONT MANUFACTURING ...Economic Impact, Input - Output Analysis, Manufacturing, Tennessee River, ...**6.0533**

WATER RESOURCES OF THE BOWLING GREEN AREA, KENTUCKY ...Aquifers-general, Groundwater Movement, Kentucky, Streams, Water Quality-general, ...**2.0528**

SALT-WATER ENCROACHMENT IN NORTH CAROLINA ESTUARIES ...Chemical-general, Estuaries, Flow Characteristics - water, Saline Water Intrusion, Water Sampling, ...**2.0826**

Mineral Processing Industry

ECONOMIC EFFECTS OF WATER ALLOCATION AMONG ALTERNATIVE INDUSTRIAL (NON-AGRICULTURAL) USES ...Economic Impact, Industry, Model Studies, Water - Alternative Uses, Water Allocation, ...**6.0597**

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SENSITIVITY OF SELECTED INSECT SPECIES TO DEPRESSED LEVELS OF PH ...Acidity, Bioindicators, Caddis-flies, Mayflies, Ph, Acidity -water, Stone Flies, Plecoptera, ...**5.1034**

THE BEHAVIOR OF SMALLMOUTH BASS AS RELATED TO ARTIFICIAL COVER ...Acidity, Behavioral Ecology, Smallmouth Bass, Soil (wildlife) Cover, Water Movement, Currents,, ...**5.1024**

ACID MINE DRAINAGE MICROBIOLOGICAL STUDIES ...Acidity, Bacterial Pollutant Sources, Identification, Mining Activities, Sewage, ...**5.1284**

STRIP-MINING AND WATER QUALITY ...Ions and Gases, Ohio, Storm Water, Strip Mines, Water Quality-general, ...**5.0888**

COMPUTER SIMULATION OF AQUIFERS OF COASTAL PLAIN OF NORTH CAROLINA ...Carbonate Aquifers, Computers-general, North Carolina, Saline Water Intrusion, Water Table Fluctuation, ...**2.0821**

RECOVERY FROM ACID POLLUTION IN FOUR STRIP-MINE LAKES ...Acidity, Iron, Lakes, Self-purification, Stratification, ...**5.0669**

BIOLOGICAL EFFECTS OF HEAVY METAL POLLUTION ...Biological, Heavy Elements, Metals, Microbial-bacterial, Pollution - Effects of , ...**5.0034**

APPLICATION OF BACTERIOPHAGES TO ELIMINATE MINE ACIDS ...Acidity, Bacterial Pollutant Sources, Bacteriophages (non-spec & Ot), Isolation, ...**5.0995**

A PILOT-SCALE STUDY OF ACID MINE DRAINAGE ...Acidity, Data Acquisition-general, Pollution Abatement, Systems Analysis, ...**5.0881**

CATAWISSA CREEK MINE DRAINAGE POLLUTION ABATEMENT PROJECT ...Acidity, Mine Hydrology, Pennsylvania, Pollution Abatement, ...**5.0998**

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COMPARISON OF ENERGY FLOW PARAMETERS OF MIDGE POPULATIONS IN BIOLOGICAL OXIDATION PONDS ...Energy Budgets, Oklahoma, Pollution Effects, Productivity - Food Chain, Sewage Lagoons, ...**5.0929**

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THE SPECIES DIVERSITY OF AQUATIC INSECTS AS RELATED TO MINE ACID POLLUTION ...Acidity, Contamination - Water, Mining Activities, Ph, Acidity -water, ...**5.1033**

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DISTRIBUTION AND ECOLOGY OF AQUATIC INSECTS OF IDAHO ...Aquatic Ecology, Bottom Sampling, Chemical-general, Idaho, Physical-general, ...**2.0393**

INSECTS ASSOCIATED WITH AQUATIC WEED PESTS OF FOREIGN ORIGIN IN LOUISIANA ...Animal Taxonomy, Louisiana, Survey Methods, Weeds, ...**5.0490**

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AQUATIC ENVIRONMENT AND FOOD HABITS OF MAYFLIES ...Aquatic Ecology, Chemical-general, Environmental Ecology, Nutrition and Metabolism, Physical-general, ...**5.0323**

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BENTHOS IN LEWIS AND CLARK LAKE ...Aquatic Ecology, Bloodworms, Aquatic Midges, Number Or Density, Reservoirs and Impoundments, South Dakota, ...**6.0514**

CHARACTERIZATION AND COMPARISON OF ESTERASE(S) PRESENT IN THE HEADS OF THE IMMATURE FORM OF TWO SPECIES OF DAMSELFY ...Comparative Enzymology, Esterase, Inhibitors, Reaction Rates, ...**5.0640**

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PATHOGENS AS BIOLOGICAL CONTROL AGENTS FOR MOSQUITO LARVAE ...Diseases, Growth, Moulting & Metamorph, Habitat Studies, Population Dynamics, Survey Methods, ...**5.0492**

DISPERSAL OF CONCENTRATED OR UNDILUTED INSECTICIDES FOR IMPROVED MOSQUITO CONTROL ...Animal Appl. -other, California, Insecticides -non-specific, Larvicides, ...**5.0493**

BEHAVIOR AND FOOD PREFERENCES OF INTRODUCED ANNUAL FISHES IN RELATION TO MOSQUITOES ...Aquatic Ecology, Behavioral Ecology, Food Supply, Killifishs - Cyprinodon, Predators and Parasite, ...**2.0575**

RELATIONSHIP OF WATER AND LAND MANAGEMENT TO MOSQUITO BREEDING IN WATER IMPOUNDMENTS AND IRRIGATED FARM AREAS ...Aquatic Ecology, Computer Matching Code, Diseases, Management, Predators and Parasite, Rearing, Water, ...**6.0255**

BIOLOGY AND CONTROL OF SALT-MARSH AND RICE-FIELD MOSQUITOES IN GULF COAST AREAS ...Aquatic Ecology, Computer Matching Code, Louisiana, Predators and Parasite, Swamps-marshes, ...**2.0576**

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Stone Flies, Plecoptera

SENSITIVITY OF SELECTED INSECT SPECIES TO DEPRESSED LEVELS OF PH ...Acidity, Bioindicators, Caddis-flies, Mayflies, Mining Industry, Ph, Acidity -water, ...**5.1034**

THE INSECT ORDER PLECOPTERA AS A BIOLOGICAL INDEX OF FRESH WATER QUALITY IN RHODE ISLAND ...Bioindicators, Environmental Ecology, Number Or Density, Pollution - Effects of , Pollution Effects, Streams, ...**5.1057**

THE INSECT ORDER PLECOPTERA AS A BIOLOGICAL INDEX OF FRESH WATER QUALITY IN RHODE ISLAND ...Bioindicators, Contamination - Water, Ions and Gases, Rhode Island, Streams, ...**5.1058**

Instrumental Services

MATHEMATICAL AND COMPUTER SERVICES FOR THE ANALYSIS OF DATA AND DESIGN OF EXPERIMENTS FOR CERTAIN FWPCA PROGRAMS ...Computers-general, Data Analysis - General, Facilities, Oregon, ...**5.0934**

Instrumentation-general

COMPARISON OF EVAPORATION INSTRUMENTS ...Evaporation, Tanks, Techniques, ...**2.0450**

TEST SITE INSTRUMENTATION ...Electronics - Applied, Instrumental Services, Surface Environments, ...**6.0271**

OXYGEN REGENERATION OF POLLUTED RIVERS ...Aeration, Delaware River, Economic Efficiency, Oxygen, Pollution Abatement, Streams, ...**5.0740**

FACTORS AFFECTING WATER YIELDS FROM SMALL WATERSHEDS IN TENNESSEE ...Conservation & Management Eng, Runoff, Small Watersheds, Soil Conditions, Water Harvesting, Water Yield, ...**4.0225**

HYDROLOGIC MEASUREMENT SYSTEMS ...Amount, Data Networks, Error Analysis, Gages, Hydrology-general, Rain-general, Technique Development, Urban Environments, ...**7.0056**

PILOT-STUDY OF SMALL WATERSHED HYDROLOGY ...Data Analysis - General, Floods, Mathematical Analysis, Rain-general, Runoff, Small Watersheds, ...**2.0379**

DEVELOPMENT OF HYDROLOGIC EQUIPMENT ...Design Instrumentation-other, Hydraulic Engineering-other, Hydrology-general, Instrumental Services, Other Telemetry, ...**7.0064**

HYDRAULIC INSTRUMENTATION ...Model Studies, Technique Development, Turbulent Flow, Water Level Fluctuation, ...**7.0063**

GREAT LAKES RESEARCH - MONITORING OF WATER CHARACTERISTICS ...Automatic Data Aquisition, Forecasting-prediction, Geophysical Analysis, Great Lakes-general, Temperature, ...**2.0649**

RESEARCH IN SEDIMENT SAMPLING EQUIPMENT ...Bed Load, Bottom Sampling, Suspension, Turbidity, Ultrasonics, ...**7.0059**

INSTRUMENTATION DEVELOPMENT FOR HYDROLOGIC DATA COLLECTION ...Electromechanical Design, Field Testing, Instrumental Services, Technique Development, ...**7.0089**

EVAPOTRANSPIRATION THEORY AND MANAGEMENT ...Evapotranspiration, Heat Flow, Internal Water Movement, Soil Environment, Thermal Properties-general, ...**2.0036**

BOREHOLE GEOPHYSICS AS APPLIED TO GEOHYDROLOGY ...Aquifers-general, Borehole Geophysics, Geophysical Analysis, Groundwater Movement, Technique Development, ...**7.0018**

RADIOISOTOPE GROUND WATER MEASUREMENTS IN SMALL DIAMETER DRILL HOLES ...Borehole Geophysics, Drilling and Coring, Groundwater, Radioisotopes, Technique Development, ...**8.0066**

DEVELOPMENT OF AUTOMATED ANALYSES FOR THE SUPPORT OF ADVANCED WASTE TREATMENT RESEARCH PROJECTS ...Automatic Data Aquisition, Chemical Analysis (water), Waste Water Treatment-general, ...**5.0863**

Instrumentation, Plant Equip.

ENCAPSULATION AND SOLIDIFICATION OF INTERMEDIATE LEVEL RADIOACTIVE WASTES IN THERMOPLASTICS ...Accidental , Encapsulation, Fire Research-other, Polymer-other, Radioisotopes, Recovery, Scrap and Wastes, ...**5.1142**

INVESTIGATION OF TESTING METHODS AND APPARATUS ...Atomic Absorption, Cement, Concrete, Infrared, Standards, Specifications, Test Methods, Ultrasonic and Sonic, ...**8.0234**

Intergovern Relations

SCENIC RIVERS STUDY ...Federal Government, Recreation Sites, Wild Rivers, ...**3.0170**

Interior Plains

Great Plains Province

THE ECONOMIC EFFECTS OF DROUGHT ON AN AGRICULTURAL ECONOMY ...Drought, Economic Impact, Meteorological Extremes, Weather, ...**2.0510**

RELATIONSHIPS BETWEEN PESTICIDAL APPLICATION AND WATER CONTAMINATION UNDER IRRIGATION IN THE GREAT PLAINS ...Irrigation-general, Kansas, Pesticides -non-specific, Pollutants - Path of , Water Application, ...**5.0430**

ECONOMIC ANALYSIS OF IRRIGATION SYSTEMS APPLICABLE TO THE NORTHERN GREAT PLAINS ...Agriculture, Economic Efficiency, Irrigation Engineering, Irrigation-general, Systems Analysis, ...**6.0496**

DEVELOPMENT OF A CHEMICAL FALLOW SYSTEM OF FARMING ...Herbicides -non-specific, Moisture Retention, Rotations, Runoff, Tillage, Cropping Systems, ...**4.0236**

RECHARGE OF GROUND WATER IN RIVER VALLEYS OF EASTERN AND CENTRAL KANSAS, AND THE HIGH PLAINS ...Artificial Recharge, Augmentation-general, Groundwater, Groundwater Mining, Natural Recharge, Water Table Fluctuation, ...**4.0116**

CONVECTIVE CLOUD SYSTEMS, NORTHERN GREAT PLAINS, ATMOSPHERIC WATER RESOURCES ...Cloud Structure, Clouds-precipitation, Convection, Cumulus, Model Studies, ...**2.0193**

SEDIMENT PRODUCTION, MOVEMENT, AND DEPOSITION IN WATERSHEDS IN THE SOUTHERN GREAT PLAINS ...Agricultural Watersheds, General Deposition, Location, Sediment Yield, Supply Rate, ...**2.0882**

PRECIPITATION CHARACTERISTICS INFLUENCING RUNOFF FROM WATERSHEDS IN THE SOUTHERN PLAINS ...Agricultural Watersheds, Amount, Patterns, Runoff, Topographic Influences, ...**2.1054**

RUNOFF PRODUCTION BY UNIT SOURCE AREAS IN THE SOUTHERN PLAINS ...Land Use, Moisture Retention, Runoff, ...**2.0875**

WATER AND WIND EROSION AND ITS CONTROL ON IRRIGATED AND NONIRRIGATED LANDS IN THE NORTHERN PLAINS ...Erosion-general, Irrigation-general, Runoff, Soil Tillage Methods -other, Wind Erosion, ...**5.0195**

MECHANICS AND PRINCIPLES OF WATER EROSION AND THEIR APPLICATION FOR EROSION CONTROL IN THE SOUTHERN PLAINS ...Erosion-general, Runoff, Soil Environment, Soil Erosion -non-specific, ...**5.0435**

ECONOMICS OF WATER MANAGEMENT TECHNIQUES IN NORTH DAKOTA ...Agricultural Watersheds, Economics-general, Irrigation-general, Management, North Dakota, ...**4.0188**

ECONOMIC ANALYSIS OF WATER USE IN IRRIGATION IN THE NORTHERN PLAINS ...Benefit-cost Analysis, Costs, Irrigation-general, Production & Processing, Rates Or Levels of Application, Water - Alternative Uses, ...**4.0077**

Intermontane Plateaus

Columbia Plateaus

HYDROLOGY OF THE COLUMBIA RIVER BASALT ...Hydrology-general, Igneous Rocks, Infiltration, Runoff, Specific Rock Unit, Tectonics-general, ...**2.0905**

Intermontane Plateaus-other

MATHEMATICAL METHODS OF EVALUATION OF RESULTS OF ATMOSPHERIC WATER RESOURCES PROGRAMS ...Error Analysis, Mountains-alpine, Physiography-general, Reliability Theory, Weather Modification-general, ...**2.0189**

Intertidal Areas

RADIOISOTOPIC TRACER STUDY TO INVESTIGATE THE MECHANICS OF LITTORAL TRANSPORT AROUND POINT CONCEPTION, CALIFORNIA ...California, Distribution, Radioisotopes, Sediment Transport-other, Tracers, ...**1.0031**

ECOLOGICAL-PHYSIOLOGICAL INVESTIGATIONS OF LITTORAL DIATOM COMMUNITIES OF THE YAQUINA RIVER ESTUARY ...Algae- Diatoms, Environment, Oregon, Physiological Ecology, ...**5.0949**

COLONIZATION RATES OF BENTHIC INVERTEBRATES IN AN OHIO RESERVOIR ...Benthic Fauna, Ohio, Productivity - Food Chain, Reservoirs and Impoundments, Water Level Fluctuation, ...**6.0424**

TRANSVERSAL DRIFTS IN BOTTOM PROFILE ...Bathymetry, Benthonic-bottom, Ocean Waves - Currents, Waves, ...**5.0254**

THE BIOLOGY OF THE INFAUNA OF A TROPICAL SOFT BOTTOM AREA ...Aquatic Ecology, Benthic Fauna, Estuaries, Florida, Pollution - Effects of , ...**5.0263**

THE EFFECT OF SELECTED PESTICIDES ON INTERTIDAL BIOTA ...Insecticides -non-specific, Pesticides -non-specific, Pollutants-general, Pollution Effects, Productivity - Food Chain, Swamps-marshes, ...**5.0522**

Invertebrate Anatomy

THE NORMAL ANATOMY AND HISTOLOGY OF SOME MARINE INVERTEBRATES ...Clams, Histology and Cytology, Pollution Effects, Water Quality-general, ...**5.1095**

Invertebrate Pathology

MASS MORTALITY OF OYSTERS ALONG THE OREGON COAST ...Bays, Mortality Rates, Oregon, Oysters, Pathology, ...**5.0985**

PACIFIC OYSTER MORTALITY STUDIES ...Invertebrates, Mortality Rates, Oysters, Pathology, ...**6.0266**

HISTOPATHOLOGIC EFFECTS OF POLLUTANTS ON CELLS AND TISSUES OF MARINE INVERTEBRATES ...Clams, Computer Matching Code, Contamination - Water, Pollution - Effects of , Pollution Effects, Pollution-other, ...**5.1081**

BIOLOGICAL ACTIVITIES OF MARINE FUNGI ...Endoparasites - other, Host-parasite Interactions, Marine Fungi (non-specific), Oysters, Pathological Physiolog, Plant Developmental Biology, ...**5.0289**

Invertebrates -non-specific

CHANGES IN STREAM COMMUNITIES ASSOCIATED WITH EFFLUENT - INDUCED EUTROPHICATION ...Aquatic Plants (non-specific), Eutrophication, Number Or Density, Pennsylvania, Streams, ...**5.1029**

WILD RIVERS ECOLOGY STUDIES ...Acidity, Fish -non-specific, Population Dynamics, Wild Rivers, Wisconsin, ...**6.0638**

THERMAL PREFERENCES OF MARINE FISHES AND INVERTEBRATES ...Behavior -animal, Fish -non-specific, Water Temperature-non-specific, ...**5.0720**

SEASONAL CHANGES IN ESTERASE ACTIVITY IN FISH AND INVERTEBRATES. INTERACTIONS BETWEEN PESTICIDES ON FISH ENZYME SYSTEMS ...Biochemical Analysis, Bluegills, Bream, Cholinesterase, Mode of Action -animal, Pesticides -non-specific, ...**5.0638**

SCREENING AQUATIC INVERTEBRATES TO DETECT AN ORGANISM SUITABLE FOR USE IN A MONITORING PROGRAM ...Bioassays, Bioindicators, Cholinesterase, Fish -non-specific, Metabolism, Monitoring Systems, ...**5.0639**

ACUTE TOXICITY OF PESTICIDES TO FRESHWATER INVERTEBRATES - DEVELOPMENT OF A LABORATORY STREAM FOR REARING AND TESTING AQUATIC INVERTEBRATES ...Captive Rearing, Invertebrate Cultures, Laboratory, Laboratory Animals, Pesticides -non-specific, ...**6.0319**

CONTINUOUS-FLOW INVERTEBRATE BIOASSAYS AND PESTICIDES AT COLUMBIA, MO. - ACUTE TOXICITY OF PESTICIDES TO FRESHWATER INVERTEBRATES ...Bioassay, Herbicides -non-specific, Insecticides -non-specific, Laboratory Animals, ...**5.0665**

UPTAKE OF ORGANIC COMPOUNDS BY MARINE INVERTEBRATES ...Amino Acids, Amino Acids -non-specific, Chemoreceptors, Marine Biology, Metabolism, Nutrition - Invertebrate, Pulse-labelling, ...**6.0058**

Iodide

SPECTROPHOTOMETRIC AND FLUOROMETRIC DETERMINATION OF SELECTED ANION WATER CONTAMINANTS ...Carbonate, Bicarbonate, Chemical Identification, Fluorometry, Phosphate, Phosphite, Spectroscopy-general, Thiocyanate, ...**5.0672**

Iodine

DISINFECTION OF SMALL QUANTITIES OF DRINKING WATER ...Chemical Treatment-general, Chlorine, Military Aspects, Potable Water, Sterilants, ...**5.0374**

THE DETERMINATION OF PLANT ROOTING AND WATER ABSORPTION PATTERNS WITH RADIOIODINE ...Absorption, Fixation, Exchange, Montana, Requirements for Water, Root Absorption, Soil Moisture -non-specific, ...**2.0716**

EFFECTIVENESS OF IODINE FOR DISINFECTION OF PUBLIC WATER SUPPLIES & TO DETERMINE PHYSIOLOGICAL EFFECTS ON A HUMAN POPULATION (ABBREV) ...Chemical Treatment-other, Pollution-water, Side Effects, ...**5.0249**

STUDY OF SNOW CRYSTAL TYPES IN GREAT LAKES SNOWSTORMS ...Activation Analysis, Great Lakes-general, Inorganic, Storm Water, Structure, ...**2.0784**

EFFECT OF THE WARM CLOUD BASE UPON CLOUDSEEDING FROM THE GROUND ...Clouds-precipitation, Nucleation, Nucleation Physics, Silver, Vapor, ...**2.0156**

DESTRUCTION OF INFECTIOUS VIRAL NUCLEIC ACID BY IODINE ...Enteroviruses of Humans, Inactivation, RNA , ...**5.0843**

Ion Exchange

Cation

THE TRANSPORT OF SALTS AND WATER ACROSS A CATION EXCHANGER UNDER A GRADIENT OF HYDROSTATIC PRESSURE. ...Desalination, Membranes-other, Streaming Potential, Thermodynamic Non Equilibrium, ...**3.0467**

REMOVAL OF STRONTIUM-90 FROM ORGANIC WASTES ...Aerobic, Anaerobic, Disposal, Flocculation, Strontium, ...**5.0082**

Ion Exchange-other

MULTICOMPONENT FIXED-BED ION EXCHANGE IN THE TREATMENT OF SALINE WATER ...Desalination, Phase Relationship, Reaction-general, Regeneration-other, ...**3.0082**

STRUCTURE IN SOLVENTS AND CONCENTRATED SOLUTIONS ...Hydrogen, Infrared, Nuclear Magnetic, Salt, Water, ...**1.0035**

INORGANIC ION EXCHANGERS AND THE NUCLEATION OF SCALE FORMING MATERIALS ...Calorimetry, Desalination, Equilibrium - Chemical, Structural Effect-other, Zirconium, ...**3.0341**

GEL SEPARATION PROCESSES FOR SALINE SOLUTIONS ...Crosslinked, Desalination, Gel Filtration, Other, ...**3.0066**

STUDY OF A SPECIFIC INFLUENCE OF IONIC SPECIES ON STRUCTURING IN WATER ...Configuration, Electrolytes, Entropy, Half Cell, Membranes-other, ...**1.0010**

ELECTROLYTIC REGENERATION OF ION EXCHANGE RESINS ...Brackish Water, Desalination, Pilot Plant, Regeneration-other, ...**3.0327**

EVALUATION OF INORGANIC MEMBRANES FOR ELECTRODIALYSIS OF BRACKISH WATERS ...Desalination, Electrodialysis, Membranes-other, Stability, Surfactants, ...**3.0209**

SEPARATION OF MAGNESIUM FROM CALCIUM IN THEIR SALINE SOLUTIONS ...Calcium, Chelation, Desalination, Magnesium, Separation-general, ...**5.0687**

RECOVERY OF METAL SALTS FROM CONCENTRATED BRINES BY CHELATION CONTRACT NO. 14-01-0001-1692 ...Chelating Agents, Cost Analysis, Material Recovery, Potable, Regeneration-other, ...**5.0142**

ELECTROCHEMICAL DEMINERALIZATION OF BRACKISH WATER ...Demineralization, Desalination, Electrochemistry-other, Electrode, Regeneration-other, ...**3.0039**

FIELD EVALUATION OF THE SUL-BISUL ION EXCHANGE PROCESS FOR DESALTING BRACKISH WATERS ...Brackish Water, Desalination, Mobile, Salinity, ...**3.0214**

DESIGN, CONSTRUCTION AND OPERATION OF A SKID-MOUNTED ION EXCHANGE PILOT PLANT ...Cost Analysis, Desalination, Economics-general, Mobile, Pilot Plants, ...**3.0329**

IMPROVEMENTS IN DESALINATION BY THE FLASH EVAPORATION PROCESS ...Additives, Desalination, Evaporation, Fluidized Bed, Scale Formation, ...**3.0408**

MODIFIED ION-EXCHANGE MEMBRANES FOR WATER PURIFICATION BY REVERSE OSMOSIS ...Cellulose Acetate, Desalination, High Pressure - 1-1000 Atm, Reverse Osmosis, ...**3.0289**

CONTINUOUS COUNTERCURRENT EXCHANGE SYSTEM FOR REMOVAL OF CALCIUM, MAGNESIUM AND DISSOLVED OXYGEN FROM FEED WATER ...Desalination, Evaporation, Other, Precipitation, Regeneration-other, ...**3.0437**

IMPROVED ION EXCHANGE POLYMERS AND MEMBRANES FOR ELECTRODIALYSIS OF SALINE WATER ...Copolymers, Electrodialysis, Membranes-other, Other, ...**3.0395**

THE THERMOSORB PROCESS FOR DESALTING WATER ...Adsorption-other, Carbon, Cost Analysis, Desalination, Thermal Treatment, ...**3.0103**

CLOSED SYSTEMS FOR ANIMAL SEWAGE TREATMENT ...Aerobic, Digestion, Disinfection, Farm Wastes, Safety, ...**1.0060**

CHEMICAL REMOVAL OF NITRATE FROM POTABLE WATER SUPPLIES ...Nitrate, Nitrite, Potable, Potable Water, Reduction-other, ...**5.0423**

FLUIDIZED EXCHANGE SYSTEMS FOR REMOVAL OF NITROGEN AND PHOSPHOROUS FROM WASTEWATER ...Fluidized Bed, Nitrate, Nitrite, Nutrients, Phosphate, Phosphite, Waste Water Treatment-general, ...**5.0556**

DETERMINATION OF THE FEASIBILITY OF REMOVAL OF ALGAL NUTRIENTS IN LAKE WATERS BY ION-EXCHANGE ...Algae- General, Eutrophication, Lakes, Nutrients, Phosphate, Phosphite, ...**2.0610**

RADIOTRACER STUDIES ON RAPID SAND FILTRATION ...Other, Radioisotopes, Reactors-other, Sand, ...**5.0295**

EFFECTS OF CHEMICAL IONS ON VIRUS INACTIVATION ...Animal Viruses (non-specific), Concentration, Inactivation, Ionic Effect, Virus, ...**5.0475**

AMMONIA REMOVAL FROM AGRICULTURAL RUNOFF BY SELECTIVE ION EXCHANGE ...Ammonia, Ammonium, Process Design, Runoff, Waste Water Treatment-general, Zeolite, ...**5.1247**

LIGAND EXCHANGE REAGENTS ...Colorimetric, Complexes, Compound, Dyes and Coloring, Spectroscopy-other, ...**5.0431**

RECLAMATION OF BIOLOGICALLY, MECHANICALLY & CHEMICALLY TREATED WASTEWATER FOR POTABLE WATER SUPPLY USES (ABBREV) ...Activated Carbon, Chlorination, Electrodialysis, Risk & Uncertainty, Waste Water Pre-treatment, ...**5.0159**

BASIC SALINOGEN ION EXCHANGE RESINS FOR SELECTIVE NITRATE REMOVAL FROM POTABLE AND EFFLUENT WATER ...Effluents-waste Water, Nitrate, Nitrite, Organic, Potable Water, Selective-removal, ...**5.0537**

SELECTIVE NITRATE AND PHOSPHATE REMOVAL ...Denitrification, Ion Selective, Nitrate, Nitrite, Phosphate, Phosphite, Selective-removal, Waste Treatment-economics, ...**5.0532**

SUPPORT OF THE ADVANCED WASTE-TREATMENT PILOT PLANT AT POMONA, CALIFORNIA ...Carbon, Denitrification, Reverse Osmosis, Sand, Waste Treatment-economics, ...**5.0110**

SORPTION ISOTHEMS OF PHENOL ON ION EXCHANGE RESINS ...Alcohols, Industrial Processes-other, Industrial Wastes, Isotherm, ...**2.0402**

AQUATIC TRANSPORT OF NUCLEAR DEBRIS ...Canals, Chemical Reactions, Exchange Capacity, Pollutants - Path of , Radioactive Fallout, ...**1.0012**

IMPROVED DETECTION TECHNIQUES TO DETERMINE RADIONUCLIDES IN FRESH AND SEA WATER ...Cesium, Fresh Water, Radioactivity-general, Sea Water-general, ...**5.1100**

ION EXCHANGE UNIT, 3000 GPH ...Demineralization, Mobile, Other, Potable Water, Radioactivity-general, ...**5.1215**

NITRATE REMOVAL FROM THE AGRICULTURAL EFFLUENTS IN THE SAN LUIS DRAIN UTILIZING ION EXCHANGE RESINS ...Chemical Treatment-other, Nitrate, Nitrite, Resins, Runoff, Waste Treatment-economics, ...**5.0182**

EUTROPHICATION - REMOVAL OF NUTRIENTS - SHAGAWA LAKE ...Activated Carbon, Coagulation, Eutrophication, Nutrients, Sediments, Tertiary Treatment, Trickling, ...**5.0594**

DISSOLVED INORGANIC REMOVAL--SELECTIVE ION AND ORGANIC REMOVAL BY ION EXCHANGE RESINS ...Activated Carbon, Demineralization, Pollutant-other, Regeneration-other, Waste Treatment-economics, ...**5.0849**

EUTROPHICATION - SEDIMENT-WATER INTERCHANGE STUDIES ...Eutrophication, Exchange Capacity, Lakes, Nutrients, Sediments, ...**5.0982**

REMOVAL OF SUSPENDED SOLIDS AND PHOSPHATE FROM A SECONDARY EFFLUENT BY ALUM COAGULATION AND DUAL MEDIA FILTRATION ...Electrodialysis, Filter-other, Reverse Osmosis, Sedimentation, Waste Treatment-economics, ...**5.0848**

EXPLORATORY STUDIES ON SIMPLIFYING DISPOSAL OF FOOD PROCESSING WASTES ...Activated Carbon, Canning Wastes, Electrodialysis, Other, Regeneration-other, Reverse Osmosis, ...**5.0057**

SORPTION KINETICS IN FLOW THROUGH GRANULAR PARTICLES ...Adsorption-other, Groundwater, Porous Media - Flow Through, Rate Determination, Tertiary Treatment, Water Quality Control-general, ...**5.1191**

Ionization

ELECTRIC FIELDS IN THE CONDENSATION AND COALESCENCE OF WATER ...Field Properties, Formation, Laboratory Analysis, Nucleation Physics, ...**3.0299**

Iowa

DYNAMICS OF FISH POPULATIONS IN NATURAL LAKES ...Food Supply, Lakes, Life History Studies, Population Dynamics, ...**6.0224**

LIMNOLOGY OF DESOTO BEND LAKE, IOWA AND NEBRASKA ...Benthic Organisms (non-specif), Lakes, Nebraska, Plankton (non-specific), Stratification, ...**7.0040**

RECESSION CHARACTERISTICS OF IOWA STREAMS ...Low Flow, Mathematical Analysis, Streams, Variation in Time, ...**5.0413**

REOXYGENATION OF IOWA STREAMS ...Aeration, Photosynthesis, Self-purification, Streams, ...**5.0417**

AN ANALYSIS OF THE ECONOMIC IMPLICATIONS OF THE PERMIT SYSTEM OF WATER ALLOCATION ...Contracts-permits, Economic Efficiency, Economic Impact, Water Allocation, Water Law-general, ...**6.0226**

EFFECTS OF LIMNOLOGICAL FACTORS ON WATER TREATMENT ...Other, Public Utilities, Reservoirs, Reservoirs and Impoundments, Water Quality-general, ...**5.0415**

INTERRELATIONSHIP OF SURFACE AND SUB-SURFACE FLOW IN THE NISHNABOTNA DRAINAGE BASIN ...Discharge-other, Drift, Groundwater Movement, River Basins, Valley, Buried, ...**2.0481**

LIMNOLOGICAL FACTORS AFFECTING PESTICIDE RESIDUES IN SURFACE WATERS ...Chlorinated Hydrocarbons, Persistance of Residues, Phytoplankton, Reservoirs and Impoundments, Runoff, Surface Water, ...**5.0416**

SIMULTANEOUS FLOW OF WATER AND HEAT IN WATER-UNSATURATED IOWA SOILS DURING EVAPORATION ...Density, Layered System, Moisture Content, Seepage, Thermal Properties-general, ...**2.0479**

WATERFOWL POPULATIONS AND RECREATIONAL USE PATTERNS IN THE PROPOSED SAYLORVILLE RESERVOIR AREA AS RELATED TO PRE-IMPOUNDMENT CONDITIONS ...Access, Frequency of Use, Population Dynamics, Pre-impoundment Sites, User Patterns, Water Fowl, N.s. , ...**6.0227**

USE OF INFRARED AND OTHER RADIATION TECHNIQUES TO EVALUATE DROUGHT IN IOWA AND ADJACENT AREAS ...Drought, Infrared Radiation, Photography-other, Spectral Reflectance, ...**2.0483**

DEVELOP AND DEMONSTRATE A METHOD FOR ASSESSING THE EXTENT OF POLLUTION FROM STORM WATER RUNOFF IN AN URBAN AREA ...Alternative Planning, Combined Sewer, Nutrients, Storm Water, Urban Environments, ...**5.0705**

WEATHER INFORMATION FOR AGRICULTURE ...Applied Climatology, General Synoptic Observations, Moisture Content, Oats, Soil Environment, ...**2.0484**

A LIMNOLOGICAL INVENTORY OF IOWA LAKES AND STREAMS ...Aquatic Ecology, Aquatic Plants (non-specific), Lakes, Streams, Survey Studies, Water Properties-general, ...**7.0042**

SOIL AND CLIMATE FACTORS AFFECTING THE EFFICIENT USE OF WATER BY CROPS ...Air - Water - Plant Relations, Applied Climatology, Evaporation, Moisture Content, Moisture Levels, Soil-water-plant Relationships, ...**2.0485**

AGRICULTURAL AND INDUSTRIAL DEVELOPMENT IN RELATION TO IOWAS ECONOMIC GROWTH ...Agriculture, Base Studies, Economics-general, Income, Model Studies, Requirement and Resources, Water Resources Development, ...**7.0043**

IRRIGATION INVESTIGATION IN IOWA ...Corn, Irrigation-general, Yield, ...**4.0105**

IOWA ECONOMETRIC MODEL ...Economics-general, Model Studies, Planning, Projections and Estimations, River Basins, ...**6.0225**

LOW-FLOW STUDIES OF IOWA STREAMS ...Available Water, Low Flow, Water Law-general, Water Quality Control-general, Water Standards, ...**2.0489**

FLOOD PROFILES AND FLOOD-PLAIN INFORMATION, CEDAR RAPIDS, IOWA ...Floodplains, Floods, Planning, Urban Environments, Water Law-general, ...**2.0490**

WATER AVAILABILITY OF MUSCATINE ISLAND, IOWA ...Aquifers-general, Available Water, Chemical-general, Prediction Models, Water Resources Development, ...**2.0488**

FLOOD PROFILES AND FLOOD-PLAIN INFORMATION, LINN COUNTY, IOWA ...Discharge-general, Floodplains, Floodproofing, Floods, Low Flow, ...**2.0491**

Iridium

STUDIES ON APPLICATION OF RADIOISOTOPE TECHNIQUES IN STREAM POLLUTION PROBLEMS IN THE PULP AND PAPER INDUSTRY ...Pollutants - Path of , Radioisotopes, ...**5.1233**

Iron

CORROSION RESEARCH ...Cathodic Protection, Desalination, Water, ...**3.0167**

PROTECTIVE FILMS FORMED BY PLASMA ANODIZATION ...Aluminum, Anodic, Brines, Desalination, Passivation, ...**3.0263**

THE EFFECT OF ORGANIC INHIBITORS ON THE DISSOLUTION KINETICS OF IRON ...Corrosion General, Electrochemical-other, Electrode, Inhibitors, Kinetics-other, ...**3.0065**

THE ROLE OF BRITTLE SURFACE FILMS IN STRESS-CORROSION CRACKING ...Crack Initiation, Propagation, Desalination, Magnesium, Stress Corrosion, ...**3.0255**

GEOCHEMICAL BEHAVIOR OF IRON AND MANGANESE IN A RESERVOIR (LAKE LYNN, WEST VIRGINIA) FED BY STREAMS CONTAINING ACID MINE DRAINAGE ...Acidity, Geochemical Analysis, Manganese, Mine Drainage Control, West Virginia, ...**2.1139**

PRECIPITATION OF PHOSPHATES FROM WATER WITH FERROUS SALTS ...Biochemical Oxygen Demand, Chemical Treatment, Phosphate, Phosphite, Precipitation, Waste Water Treatment-general, ...**5.0882**

IRON AND MANGANESE REMOVAL FROM SMALL GOUND WATER SUPPLIES ...Demineralization, Filtration, Groundwater, Manganese, Technique Development, ...**5.1053**

PRACTICAL APPLICATION OF FOAM FRACTIONATION TREATMENT OF LOW QUAITY WATER ...Color, Cost Analysis, Foam, Groundwater, Pilot Plant, ...**5.0037**

REMOVAL OF PHOSPHATE FROM WATER BY ALUMINUM AND IRON ...Aluminum, Complexes, Mechanisms, Phosphate, Phosphite, Waste Water Treatment-general, ...**5.0732**

CHANGES IN WATER QUALITY PARAMETERS OF RESERVOIRS DURING REGULATED FLOW CONDITIONS ...Eutrophication, Manganese, Tennessee, Water Properties-general, Water Quality-general, ...**5.1129**

INTERACTIONS OF SILICA WITH IRON AND ALUMINUM ...Aluminum, Analysis and Detection, Coagulation, Complexing, Water Treatment -- General, ...**5.0557**

CORROSION AND TUBERCULATION IN DISTRIBUTION SYSTEMS ...Casting of Materials, Coatings-general, Corrosion Prevention-other, Water, ...**5.0373**

RECOVERY FROM ACID POLLUTION IN FOUR STRIP-MINE LAKES ...Acidity, Lakes, Mining Industry, Self-purification, Stratification, ...**5.0669**

FOAM SEPARATION FLOTATION OF COLLOID ORGANIC SYSTEMS ...Chromium, Colloidal Phenomena, Flotation, Foam, Process Design, Pulp and Paper Wastes, Sulfate, Sulfite, Surfactants, ...**5.0445**

MICROBIOLOGICAL REMOVAL OF IRON FROM MINE DRAINAGE WATERS ...Acid Mine Wastes, Microbial-bacterial, Oxidation-other, Reduction-other, Sulfur Bacteria, ...**5.0925**

BIOLOGICAL TREATMENT OF ACID MINE WATER ...Acid Mine Wastes, Acidity, Anaerobic, Mining Activities, Model Studies, Process Design, ...**5.0795**

PARAMETRIC STUDY OF THE KINETICS OF PRECIPITATION AND NATURE OF THE PRECIPITATE OBTAINED IN PHOSPHATE REMOVAL USING IRON AND ALUMINUM SALT ...Aluminum, Phosphate, Phosphite, Precipitation, Solubility, Tertiary Treatment, ...**5.0075**

TREATMENT OF ACID RINSE WATERS ...Aeration, Coagulation, Lime Treatment, Metal Pickling Wastes, Treatment-other, Water Standards, ...**5.0899**

INVESTIGATIONS OF THE REMOVAL OF IRON FROM GROUNDWATER SUPPLIES IN ILLINOIS ...Demineralization, Filtration, Groundwater, Illinois, Precipitation, ...**5.0375**

CONTROL OF BIOLOGICAL GROWTHS IN RAPID SAND FILTERS AS RELATED TO IRON REMOVAL ...Disinfection, Nitrification, Nitrogen Bacteria, Repression, Sand, ...**5.0377**

REMOVAL OF PHOSPHATE FROM WATER BY ALUMINUM AND IRON ...Aluminum, Chemical Treatment, Chemical Treatment-general, Phosphate, Phosphite, Reaction-general, ...**5.0738**

ESTIMATING ACID MINE DRAINAGE POTENTIAL FROM COAL BEDS BY USE OF THE SOXHLET EXTRACTOR ...Acid Mine Wastes, Acidity, Coal-general, Extraction, Sulfate, Sulfite, ...**5.0993**

CHEMISTRY OF HYDROSOLIC METALS IN NATURAL WATER ...Aeration, Aluminum, Demineralization, Geochemical Analysis, Manganese, Solution Chemistry, ...**5.0119**

Irrigation

Border Irrigation

HYDRAULIC OPERATING CHARACTERISTICS OF LOW GRADIENT BORDER SYSTEMS PHASE II ...Infiltration, Irrigation, Irrigation Engineering, Water Application Methods, ...**3.0139**

SPRING IRRIGATION OF ALFALFA ...Alfalfa, Irrigation, Rhizosphere, Temperature, ...**3.0313**

IRRIGATION WATER USE EVALUATION ...Furrow Irrigation, Irrigation Engineering, Management, Runoff, Water Table Fluctuation, ...**3.0383**

LOW GRADIENT BORDER CHECK IRRIGATION ...Irrigation, Management, Slope - Degree of , ...**4.0063**

Flood Irrigation

SPRINKLER IRRIGATION OF CITRUS UNDER SOUTHWESTERN CONDITIONS ...Citrus, Irrigation, Southwest, Sprinkler Irrigation, Trees, ...**2.0052**

BIOLOGY AND CONSUMPTIVE WATER USE OF PERENNIAL RANGE PLANTS UNDER DESERT CONDITIONS ...Arid and Desert, Consumptive Use, Management and Fertility, Perennial, Phenology, Soil-water-plant Relationships, ...**3.0231**

LEACHING REQUIREMENT AND SALINITY STUDIES WITH BEARING ORANGE TREES ...Citrus, Leaching-other, Soil and Rock Leaching, Trees, Water Salinity, ...**4.0041**

IRRIGATED PASTURE AND MEADOW ESTABLISHMENT AND MANAGEMENT ...Grasses -non-specific, Irrigation, Legume-grass Mixtures, Legumes -other..mesquite... , Montana, North Dakota, Oregon, ...**3.0472**

Furrow Irrigation

THE EFFECT OF IRRIGATION METHOD, AND MOISTURE AND FERTILITY LEVELS UPON MAXIMIZING WATER USE EFFICIENCY AND QUALITY COTTON FIBER PRODUCTION ...Cotton, New Mexico, Rates Or Levels of Application, Soil Fertility, Subsurface Irrigation, Water Loss Control, ...**3.0337**

THE HYDRAULICS OF SPATIALLY VARIED STEADY FLOW IN AN IRRIGATION DISTRIBUTION CHANNEL WITH FURROW OUTLETS ...Channels, Engineering Structures-general, Flow Characteristics -water, Orifice, Weir, ...**3.0398**

LEMON PRODUCTION IMPROVEMENT ...Arizona, Citrus, Irrigation, Sprinkler Irrigation, Trees, ...**2.0067**

MICROMETEOROLOGY OF SOYBEANS ...Environmental-disease Relation, Evapotranspiration, Irrigation, Micrometeorology, Soybeans, ...**2.0070**

SOIL PHYSICAL CONDITIONS IN RELATION TO IRRIGATION ...Aggregates-other, Irrigation, Moisture Retention, Moisture Tension, Physical Properties-general, Sprinkler Irrigation, ...**2.0146**

DISTRIBUTION, APPLICATION AND USE OF WATER ...Irrigation Engineering, Model Studies, Moisture Content, Soil-water-plant Relationships, Water Yield, ...**3.0304**

IRRIGATION WATER USE EVALUATION ...Border Irrigation, Irrigation Engineering, Management, Runoff, Water Table Fluctuation, ...**3.0383**

ROW CROP IRRIGATION IN NORTHWEST LOUISIANA - COTTON IRRIGATION ...Cotton, Evapotranspiration, Irrigation, Louisiana, ...**2.0533**

ROW CROP IRRIGATION IN NORTHEAST LOUISIANA ...Corn, Cotton, Evapotranspiration, Irrigation, Louisiana, ...**2.0534**

LAND FORMING FOR DRAINAGE AND FURROW IRRIGATION ...Data Analysis - General, Drainage, Irrigation, Irrigation Engineering, Pumping, ...**5.1131**

DESIGN FACTORS IN SURFACE IRRIGATION ...Infiltration, Irrigation Engineering, Water Application Methods, ...**3.0477**

IRRIGATION AND EVAPOTRANSPIRATION OF WATER FOR CROPS IN IMPERIAL VALLEY ...Consumptive Use, Evapotranspiration, Flow Characteristics -water, Internal Water Movement, Irrigation, ...**3.0038**

Irrigation-general

FOREST TREE NUTRITION AND FOREST FERTILIZATION ...Physiology, Plant Chemistry, Pines, Potassium, Soil Fertility, Soils and Fertilizer, ...**2.0815**

DOCTORAL DISSERTATION RESEARCH IN POLITICAL SCIENCE ...Federal Government, Mexico, Policy Making, Power Structure, Water Supply-general, ...**3.0157**

SOCIAL CONSEQUENCES OF VARIATION IN AGRICULTURAL IRRIGATION ...Formosa - Taiwan, Management, Social Aspects, Social Change, ...**6.0375**

THE EFFECTS OF SALINE IRRIGATION WATER ON SODIUM ACTIVITIES AND PHYSICAL PROPERTIES OF LATOSOLIC SOILS ...Hawaii, Irrigation, Saline and Alkaline Soils, Salinity, Soil Environment, ...**3.0199**

DRAINAGE INVESTIGATIONS OF PROPOSED IRRIGATED SOILS IN ...Drainage, Permeability, Soil Environment, ...**2.0974**

ECONOMIC SURVEY OF BEAVERHEAD COUNTY, MONTANA ...Economic Impact, Project Post-evaluation, Water Utilization -general, ...**6.0331**

EVALUATION OF POLYVINYL CHLORIDE (PVC) AND VINYL CLAD ALUMINUM PIPE USED FOR CARRYING IRRIGATION WATER WHEN BURIED WITHIN THE FROST ZONE ...Aluminum, Cladding, Joining, Bonding-general, Pipe, Tube, Polyvinyls-other, Soils, ...**8.0271**

REGION 2 - WEED CONTROL ...Contamination - Water, Drainage, of Aquatic Plants, Plant Pollutants, ...**3.0093**

EFFECTS OF EARLY WATER ON WATERFOWL PRODUCTION ...Benefit-cost Analysis, Spawn Or Nesting Sites, Water Fowl, N.s. , Water Supply-general, Water Utilization -animal, ...**2.0214**

ON-FARM IRRIGATION WATER SUPPLIES AND COSTS IN RELATION TO CROPPING SYSTEMS AND PRODUCTION ADJUSTMENTS IN THE SACRAMENTO VALLEY ...California, Economic Efficiency, Water - Alternative Uses, Water Costs, Water Quantity-general, ...**6.0051**

ECONOMIC ASPECTS OF SUPPLEMENTAL IRRIGATION IN MISSOURI ...Corn, Economics-general, Moisture -non-specific, Sub - Humid, Temperature -non-specific, ...**6.0320**

VALUE OF WATER FOR IRRIGATION IN THE KANSAS RIVER VALLEY ...Benefit-cost Analysis, Consumptive Use, Projections and Estimations, Water Costs, Water Demand, ...**6.0236**

EFFECTS OF IRRIGATION DEVELOPMENT ON TRADE PATTERNS AND INCOME GENERATION ...Economic Impact, Input - Output Analysis, Model Studies, Planning, ...**6.0412**

ECONOMIC AND ENGINEERING ASPECTS OF WATER IN DELAWARES AGRI-BUSINESS INDUSTRY ...Agri Business, Disposal Wastes, Food Processing Industry, Optimization, Projections and Estimations, Water Resources Development, ...**6.0120**

RELATIONSHIPS BETWEEN PESTICIDAL APPLICATION AND WATER CONTAMINATION UNDER IRRIGATION IN THE GREAT PLAINS ...Great Plains Province, Kansas, Pesticides - non-specific, Pollutants - Path of , Water Application, ...**5.0430**

ECOLOGY OF NEMATODES IN IRRIGATION WATER ...Animal Wastes - Feed Lots, Bioindicators, Longevity, Nematoda -other, Pollution - Effects of , ...**5.1232**

METHODS FOR DETERMINING THE ECONOMIC PRODUCTIVITY OF IRRIGATION WATER FOR THE PRODUCTION OF SUGAR IN HAWAII ...Hawaii, Management, Sugar Cane, Yield, ...**6.0171**

EFFECTS OF MARGINAL QUALITY IRRIGATION WATER ON THE ACCUMULATION OF SALTS AND ALKALI IN SOUTH DAKOTA SOILS ...Saline and Alkaline Soils, Saline Soils, Soil pH , South Dakota, Use of Impaired Water, ...**3.0434**

IDENTIFICATION OF IRRIGATION RETURN WATER IN THE SUBSURFACE ...Chemical-general, Hawaii, Physical-general, Springs, Tritium, ...**5.0314**

ECONOMIC ANALYSIS OF WATER USE IN ILLINOIS AGRICULTURE ...Corn, Economics-general, Illinois, ...**6.0213**

THE ENGINEERING AND ECONOMIC ASPECTS OF USING SEWAGE EFFLUENT FOR IRRIGATION ...Louisiana, Sewage, Use of Impaired Water, Water Costs, ...**5.0463**

MAXIMIZING PRODUCTIVITY OF WATER USED FOR IRRIGATION OF AGRICULTURAL LANDS ...Model Studies, Optimization, Water - Alternative Uses, Water Allocation, ...**6.0610**

A PHYSICAL AND ECONOMIC ANALYSIS OF ALTERNATIVE IRRIGATION METHODS IN A SUB-HUMID CLIMATE ...Agriculture, North Dakota, Production & Processing, Sub - Humid, ...**6.0415**

ECONOMIC CONSEQUENCES OF INTERBASIN WATER TRANSFERS ...Benefit-cost Analysis, Economic Impact, River Basins, Water Transfer, ...**6.0451**

IRRIGABLE ACREAGE IN NEW MEXICO AND PROJECTED DEMANDS FOR IRRIGATION WATER ...Economics-general, Irrigation, New Mexico, Water Costs, Water Demand, ...**6.0360**

SALINITY ABOVE A WATER TABLE AS AFFECTED BY RAINFALL AND IRRIGATION ...Groundwater Movement, Moisture Tension, Permeability, Salinity, Soil and Rock Leaching, ...**2.0970**

DEVELOPMENT OF ANALYTICAL METHODS FOR PESTICIDE CONTAMINANTS IN DOMESTIC, IRRIGATION AND POND WATERS ...Chlorinated Hydrocarbons, Emission, Gas, Pollutants-general, Ponds, ...**5.0137**

ECONOMIC EFFICIENCY IN THE ALLOCATION OF IRRIGATION WATER OVER TIME ...Aquifers-general, Economic Efficiency, Water - Alternative Uses, Water Allocation, Water Demand, ...**6.0444**

INVESTIGATION OF SEEPAGE REDUCTION BY NATURAL PROCESSES IN IRRIGATION CANALS ...Canals, Linings-pavings, Seepage, Soil Environment, Tensiometer, ...**3.0207**

EFFECT OF WATER AVAILABILITY ON PHOTOSYNTHESIS OF PLANTS ...Available Water, Corn, Drought, Moisture Content -plants, Photosynthesis, Soybean, ...**2.0426**

IRRIGABILITY CLASSIFICATION OF NEW MEXICO SOILS AS A GUIDE FOR WATER IMPORTATION ...New Mexico, Soil Environment, Soil Types, ...**2.0773**

DECISION MODELS FOR MINIMIZING COST OF INFORMATION OR ERROR IN ESTIMATING BENEFIT-WATER RELATIONSHIPS IN IRRIGATION. (ABBREV) ...Benefit-cost Analysis, Mathematical Analysis, Model Studies, Reliability, Systems Analysis, ...**6.0359**

MODEL STUDY TO PREDICT SALT DISTRIBUTION AND CONCENTRATION OF WATER IN SOIL PROFILES ...Arid and Desert, Model Studies, Moisture Content, Saline Properties, Soil Chemical Properties, ...**5.0750**

UNDERSTANDING AND IMPROVING THE SOIL-PLANT ENVIRONMENT FOR MORE EFFICIENT UTILIZATION OF WATER ...Energy Budgets, Evapotranspiration, Modified Water Use, Requirements for Water, Soil-water-plant Relationships, ...**2.0968**

ECONOMIC ANALYSIS OF IRRIGATION SYSTEMS APPLICABLE TO THE NORTHERN GREAT PLAINS ...Agriculture, Economic Efficiency, Great Plains Province, Irrigation Engineering, Systems Analysis, ...**6.0496**

EVALUATION AND FUNCTIONAL OPERATION OF IRRIGATION SYSTEMS ...Irrigation Engineering, Management, South Dakota, Yield, ...**3.0433**

DISPOSAL OF PAPER MILL EFFLUENT THROUGH IRRIGATION OF BOTTOMLAND HARDWOOD UNDER LOUISIANA CONDITIONS ...Disposal Wastes, Louisiana, Pulp and Paper Wastes, Pulp, Paper , and Logging, Waste Disposal -underground, ...**6.0250**

WATER REQUIREMENTS FOR SALINITY CONTROL IN UNSATURATED SOILS ...Saline Properties, Saturated-unsaturated, Soil and Rock Leaching, Water Application Methods, ...**5.0751**

USE OF REACTOR COOLING WATER FROM NUCLEAR POWER PLANTS FOR IRRIGATION OF AGRICULTURAL CROPS ...Atomic Plants, High Temp. - 85f Or Above, Photosynthesis, Respiration, Transpiration and Evap, ...**3.0400**

OCCURRENCE OF PESTICIDES IN AQUATIC ENVIRONMENTS ...Aquatic Or Soil-aquatic Cycles, Food Chains, Animal And/or Man, Reservoirs and Impoundments, Runoff, ...**5.1237**

QUALITY OF IRRIGATION RETURN FLOW ...Internal Water Movement, Irrigation, Saline and Alkaline Soils, Salinity, Water Quality-general, ...**5.1196**

FACTORS AFFECTING PRODUCTION OF PECANS IN ARIZONA ...Irrigation, Mineral Nutrition, Moisture Content, Pecans, Hickory Nuts, Saline Properties, Saline Soils, ...**2.0046**

GROUND WATER, RESOURCES AND RECHARGE - RICE ...Arkansas, Artificial Recharge, Groundwater, Pollution - Effects of , Water Wells, ...**6.0026**

RICE FARMS IN ARKANSAS ...Arkansas, Benefit-cost Analysis, Costs, Management, Rice, ...**3.0026**

CHEMICAL AND MINERALOGICAL RELATIONSHIPS BETWEEN SUBMERGED SOILS AND RICE CULTURE ...Aquatic Soils, Arkansas, Mineralogy, Rice, ...**4.0021**

IMPURITIES OF IRRIGATION WATERS AFFECTING SOIL PROPERTIES ...Saline and Alkaline Soils, Saline Soils, Soil Environment, Use of Impaired Water, Water Quality-general, ...**3.0043**

IRRIGATION MANAGEMENT FOR CROPS ...Infiltration, Management, Soil Compaction Or Density, Soil Environment, ...**2.0090**

ANIMAL, FORAGE AND WATER RESOURCES FOR BEEF PRODUCTION ...Management, Quality and Utilization, ...**5.0086**

RELATION OF PHYSICAL CONDITIONS OF SOILS AND RESULTS OBTAINED FROM IRRIGATION ...Internal Water Movement, Irrigation, Soil Conditions, Soil Morphology, Profiles, Soil-water-plant Relationships, ...**2.0344**

IMPLICATIONS OF IRRIGATION TO THE MARKETING OF SPECIALTY CROPS ...Kansas, Production & Processing, Specialty Crops, ...**6.0237**

CRITERIA FOR EVALUATION AND FUNCTIONAL DESIGN OF IRRIGATION SYSTEMS ...Applied Climatology, Drought, Irrigation, Moisture Levels, Moisture Tension, ...**2.0524**

WATER REQUIREMENTS OF CROPS ...Climate-general, Irrigation, Management, Moisture Content, Requirements for Water, Soil-water-plant Relationships, ...**2.0654**

ECONOMIC AND LEGAL FACTORS IN PROVIDING, USING, AND MANAGING WATER RESOURCES IN AGRICULTURE ...Agriculture, Legal Review, Management, North Central, Optimization, ...**6.0323**

SOIL-PLANT-WATER RELATIONSHIPS ...Soil - Crop Relationships, Soil Environment, Soil Morphology, Profiles, Yield, ...**2.0790**

ECONOMIC EVALUATION OF IRRIGATION IN NORTH DAKOTA ...Computers-general, Economics-general, North Dakota, Optimization, ...**3.0379**

WATER YIELDS FROM SHALLOW GROUND AQUIFERS ...Aquifers-general, Permeability, Recharge -general, Water Yield, ...**4.0214**

THE DRAINAGE OF IRRIGATED LANDS ...Drainage, Permeability, Steady, Subsurface Flow, Water Table Fluctuation, ...**4.0251**

COMBINED INFLUENCE OF ATMOSPHERIC DESICCATION AND SOIL WATER POTENTIAL ON THE IRRIGATION NEED AND WATER POTENTIAL OF PLANTS ...Energy-general, Evapotranspiration, Moisture Tension, Osmotic and Turgor Pressure, ...**2.1078**

RESPONSE OF ALASKA'S ADAPTED CROPS TO SUPPLEMENTAL WATER ...Alaska, Benefit-cost Analysis, Irrigation, Soil-water-plant Relationships, Water Sources -general, ...**2.0030**

RAINFALL CHARACTERISTICS, DROUGHT INCIDENCE AND THE DEVELOPMENT OF A RAINFALL DEFICIENCY INDEX FOR THE AGRICULTURAL REGIONS OF PUERTO RICO ...Drought, Meteorological Extremes, Patterns, Puerto Rico, Rain, ...**2.0932**

A FORECAST OF AGRICULTURAL DEVELOPMENT IN THE IRRIGATED AREAS OF SPAIN ...Agriculture, Benefit-cost Analysis, Irrigation, Production & Processing, Spain, ...**6.0532**

METHODOLOGIES FOR PREDICTING CLIMATIC SUITABILITY OF NEW AREAS FOR IRRIGATED AGRICULTURE ...Alpine, Applied Climatology, Arid and Desert, California, Cold - Climates, Forecasting-prediction, ...**2.0096**

PROCEDURES FOR ESTIMATING CROP WATER REQUIREMENTS FOR USE IN WATER ALLOCATIONS AND FOR IMPROVEMENT OF IRRIGATION EFFICIENCY ...Evapotranspiration, General Synoptic Observations, Lysimeters, Requirements for Water, Water Allocation, ...**3.0047**

JORDANS EAST GHOR DEVELOPMENT PROJECT ...Agriculture, Income, Jordan, Land, Land & Water Use -other, ...**4.0180**

THE NANGARHAR CANAL PROJECT OF EASTERN AFGHANISTAN ...Afghanistan, Canals, Electric Power Plants, Hydrology-general, Water Resources Development, ...**4.0179**

SOIL-PLANT-ATMOSPHERE COMPONENTS IN IRRIGATION STUDIES OF BLACK WALNUT TREES IN SOUTHERN ILLINOIS ...Air - Water - Plant Relations, Moisture Tension, Soil-water-plant Relationships, Transpiration, Walnuts -black & English, ...**2.0401**

A STUDY OF THE PHYSIOLOGIC AND CULTURAL FACTORS WHICH INFLUENCE PRODUCTION OF TREE FRUITS ...Drought, Herbicides and Other Chem, Irrigation, Trees, ...**2.0074**

IRRIGATION STUDIES WITH APRICOTS AT WOLFSKILL EXPERIMENTAL ORCHARDS ...Apricot, Growth Rate, Irrigation, Trees, Yield, ...**2.0099**

SOIL-MOISTURE-PLANT RELATIONS OF AVOCADO TREES ...Lauraceae - Sassafras... , Moisture Content, Soil-water-plant Relationships, Temperature, Trees, ...**2.0148**

IRRIGATION STUDIES WITH VEGETABLES ...Aerial, California, Root, Saline Soils, Soil-water-plant Relationships, Water Quality-general, ...**2.0137**

EFFECTS OF ON-FARM IRRIGATION WATER SUPPLIES AND COSTS ON CROPPING SYSTEMS AND PRODUCTION AD-

JUSTMENTS ...Agriculture, California, Production & Processing, Water Costs, Water Demand, ...**6.0052**

HYDRAULIC STUDIES AND RESEARCH ON CALIFORNIA WATER FACILITIES ...Flow Characteristics -water, Fluid Flow-general, Irrigation, Model Studies, Synthetic Hydrology-general, ...**7.0010**

IRRIGATION IN RELATION TO CROPPING SYSTEMS ...Model Studies, Water Allocation, Water Costs, Water Sources -general, Water Yield, ...**6.0053**

DEVELOPMENT OF ANALYTICAL METHODS FOR PESTICIDE CONTAMINANTS IN DOMESTIC, IRRIGATION, LAKE, AND POND WATERS ...Chemical Analysis, Chemical Analysis (water), Chemical Treatment-general, Lakes, Pesticides -non-specific, Ponds, ...**5.0139**

RELATIONSHIP BETWEEN IRRIGATION WATER COMPOSITION AND SOIL PROPERTIES ...California, Clovers -red,alsike,ladino... , Movement, Availability, Saline and Alkaline Soils, Salinity, ...**3.0034**

THE EFFECT OF VARIOUS COMMERCIAL FERTILIZER PLACEMENTS AND IRRIGATION PRACTICES ON THE YIELD AND QUALITY OF RUSSET BURBANK POTATOES ...Band Width, Irrigation, Potatoes, Soil Temp. -non-specific, Yield, ...**2.0228**

IMPROVEMENT OF HIGH ALTITUDE (7600) VEGETABLE CROPS ...Brassica -the Cabbage Group, Elevational Levels, Altitude, Irrigation, Lettuce, Quality -non-specific, ...**4.0055**

WATER CONTROL FOR FOREST PRODUCTION ...Drainage, Forests, Moisture Content, Palms, Water Table Fluctuation, ...**2.0314**

SHALLOW WELLS AND IRRIGATION PITS FOR IRRIGATION AND OTHER FARM WATER SUPPLY IN THE COASTAL PLAINS ...Aquifers-general, Coastal Plain, Pumping, Terrain Analysis, Water Wells, ...**3.0194**

EVALUATION OF THE SULFUR SUPPLYING CAPACITY OF HAWAIIAN SOILS ...Hawaii, Movement, Availability, Rain-other, Soil Chemical Properties, Sulfur, ...**2.0373**

SOIL-WATER RELATIONS OF HAWAIIAN SOILS ...Hawaii, Mineralogy, Moisture Retention, Permeability, Soil Structure-general, Soil Tests, ...**2.0374**

SALINITY TOLERANCES OF CERTAIN TROPICAL SOILS AND RELATIONSHIPS BETWEEN SODIUM ION ACTIVITIES AND SOIL PHYSICAL PROPERTIES ...Chemical Analysis - Soils, Saline Properties, Semi - Arid, Sodium, Soil Chemical Properties, Tropic, ...**3.0200**

STUDY OF IRRIGATION SYSTEM DESIGN CRITERIA FOR HAWAIIAN VEGETABLE CROPS ...Economics-general, Hawaii, Irrigation, Soil-water-plant Relationships, Water Yield, ...**2.0380**

IRRIGATION OF WINTER WHEAT IN SOUTHERN IDAHO ...Irrigation, Moisture Content, Moisture Levels, Soil-water-plant Relationships, Wheat, ...**3.0208**

THE FEASIBILITY OF REUSE OF CHLORINATED SEWAGE EFFLUENT FOR FERTILIZATION AND IRRIGATION IN IDAHO (ABBREV) ...Chlorination, Sewage, Stream Rehabilitation, Use of Impaired Water, Water Reuse, ...**5.0327**

AN ECONOMIC AND LEGAL APPRAISAL OF THE USE OF WATER FOR IRRIGATION AND OTHER PURPOSES ON ILLINOIS FARMS ...Agriculture, Illinois, Legal Review, Legislative Processes, Water Law-general, ...**6.0214**

IRRIGATION INVESTIGATION IN IOWA ...Corn, Iowa, Yield, ...**4.0105**

STUDY OF ENGINEERING PRACTICES OF IRRIGATION IN KANSAS ...Irrigation Engineering, Kansas, Slopes, Terrace-bench, Tillage, Cropping Systems, Yield, ...**8.0201**

IRRIGATION PROJECT ...Corn, Milo and Grain Sorghum, ...**2.0512**

ENGINEERING PHASES OF SOIL AND WATER MANAGEMENT ...Drainage Engineering, Erosion-general, Management, Stabilization-general, ...**8.0220**

PEACH NITROGEN, PRUNING AND IRRIGATION STUDY ...Moisture Content, Nitrogen, Peaches, Trees, ...**4.0185**

WATER SUPPLY FROM AGRICULTURAL WATERSHEDS AND UTILIZATION IN IRRIGATION ...Agricultural Watersheds, Forecasting-prediction, Moisture Content, Patterns, Runoff, Water Yield, ...**4.0187**

IRRIGATION AND WATER CONSERVATION ...Irrigation, Modified Water Use, Water Loss Control, ...**2.0835**

EFFECTS OF IRRIGATION DEVELOPMENT ON TRADE PATTERNS AND INCOME GENERATION ...Economic Impact, Income, Projections and Estimations, ...**6.0411**

A PHYSICAL AND ECONOMIC ANALYSIS OF ALTERNATIVE IRRIGATION METHODS IN A SUB-HUMID CLIMATE ...Applied Climatology, Evapotranspiration, Model Studies, Sub - Humid, Water Balance-budget, ...**3.0384**

THE EXTENT OF IRRIGATION DEVELOPMENT IN NORTH DAKOTA AND ITS ECONOMIC IMPACT ...Economic Impact, Impact, Model Studies, Production & Processing, Water - Alternative Uses, Water Resources Development, ...**3.0380**

CULTURAL AND MANAGEMENT STUDIES FOR GRAIN SORGHUM ON THE HIGH PLAINS OF EASTERN NEW MEXICO ...Irrigation, Management, Milo and Grain Sorghum, New Mexico, Space Competition, ...**6.0358**

FARM IRRIGATION EFFICIENCY AS INFLUENCED BY DESIGN, CONSTRUCTION, AND OPERATION OF IRRIGATION SYSTEMS IN SOUTHWESTERN NEW MEXICO ...Irrigation, Irrigation Engineering, New Mexico, Rhizosphere, ...**2.0775**

LAND AND WATER VALUES IN EASTERN NEW MEXICO ...Groundwater, Land, New Mexico, Price & Value, Water Costs, ...**6.0361**

WATER REQUIREMENTS FOR CROP PRODUCTION IN THE ROSWELL UNDERGROUND WATER BASIN ...Groundwater Basins, Irrigation, Requirements for Water, Tillage, Cropping Systems, Water Costs, ...**3.0334**

TREE NUTRITION AND FOREST FERTILIZATION ...Growth Rate, New York, Site Index and Site Quality, Soils and Fertilizer, ...**2.0788**

IMPROVING IRRIGATION WATER SUPPLY FORECASTS AND THEIR USE ...Forecasting-prediction, Frost and Permafrost, Moisture Content, Moisture Meters, Runoff, Water Yield, ...**3.0401**

VEGETABLE CROPS FERTILIZER, PLANT NUTRITION, AND IRRIGATION PROBLEMS ...Aerial, Irrigation, Oregon, Root, Soil Fertility -non-specific, ...**2.0895**

IRRIGATION FEASIBILITY ON THE DAYTON, AMITY, WOODBURN, WILLAMETTE AND RELATED SOILS OF THE WILLAMETTE VALLEY ...Benefit-cost Analysis, Modified Water Use, Soil Environment, Tillage, Cropping Systems, Water Costs, ...**2.0888**

GENERAL SOIL MAPS OF REGIONS IN OREGON WITH POTENTIAL FOR IRRIGATION ...Aerospatial, Mapping, Oregon, Saline Properties, Soil Morphology, Profiles, ...**6.0463**

WATER NEEDS FOR IRRIGATION IN OREGON ...Agricultural Watersheds, Requirements for Water, Soil Conditions, Water Application Methods, Water Demand, ...**6.0462**

LAND FORMING FOR IRRIGATION AND DRAINAGE IN SUGARCANE PRODUCTION UNDER PUERTO RICAN CONDITIONS ...Drainage, Irrigation, Puerto Rico, Sugar Cane, Water Harvesting, ...**3.0425**

THE INFLUENCE OF WATER AND CLIMATE ON THE YIELD AND SUCROSE CONTENT OF SUGARCANE ...Applied Climatology, Microclimate-general, Puerto Rico, Sugar Cane, Yield, ...**4.0211**

FARM MANAGEMENT STUDY OF THE SUGARCANE FARMS SERVED BY THE LAJAS VALLEY IRRIGATION DISTRICT ...Costs, Production & Processing, Puerto Rico, Sugar Cane, Water Costs, ...**3.0427**

STUDIES ON VEGETABLE CULTURE ...Aerial, Drainage, in Horticulture, Irrigation, ...**2.0949**

IRRIGATION OF COTTON AND CORN. ...Corn, Cotton, Irrigation, Rates Or Levels of Application, Yield, ...**2.0960**

THE INVESTIGATION OF SOIL PROBLEMS IN RELATION TO IRRIGATION DEVELOPMENT IN SUBHUMID AREAS ...Irrigation, Soil-water-plant Relationships, Sub - Humid, ...**2.0967**

IRRIGATED GRASS INVESTIGATIONS ON THE BELLE FOURCHE PROJECT ...Alfalfa, Grasses -non-specific, Harvest and Storage, South Dakota, ...**2.0977**

IRRIGATION STUDIES FOR THE HIGH PLAINS ...Consumptive Use, Moisture Levels, Requirements for Water, Texas, ...**2.1050**

CITRUS FERTILIZER TEST ON SEVERAL PRINCIPAL CITRUS SOIL TYPES IN THE LOWER RIO GRANDE VALLEY OF TEXAS ...Citrus, Concentration Within Fertilize, Irrigation, Rates Or Levels of Application, Soil Types, ...**2.1034**

FEASIBILITY OF THE ESTABLISHMENT OF PERMANENT SALINE-TYPE AGRICULTURE ON ALLUVIAL SOILS OF THE PECOS RIVER VALLEY OF TEXAS ...Irrigation, Saline and Alkaline Soils, Soil Chemical Properties, Soil Conditions, Soil-water-plant Relationships, Texas, ...**3.0447**

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THE DISPOSITION OF PESTICIDES IN SOIL AND CLOSELY RELATED WATER ...Farm Pond, Management, Pesticides -non-specific, Pollutants - Path of , Soil and Rock Leaching, ...**5.0276**

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Liquid Lubricants

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Lubricants and Fluids - Other

INSULATING MINERAL OILS AND SYNTHETIC LIQUIDS AND LUBRICATING OILS ...Electrical Materials, Liquid Lubricants, Oxidation, Standards, Specifications, Test Methods, ...**8.0059**

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METHODS OF CONTROLLING CLUBMOSS (SELAGINELLA DENSA RYDB) AND REDEVELOPING THE PRODUCTIVE CAPACITY OF RANGES FOLLOWING CLUBMOSS CONTROL ...Applied Ecology, Management and Fertility, Weeds - physiological Studies, ...**4.0160**

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MEASURING EVAPOTRANSPIRATION AND PHOTOSYNTHESIS OVER SHORT PERIODS OF TIME IN THE FIELD ...Alfalfa, Evapotranspiration, Humidity, Photosynthesis, Wind Or Air Movement, ...**2.0725**

ENERGY SOURCES FOR EVAPOTRANSPIRATION IN THE PLAINS REGION ...Antitranspirants, Evapotranspiration, Nebraska, Radiation-general, Water Loss Control, ...**2.0721**

EVAPOTRANSPIRATION BY SUGAR CANE ...Consumptive Use, Evapotranspiration, Internal Water Movement, Sprinkler Irrigation, ...**3.0198**

EVAPOTRANSPIRATION AND ITS CHEMICAL REDUCTION ...Agricultural Watersheds, Antitranspirants, Evapotranspiration, Kansas, Meteorology, ...**3.0244**

LYSIMETER INVESTIGATIONS OF GAINS AND LOSSES OF MINERAL ELEMENTS ...Mineralogy, Soil and Rock Leaching, ...**2.0144**

PROCEDURES FOR ESTIMATING CROP WATER REQUIREMENTS FOR USE IN WATER ALLOCATIONS AND FOR IMPROVEMENT OF IRRIGATION EFFICIENCY ...Evapotranspiration, General Synoptic Observations, Irrigation-general, Requirements for Water, Water Allocation, ...**3.0047**

PILOT EVAPOTRANSPIRATION STUDY WITH LYSIMETERS OF WATER USE BY SUGAR CANE, PINEAPPLE AND TROPICAL TRUCK CROPS ...Evapotranspiration, Pineapple, Sugarcane, Tropic, Yield, ...**2.0372**

THE LOSS OF FERTILIZERS BY LEACHING FROM THE SUGARCANE SOILS OF PUERTO RICO ...Fertilizer Losses, Methods of Application, Other, Puerto Rico, Sugar Cane, ...**2.0938**

HIGH ALTITUDE EVAPOTRANSPIRATION FROM NATIVE MEADOWS ...Energy Budgets, Evapotranspiration, Harvest and Storage, Microclimate-general, Nuclear Moisture Meters, ...**3.0493**

INTERCEPTION AND WATER LOSSES FROM A FOREST FLOOR-SHRUB LAYER ...Ecology and Morphology, Interception, New Jersey, Other Water Conditions, Water Loss Control, ...**2.0770**

CONSUMPTIVE USE OF WATER BY SALT CEDARS ...Consumptive Use, New Mexico, Other Water Conditions, Saltcedar, Tamarisk, Water Table - Depth of , ...**3.0113**

FACTORS GOVERNING EVAPOTRANSPIRATION OF WATER IN COASTAL REGIONS ...Climate, Energy-general, Evapotranspiration, Moisture Tension, Soil Environment, ...**8.0012**

IRRIGATION SYSTEMS FOR EFFICIENT WATER USE IN THE GREAT BASIN ...Arid and Desert, Evapotranspiration, Great Basin, Sprinkler Irrigation, Water Balance-budget, ...**3.0314**

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THE PHYSIOLOGICAL BASIS OF THE TOLERANCE OF HORTICULTURAL CROPS TO COLD, DROUGHT, AND WATER ...Cold Resistance and Hardiness, Drought, ...**2.0500**

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RECOVERY OF SALTS FROM SALINE WATERS VIA SOLVENT EXTRACTION ...Brines, Desalination, Distribution Coefficient, Extraction, Material Recovery, ...**5.0162**

MINERAL RECOVERY FROM CONCENTRATED BRINES ...Brines, Chloride, Desalination, Great Salt Lake, Potassium, Regeneration-other, ...**5.1198**

THE ROLE OF BRITTLE SURFACE FILMS IN STRESS-CORROSION CRACKING ...Crack Initiation, Propagation, Desalination, Iron, Stress Corrosion, ...**3.0255**

SEPARATION OF MAGNESIUM FROM CALCIUM IN THEIR SALINE SOLUTIONS ...Calcium, Chelation, Desalination, Ion Exchange-other, Separation-general, ...**5.0687**

ION HYDRATION AND ION INTERACTION ...Assoc & Dissoc, Attenuation, Calcium, Hydration, Salt, Ultrasonic, Ultrasonics, ...**1.0059**

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LOGISTIC SUPPORT AND MAINTENANCE OF FACILITIES ...Atlantic Ocean-north, Lakes, Marine Biology, Research Facilities, ...**9.0009**

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A BENTHIC COMMUNITY OF THE PENOBSCOT RIVER ESTUARY ...Aquatic Ecology, Benthic Organisms (non-specif), Estuaries, Industrial Wastes, Productivity - Food Chain, ...**5.0473**

STUDY OF STRIPED BASS POPULATIONS IN MAINE COASTAL WATERS ...Aquatic Ecology, Basses -sea,white, White Perch, Estuaries, Migration, ...**5.0470**

STREAM RESTORATION AND CONTROLLED FLOWS ...Dams-other, Lake Trout, Brook Trout, Logging, Transport, Equipment, Salmon & Trout - Non-specific, Stream Rehabilitation, ...**4.0129**

PHASE II-STUDY OF A RIVER SYSTEM AS A CHEMICAL REACTOR ...Industrial Wastes, Other O.r. , Reactors-other, Systems Analysis, Water Quality Control-general, ...**5.0466**

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EVOLUTION OF ALLOPATRIC POPULATIONS ...Captive Rearing, Ecological, Lake Trout, Brook Trout, Population Dynamics, ...**5.0464**

EFFECTS OF COARSE SKELETON ON PHYSICAL PROPERTIES OF SOIL ...Physical Properties-general, Potatoes, Runoff, Soil Compaction Or Density, ...**2.0553**

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THE EFFECT OF LIVESTOCK UTILIZATION ON WATERFOWL HABITAT AND PRODUCTION ...Habitat Studies, Utah, Vasc. plant & Vert. -other, Water Fowl, N.s. , Wetlands, ...**6.0595**

EFFECT OF GRAZING MANAGEMENT ON RANGE LIVESTOCK NUTRITION AND ON THE RANGE RESOURCE ...Cutting &/or Grazing Effects, Diet Or Ration -other, Management, Management and Fertility, Quality and Utilization, ...**2.0971**

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DEER FOODS ON WATERSHEDS TREATED FOR INCREASED WATER YIELD ...Arizona, Food Supply, Forages, N. s. , Water Yield, ...**4.0004**

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EFFECT OF RANGE AND WATER ON MULE DEER POPULATION ...New Mexico, Population Dynamics, Range Or Territorial Distr. , Relations - Forage - Timber, Water Utilization -animal, ...**3.0338**

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AQUATIC BIOLOGY INVESTIGATIONS ...Lake Trout, Brook Trout, Lakes, New York, Streams, Water Fowl, N.s. , ...**2.0786**

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SALINE WATERS AND LIVESTOCK PRODUCTION ...Salinity, Swine, Water, Water Utilization -animal, ...**5.0831**

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FARM ANIMAL WASTE DISPOSAL ...Animal Waste Removal-treatment, Galliformes - Fowl-other, Livestock -non-specific, Sewage Lagoons, Waste Water Treatment-general, ...**5.0407**

FARM ANIMAL WASTE DISPOSAL ...Animal Waste Removal-treatment, Chickens, Sewage Lagoons, Waste Disposal-general, ...**5.0835**

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SUPPORT OF THE COMMITTEE ON WATER ...Committee-support, Hydrology-general, Teaching and Research, ...**9.0003**

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SPRING POND ECOLOGY AND MANAGEMENT ...Fishing, Habitat Studies, Ponds, Productivity (agricultural), Salmon & Trout - Non-specific, ...**3.0488**

FISH STOCKING EVALUATION ...Captive Rearing, Largemouth Bass, Nets, Ponds, Stocking of Fish & Shellfish, ...**6.0542**

SYSTEMS ANALYSIS FOR GROUNDWATER MANAGEMENT ...Economic Efficiency, Groundwater Basins, Model Studies, Saline Water Intrusion, Systems Analysis, ...**5.0071**

THE LOCAL WATER DISTRICT AS AN URBAN WATER-POLICY DETERMINING ENTITY ...California, Public Utilities, State-local Government, Urban Environments, ...**6.0060**

APPRAISAL OF WATER MANAGEMENT INSTITUTIONS-SURVEY OF OREGON WATER LAW ...Administrative Structures, Legal Review, Water Rights-general, Water Standards, Water Transfer, ...**6.0455**

A COMPREHENSIVE WATER RESOURCES ANALYSIS OF A TYPICAL OVERDRAWN BASIN IN AN IRRIGATED SEMIARID AREA - PECOS RIVER BASIN, NEW MEXICO ...Impact, Land, New Mexico, River Basins, Systems Analysis, ...**6.0366**

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OPERATIONS RESEARCH STUDY OF WATER RESOURCES DEVELOPMENT AND MANAGEMENT IN THE TUCSON AREA ...Arizona, Operations Research, Optimization Technique, Research - Development, Simulation Theory, Water Resources Development, ...**6.0015**

METHODOLOGY FOR INTEGRATING WATER QUALITY MANAGEMENT WITH THE MANAGEMENT OF THE TOTAL WATER RESOURCES IN MINNESOTA ...Data Acquisition-general, Minnesota, Technique Development, Water Quality Control-general, ...**5.0605**

ANALYSIS OF LITERATURE ON THE RECREATIONAL ASPECTS OF WATER RESOURCES RESEARCH ...Planning, Recreation Sites, Survey Studies, ...**6.0212**

LIMNOLOGICAL INVESTIGATIONS OF TEXAS IMPOUNDMENTS FOR WATER QUALITY MANAGEMENT PURPOSES ...Chemical-general, Nutrients, Reservoirs and Impoundments, Texas, Water Quality Control-general, ...**5.1148**

ANALYSIS OF SMALL WATER MANAGEMENT STRUCTURES ...Administrative Structures, Hydraulic Structures, Water Control Works-general, Water Distribution Systems, Water Transfer, ...**4.0260**

POLLUTION TAXES AND THE COSTS OF WATER QUALITY MANAGEMENT ...Benefit-cost Analysis, Economic Efficiency, Self-purification, Water Costs, Water Quality Control-general, ...**6.0423**

THE USE OF SYSTEMS ANALYSIS IN THE DEVELOPMENT OF WATER RESOURCES MANAGEMENT PLANS FOR NEW YORK STATE ...Model Studies, New York, Planning, Systems Analysis, ...**6.0373**

BENEFITS FROM INTEGRATED WATER MANAGEMENT IN THE NEW YORK METROPOLITAN REGION ...Administrative Structures, Model Studies, New York, Urban Environments, Water Sources -general, ...**6.0393**

UTILIZATION OF PHYSICAL AND MATHEMATICAL MODELS IN ESTUARINE WATER RESOURCES RESEARCH AND MANAGEMENT ...Computers-general, Estuaries, Model Studies, Shoreline - Coastline, Tides, ...**6.0607**

STOCHASTIC MODELS FOR WATER RESOURCES MANAGEMENT ...Alternative Planning, Application, Runoff, Stochastic Models, Streams, ...**6.0383**

APPLICATION OF SIMULATION THEORY TO WATER RESOURCES PLANNING AND MANAGEMENT ...Model Studies, Optimization, Planning, River Basins, ...**6.0340**

DEVELOPEMNT AND IMPLEMENTATION OF A MANAGEMENT STRATEGY FOR WATER RESOURCES RESEARCH ...Operations Research, Planning, Projections and Estimations, Systems Analysis, Water Resources Development, ...**6.0112**

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EVALUATION OF GROUNDWATER RESOURCES, LIVERMORE VALLEY, CALIFORNIA ...Data Acquisition-general, Groundwater Basins, Model Studies, Subsurface Flow, Water Yield, ...**4.0025**

THE MANAGEMENT AND CONTROL OF WATER IN PUERTO RICO ...Control and Protection, Data Analysis - General, Puerto Rico, Types of Resources, Water Quality-general, Water Supply-general, ...**6.0480**

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A METHODOLOGY FOR PLANNING OPTIMAL REGIONAL WASTE MANAGEMENT SYSTEMS ...Effluents-waste Water, Model Studies, Optimization, Regional Areas, Waste Water Treatment-general, ...**6.0280**

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EVALUATION AND FUNCTIONAL OPERATION OF IRRIGATION SYSTEMS ...Irrigation Engineering, Irrigation-general, South Dakota, Yield, ...**3.0433**

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AN ECONOMIC ANALYSIS OF THE PUBLIC WATER SUPPLY DISTRICT ...Economics-general, Social Aspects, State-local Government, Water Supply-general, ...**6.0322**

RESEARCH AND ANALYSIS TO PLAN, DEVELOP, AND MANAGE A GROUND AND SURFACE WATER SUPPLY ...Nevada, Price & Value, Water Supply-general, ...**6.0339**

SYSTEMATIC ANALYSIS OF MANAGEMENT EFFECTIVENESS OF THE WATER QUALITY CONTROL BOARD SYSTEM OF CALIFORNIA ...California, Model Studies, Operations Research, State-local Government, Water Quality Control-general, ...**6.0035**

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CASE STUDY OF REMEDIAL FLOOD MANAGEMENT IN AN URBAN AREA-PHASE I ...Alternative Planning, Floodplains, Floods, Planning, Urban Environments, ...**6.0166**

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AN APPRAISAL OF FLOOD REGULATIONS IN THE STATES OF ILLINOIS, INDIANA, IOWA, MISSOURI AND OHIO ...Alternative Planning, Central, Floodplains, Floodproofing, Water Rights-other, ...**6.0209**

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A REGIONAL STUDY OF THE CHANGING OCCUPANCY AND DEVELOPMENT OF AN ALLUVIAL LOWLAND ...Alluvial Deposits, Land Use, Mississippi, Model Studies, Regional Areas, ...**7.0031**

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ECONOMICS OF WATER QUALITY IN A REGIONAL SYSTEM ...Alternative Planning, Benefit-cost Analysis, Delaware Bay, Estuaries, Water Quality-general, ...**5.1011**

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COOPERATIVE WATERSHED MANAGEMENT IN SNOWLANDS AND LOWER CONIFER ZONES OF CALIFORNIA ...California, Coniferous Forests, Forest Watersheds, Moisture Tension, Snowmelt, ...**4.0022**

IMPROVEMENT OF IRRIGATION MANAGEMENT AND SALINITY CONTROL IN THE IMPERIAL VALLEY. ...Drainage, Drainage Engineering, Saline and Alkaline Soils, Sprinkler Irrigation, Water Table Fluctuation, ...**3.0048**

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SOIL MANAGEMENT UNDER DRYLAND CONDITIONS ...Erosion-general, Modified Water Use, Soil Conditions, Storage of Water, Tillage, Cropping Systems, ...**4.0113**

SOIL MANAGEMENT INVESTIGATIONS ON IRRIGATED LAND ...Irrigation, Rotations, Soil Analysis, Soil Comparison, Tillage, Cropping Systems, Water Application Methods, ...**4.0114**

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AQUIFER STUDIES IN MARYLAND - SEDIMENTARY ROCKS IN THE COASTAL PLAIN ...Aquifers-general, Geologic Sections, Hydrology-general, Specific Rock Unit, Subsurface, Water Allocation, ...**2.0561**

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IMPROVEMENT AND MANAGEMENT OF THE COMMUNITY PASTURES OF THE PERSHING COUNTY WATER CONSERVATION DISTRICT NEAR BATTLE MOUNTAIN, NEVADA ...Evaluation, in Forages and Pasture, Nevada, Phreatophytes, Storage of Water, ...3.0316

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THE ACCUMULATION OF FISSION PRODUCTS BY MARINE FISH AND SHELLFISH ...Chlorideae -other, Contamination - Water, Estuaries, Food Chains, Radioactivity-general, Radioecology, ...**5.0805**

ECOLOGICAL SIGNIFICANCE OF ORGANIC RELEASE PRODUCTS OF MARINE AND FRESHWATER ANIMALS ...Aquatic Ecology, Biological Rhythms, Metabolism, Mucus, Productivity - Food Chain, ...**2.0342**

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DISTRIBUTION OF DEMERSAL FISHES IN INSHORE WATERS ...Environmental Ecology, Fish -non-specific, Marine Biology, Mortality Rates, Nets, Vertical Distribution, ...**5.1260**

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DISTRIBUTION OF LIFE WITH DEPTH ...Continental Shelf, Marine Photography-television, North Carolina, Photography-other, Vertical Distribution, ...**5.0272**

EFFECTS OF PESTICIDES ON MARINE ANIMALS ...Dieldrin, Laboratory Animals, Metabolism, Mode of Action -animal, Respiration, ...**5.0261**

BIONOMICS OF FISHES AND SHELLFISHES ...Aquaculture & Fish-farming, Bays, Economics-general, Environmental Ecology, Oregon, Productivity - Food Chain, ...**2.0896**

RELATIONSHIP OF TUBE-AND REEF BUILDING MARINE ANNELIDS TO COASTAL ENGINEERING AND CONSERVATION PROBLEMS IN FLORIDA ...Coastal Engineering-other, Environmental Ecology, Florida, Lugworms, Marine Segmented-worm, Vertical Distribution, ...**3.0187**

OREGON FISHES - THEIR CLASSIFICATIONS, DISTRIBUTIONS AND LIFE HISTORIES ...Animal Taxonomy, Fresh Water, Life History Studies, Oregon, Vertical Distribution, ...**6.0450**

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EFFECT OF EURASIAN WATERMILFOIL CONTROL PROCEDURES ON WILDLIFE AND OTHER ORGANISMS IN AQUATIC ENVIRONMENTS ...Aquatic Environments, Contamination - Water, Diquat, Evaluation, Water Milfoil, Waterweed... , 2,4-d, ...**5.0505**

DISTRIBUTION OF YOUNG STAGES OF COASTAL FISHES ...Continental Shelf, Estuaries, Fish -non-specific, Maturity & Growth Stages, Number Or Density, Ships and Cruises, ...**6.0345**

INFLUENCE OF THE PHYSICAL ENVIRONMENT ON DISTRIBUTION OF YOUNG STAGES OF COASTAL GAME FISH ...Continental Shelf, Environmental Ecology, Fish -non-specific, Maturity & Growth Stages, Physical-general, Range Or Territorial Distr. , ...**6.0346**

TEMPERATURE TOLERANCE OF MARINE ANIMALS THROUGH BEHAVORIAL RESPONSES ...Behavior -animal, Environment Resistance, Mortality Rates, Thermal, Water Temperature-non-specific, ...**6.0344**

THERMAL PREFERENCES OF MARINE FISHES AND INVERTEBRATES ...Behavior -animal, Fish -non-specific, Invertebrates -non-specific, Water Temperature-non-specific, ...**5.0720**

EFFECTS OF HOT WATER MASSES ON MARINE FISHES ...Atlantic Ocean-north, Behavior -animal, Fish -non-specific, High Temp. -85f Or Above, Thermal, ...**5.0721**

SAN PABLO BAY STUDY ...Bays, Benthic Fauna, Bottom Sampling, Excavation, Spoil Banks, Water Sampling, ...**6.0038**

ACCUMULATION OF RADIOACTIVITY BY INVERTEBRATES ...Contamination - Water, Metabolism, Pollution Effects, Productivity - Food Chain, Radioactivity-general, ...**5.0804**

MICROBIOLOGY OF MARINE AND ESTUARINE INVERTEBRATES ...Estuaries, Marine Bacteria (non-specific), Microbiological Analysis, Oysters, ...**2.0586**

HISTOPATHOLOGIC EFFECTS OF POLLUTANTS ON CELLS AND TISSUES OF MARINE FISHES ...Computer Matching Code, Contamination - Water, Killifishs - Cyprinodon, Pollution - Effects of , Pollution Effects, ...**5.1080**

HISTOPATHOLOGIC EFFECTS OF POLLUTANTS ON CELLS AND TISSUES OF MARINE INVERTEBRATES ...Clams, Computer Matching Code, Contamination - Water, Invertebrate Pathology, Pollution - Effects of , Pollution Effects, Pollution-other, ...**5.1081**

REARING AND SENSITIVITY STUDIES OF VARIOUS LIFE STAGES OF MARINE MACROINVERTEBRATES ...Bioindicators, Crabs, All, Shrimps - Common, Whole Body Culture & Rearing, ...**5.1079**

USE OF MARINE PLANKTONIC ORGANISMS FOR EVALUATING THE QUALITY OF MARINE AND ESTUARINE WATERS ...Bioassays, Estuaries, Phytoplankton, Pollution - Effects of , Pollution Effects, Zooplankton, ...**5.1093**

DEVELOPMENT OF CULTURE METHODS FOR ECOLOGICALLY IMPORTANT MARINE ZOOPLANKTON SPECIES ...Aquatic Ecology, Copepods, Environmental Physiology, Invertebrate Cultures, Zooplankton, ...**5.1096**

DETERMINATION OF SELECTED ENVIRONMENTAL REQUIREMENTS OF IMPORTANT SPECIES OF MARINE ZOOPLANKTON ...Copepods, Oxygen, Water Salinity, Water Temperature-non-specific, Zooplankton, ...**5.1097**

THE NORMAL ANATOMY AND HISTOLOGY OF SOME MARINE INVERTEBRATES ...Clams, Histology and Cytology, Invertebrate Anatomy, Pollution Effects, Water Quality-general, ...**5.1095**

UPTAKE OF ORGANIC COMPOUNDS BY MARINE INVERTEBRATES ...Amino Acids, Amino Acids -non-specific, Chemoreceptors, Invertebrates -non-specific, Marine Biology, Metabolism, Nutrition - Invertebrate, Pulse-labelling, ...**6.0058**

EPIZOOTICS IN EXPERIMENTAL MARINE SHELLFISH POPULATIONS ...Epizootic, Freshwater Mussels, Scallops, Mortality Rates, Oysters, Pathology, ...**6.0631**

MARINE TOXINS OF THE TROPICAL PACIFIC ...Algal Metab.(non-specific &ot), Animal Origin, Fish -non-specific, Other, Polynesia, Toxicology, ...**5.0315**

TOXIC AND OTHER CHEMICALS IN MARINE BIOTA ...Bioassay, Dibrom, Diquat, Mollusks -non-specific & Other, Paraquat, ...**5.1074**

ACCUMULATION AND ELIMINATION OF VIRUSES BY SHELLFISH ...Enteroviruses of Humans, Oysters, Pathology, ...**5.1227**

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LOGISTIC SUPPORT AND MAINTENANCE OF FACILITIES ...Atlantic Ocean-north, Lakes, Maine, Research Facilities, ...**9.0009**

DISTRIBUTION OF DEMERSAL FISHES IN INSHORE WATERS ...Environmental Ecology, Fish -non-specific, Mortality Rates, Nets, Vertical Distribution, ...**5.1260**

BENTHIC COMMUNITIES ...Benthonic-bottom, Engineering Structures-general, Environmental Ecology, Estuaries, Productivity - Food Chain, ...**6.0156**

COASTAL AND INSHORE OCEANOGRAPHY ...Alaska, Estuaries, General, Other Sea Water Properties, Shoreline - Coastline, ...**2.0015**

ESTUARINE INVENTORY (FORMERLY CHEMICAL ENVIRONMENT) ...Estuaries, Florida, Gulf of Mexico, Physiography-general, Sedimentology-general, ...**2.0325**

DETERMINATION OF SELECTED ENVIRONMENTAL REQUIREMENTS OF IMPORTANT MARINE PHYTOPLANKTON SPECIES ...Axenic Culture, Environment, Growth and Differentiation, Marine Plants, Phytoplankton, ...**5.1094**

UPTAKE OF ORGANIC COMPOUNDS BY MARINE INVERTEBRATES ...Amino Acids, Amino Acids -non-specific, Chemoreceptors, Invertebrates -non-specific, Metabolism, Nutrition - Invertebrate, Pulse-labelling, ...**6.0058**

Marine Biology (non-specific)

HYDROSTATIC PRESSURE-TEMPERATURE, AS ENVIRONMENTAL PARAMETERS, ON GROWTH, BIOCHEMISTRY AND PHYSIOLOGY OF MICROORGANISMS ...Growth (non-specific & Ot.), Microorganisms (non-specific), Pressure & Mech Stress, Temperature, ...**6.0459**

OPTIMUM ECOLOGICAL DESIGNS FOR ESTUARINE SYSTEMS OF NORTH CAROLINA ...Domestic Wastes-general, Estuaries, North Carolina, Pollution - Effects of , Pollution Effects, Productivity - Food Chain, ...**2.0820**

ECOLOGY OF LOUISIANAS ESTUARINE WATERS - MARINE LABORATRY ...Aquatic Ecology, Estuaries, Louisiana, Shoreline - Coastline, ...**2.0542**

PESTICIDE KINETICS ...Aquatic Or Soil-aquatic Cycles, Degradation -non-specific, Estuaries, Insecticides -non-specific, Pollutants - Path of , ...**5.0271**

DEVELOPMENT OF METHODOLOGY FOR ISOLATION OF VIRUSES FROM SEA WATER ...Animal Viruses (non-specific), Concentration, Physical Parameters, Viral Pollutant Sources, ...**5.1228**

Marine Environments-general

PROBABLE EFFECTS ON MARINE ENVIRONMENTS OF DISPERSING BRINE EFFLUENTS FROM LARGE DESALINATION PLANTS IN THE GULF OF CALIFORNIA ...Atomic Plants, Brines, Desalination, Gulf of California, Pollution - Effects of , ...**3.0020**

MEASUREMENT OF RADIONUCLIDES IN ESTUARINE AND MARINE ENVIRONMENTS (A COOPERATIVE AGREEMENT WITH ATOMIC ENERGY COMMISSION) ...Estuaries, Pollution - Effects of , Pollution Effects, Radioactivity-general, Reactor Sites & Rad Waste, ...**2.0819**

Marine Geology

Marine Geology-general

SUBMARINE SPRINGS ...Bibliography, Discharge-general, Ocean Environment, Springs, Subsurface Environments, ...**2.0319**

Sediments

Biology

FREQUENCY DISTRIBUTION OF BIOLOGICAL POLLUTANTS IN SHELLFISH AND THE MARINE ENVIRONMENT ...Coliforms (non-specific), Enteroviruses of Humans, Gulf of Mexico, Oysters, Pollution-water, ...**5.0016**

Chemistry

MARINE HYDROLOGY AND GEOCHEMISTRY, ATLANTIC CONTINENTAL SHELF AND SLOPE ...Continental Shelf, Distribution, Mixing, Ocean Environment, Saline Water Intrusion, ...**2.0623**

Distribution

RADIOISOTOPIC TRACER STUDY TO INVESTIGATE THE MECHANICS OF LITTORAL TRANSPORT AROUND POINT CONCEPTION, CALIFORNIA ...California, Intertidal Areas, Radioisotopes, Sediment Transport-other, Tracers, ...**1.0031**

FIELD MEASUREMENTS OF THE TEMPORAL AND SPATIAL VARIATIONS IN CONCENTRATION AND PARTICLE SIZE DISTRIBUTION OF SUSPENDED MATERIALS IN THE UPPER ...Chesapeake Bay, Maryland, Mineralogy, Size, Turbidity, ...**2.0558**

COOPERATIVE GULF OF MEXICO INVENTORY AND STUDY - III SEDIMENTOLOGY ...Aquatic Ecology, Atlases-maps, Environmental Ecology, Estuaries, Gulf of Mexico, ...**2.0671**

MARINE HYDROLOGY AND GEOCHEMISTRY, ATLANTIC CONTINENTAL SHELF AND SLOPE ...Chemistry, Continental Shelf, Mixing, Ocean Environment, Saline Water Intrusion, ...**2.0623**

GEOCHEMISTRY OF SAN FRANCISCO BAY ...Bays, Clays, Mineral Associations, San Francisco Bay, Trace Element Analysis, ...**2.0121**

ORGANIC GEOCHEMISTRY OF SAN FRANCISCO BAY WATERS AND SEDIMENTS ...Clays, Organics, Sedimentation, ...**2.0123**

Mechanical Properties

CIVIL ENGINEERING STRUCTURES IN THE OCEANS ...Engineering Studies-other, Foundations-general, Hydraulic Structures, Hydrodynamics, Soil Dynamics, Wave Action, ...**8.0165**

Mineralogy

FIELD MEASUREMENTS OF THE TEMPORAL AND SPATIAL VARIATIONS IN CONCENTRATION AND PARTICLE SIZE DISTRIBUTION OF SUSPENDED MATERIALS IN THE UPPER ...Chesapeake Bay, Distribution, Maryland, Size, Turbidity, ...**2.0558**

Sedimentation

CLAY-INORGANIC AND ORGANIC-INORGANIC ASSOCIATIONS IN AQUATIC ENVIRONMENTS ...Activation Analysis, Chemical Reactions, Clays, Exchange Capacity, Organic, Suspension, ...**2.0019**

EFFECTS OF POLLUTANTS ON SUBMARINE PLANT SYNECOLOGY ...Applied Ecology, Industrial Wastes, Nutrients, Plant Prod. (non-specific), Plant Succession, Sediments, ...**5.1221**

ORGANIC GEOCHEMISTRY OF SAN FRANCISCO BAY WATERS AND SEDIMENTS ...Clays, Distribution, Organics, ...**2.0123**

QUANTITATIVE AND QUALITATIVE CHARACTERISTICS OF MATERIALS CONTRIBUTING TO SEDIMENTATION IN LAKE ERIE ...Lake Erie, Location, Organic, Organics, Rate of Deposition, ...**2.0628**

Structure-geomorphology

Coastlines-shorelines

GENERAL COASTAL INLET STUDIES ...Coastal Engineering-other, Discharge-other, Model Studies, Synthetic Hydrology-general, Tides, Velocity -water, ...**2.0689**

Geomorphology-topography

AN ANALYTICAL AND EXPERIMENTAL STUDY OF BED FORMS UNDER WATER WAVES ...Channel Roughness, Friction, Model Studies, Water Tunnels Tables, Wave Action, Waves, ...**2.0347**

MECHANICS OF WAVE ACTION IN DEEP AND SHALLOW WATER ...Internal Waves, Longshore Currents, Sand Bars, Tsunami, Waves, ...**2.0258**

Islands

ISLAND STUDY ...Conservation-general, Inventories, Planning, Recreation Sites, Survey Studies, ...**3.0171**

Marine Mapping

DEVELOPMENT OF OFFSHORE SOURCES OF SAND SUITABLE FOR BEACH RESTORATION AND NOURISHMENT ...Beach, Ocean Coring and Dredging, Ocean Mining, Shoreline Structures, Size, ...**8.0154**

Marine Photography-television

DEPTH CONTOURING BY COLOR SEPARATION ...Bathymetry, Electronics - Applied, Optical, Photogrammetry, Satellites, ...**6.0276**

DISTRIBUTION OF LIFE WITH DEPTH ...Continental Shelf, North Carolina, Photography-other, Vertical Distribution, ...**5.0272**

Marine Plants

ULTRAVIOLET ABSORPTION IN COASTAL WATERS ...Biological, Physical Parameters, Plant Prod. (non-specific), Sewage, Shoreline - Coastline, ...**5.0112**

DEMONSTRATION OF THE LIMITATIONS AND EFFECTS OF WASTE DISPOSAL ON AN OCEAN SHELF ...Ocean, Outlet, Pollution - Effects of , Pollution Effects, Sewers, ...**5.0248**

SENSITIVITY OF BENTHIC MICROFLORA TO POLLUTION GRADIENTS ...Benthic Flora, Bioindicators, Estuaries, Plant Prod. (non-specific), Water Standards, ...**5.1059**

COLLECTION AND ESTABLISHMENT IN CULTURE OF SPECIES AND STRAINS OF MARINE PHYTOPLANKTON ORGANISMS ...Algal Culture, Culture Collections, Phytoplankton, Pollution-general, ...**5.1063**

DETERMINATION OF SELECTED ENVIRONMENTAL REQUIREMENTS OF IMPORTANT MARINE PHYTOPLANKTON SPECIES ...Axenic Culture, Environment, Growth and Differentiation, Marine Biology, Phytoplankton, ...**5.1094**

DEVELOPMENT OF A METHOD FOR CHRONIC TOXICITY BIOASSAY USING MARINE PLANKTONIC ALGAE ...Algal Culture, Bioassays, Microbiological Analysis, Monitoring (long Term Studies), Phytoplankton, Technique Development, Toxicology, ...**5.1088**

STUDY OF NITROGEN METABOLISM IN MARINE ALGAE ...Bioindicators, Enzymes, Microbiological Analysis, Pollution - Effects of , Quantitative & Qualitative, ...**5.1089**

Marine Pollution

Industrial Wastes

EFFECTS OF POLLUTANTS ON SUBMARINE PLANT SYNECOLOGY ...Applied Ecology, Nutrients, Plant Prod. (non-specific), Plant Succession, Sedimentation, Sediments, ...**5.1221**

COMPARATIVE TOXICITIES OF METALS TO ESTUARINE FISHES ...Bioassays, Estuaries, Killifishs - Cyprinodon, Mineral Origin, Solid Waste, ...**5.1084**

Oil

MARINE OIL-WATER MONITORING INSTRUMENTATION SYSTEM SUBGROUP V ...Detectors, Industrial Waste-other, Infrared, Infrared Radiation, Instrumental Services, Oil - Technological Testing, ...**5.0336**

OIL SLICK ANALYSES ...Aircraft, Instrumental Services, Optical Devices, Satellites, Transducers, ...**6.0275**

THE SPREADING OF OIL FILMS ...Forecasting-prediction, Ocean Currents, Pollution Abatement, Tides, Waves, ...**5.0787**

OIL CONTAMINATION OF OYSTERS FROM OIL WELL DRILLING MUDS ...Industrial Wastes, Oysters, Petroleum Industry, Pollution Effects, ...**5.0449**

EFFECTS OF CRUDE OILS AND THEIR EMULSIONS TO MARINE ORGANISMS ...Chelating Agents, Emulsion, Petroleum Chemistry, Poisons-other, Removal--organics, ...**5.1082**

EFFECTS OF PETROLEUM AND PETROLEUM WASTES UPON IMPORTANT SPECIES OF ESTUARINE PHYTOPLANKTON AND ZOOPLANKTON ...Contamination - Water, Contamination, Pollution-water, Estuaries, Petroleum, Phytoplankton, Zooplankton, ...**5.1086**

Pollution-general

PHYSICAL FACTORS AFFECTING OREGON COASTAL POLLUTION ...Circulation General, Density, Shoreline - Coastline, Tidewater Areas, Water Quality-general, ...**5.0951**

AIRPHOTO ANALYSIS OF OCEAN OUTFALL DISPERSION ...Diffusion, Longshore Currents, Ocean, Outlet, Photogrammetry, ...**5.0941**

COLLECTION AND ESTABLISHMENT IN CULTURE OF SPECIES AND STRAINS OF MARINE PHYTOPLANKTON ORGANISMS ...Algal Culture, Culture Collections, Marine Plants, Phytoplankton, ...**5.1063**

DISPERSION OF WATER AND SEDIMENTS IN THE SURF ZONE ...Beaches, Pollutants - Path of , Shoreline - Coastline, Size, Waves, ...**5.0151**

FAUNAL PRODUCTION ...Estuaries, Pollution Effects, Productivity - Food Chain, Vertical Distribution, Water Environment -other, ...**6.0154**

LABORATORY BIOASSAYS ...Contamination - Water, Laboratory, Laboratory Animals, Pollution - Effects of , Wildlife, ...**5.0270**

STUDY ON METHODOLOGY FOR VIRAL EXAMINATION OF SEAWATER AND SHELLFISH ...Enteroviruses of Humans, Food Spoilage Detection, Shellfish, N.s. , Viral Pollutant Sources, ...**5.1071**

Pollution-other

HISTOPATHOLOGIC EFFECTS OF POLLUTANTS ON CELLS AND TISSUES OF MARINE INVERTEBRATES ...Clams, Computer Matching Code, Contamination - Water, Invertebrate Pathology, Pollution - Effects of , Pollution Effects, ...**5.1081**

Radioactivity

ECOLOGICAL STUDIES OF RADIOACTIVITY IN THE COLUMBIA RIVER ESTUARY AND ADJACENT PACIFIC OCEAN ...Columbia River, Contamination - Water, Organ Sampling Devices, Pacific Ocean-north, Pollutants - Path of , ...**6.0452**

TRITIUM AS A TRACER FOR MIXING PROCESSES ...Mixing, Ocean Currents, Salinity, Tracers, Tritium, ...**5.0264**

RADIONUCLIDES IN THE SAVANNAH RIVER ESTUARY AND ADJACENT COASTAL WATERS ...Atomic Plants, Estuaries, Pollutants - Path of , Radioactivity-general, Tracers, ...**5.1098**

Sewage

MARINE WASTE DISPOSAL AND SEA URCHIN ECOLOGY ...California, Pollution Effects, Productivity - Food Chain, Sea Urchins & Other Echinoderm, ...**5.0130**

ULTRAVIOLET ABSORPTION IN COASTAL WATERS ...Biological, Marine Plants, Physical Parameters, Plant Prod. (non-specific), Shoreline - Coastline, ...**5.0112**

ECOLOGY & NITROGEN CYCLE IN A MARINE PLANT COMMUNITY ...Bering Sea, Nitrogen, Physiological Ecology, Potamogeton, Ruppia, Zostera.., Primary Productivity, ...**5.0035**

Ship Wastes

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Maryland

HIGHWAY DRAINAGE STUDY ...Drainage, ...**2.0579**

COLLECTION OF HYDROLOGIC DATA OF SMALL DRAINAGE AREAS ...Data Acquisition-general, Drainage, Runoff, Small Watersheds, Storm Water, ...**2.0560**

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DEVELOPMENT OF COMPUTER MODELS & METHODOLOGY FOR FORECASTING & EVALUATING MUNICIPAL & INDUSTRIAL WATER REQUIREMENTS ...Digital Computers, Model Studies, Projections and Estimations, Urban Environments, Water Demand, ...**6.0252**

DEMAND FOR AND AVAILABILITY OF LAND AND WATER ORIENTED RECREATION FACILITIES IN MARYLAND - ECONOMIC ANALYSIS ...Demand Analysis, Forecasting-prediction, Production & Processing, Recreation Sites, Types of Resources, ...**6.0259**

TIME OF TRAVEL - PRINCIPAL MARYLAND STREAMS ...Dyes, Pollutants - Path of , Streams, Velocity -water, ...**2.0565**

EVALUATION OF MAGOTHY AQUIFER - ANNAPOLIS AREA ...Atlases-maps, Available Water, Clastic Aquifers, Model Studies, Saline Water Intrusion, ...**2.0564**

EXPLORATION AND MAPPING OF THE SALISBURY PALEOCHANNEL ...Atlases-maps, Borehole Geophysics, Channels, Geophysical Analysis, Valley, Buried, ...**2.0566**

FLOOD FREQUENCY AND LOW-FLOW ANALYSES ...Floods, Flow Characteristics -water, Low Flow, Peak Flow, Statistical Models, ...**5.0481**

EXTENT OF BRACKISH WATER IN TIDAL RIVERS ...Brackish Water, Saline Water Intrusion, Salinity, Tidal Streams, Tides, ...**2.0562**

POPULATION ECOLOGY OF FORAMINIFERA IN THE CHOPTANK RIVER ...Aquatic Ecology, Environmental Ecology, Foraminifera, Population Dynamics, Water Properties-general, ...**6.0126**

SYSTEMS STUDY - MARYLAND PROJECT ...Alternative Planning, Hydrology-general, Management, Planning, Water Resources Development, ...**6.0603**

SEDIMENTATION AND HYDROLOGY-ROCK CREEK AND ANACOSTIA RIVER BASINS, MARYLAND ...Erosion-general, Groundwater, Land Use, Sediment Yield, Urban Environments, ...**4.0130**

CULTURE OF SHELLFISH IN ARTIFICIAL AND NATURAL SALT PONDS ...Captive Rearing, Commercial Fishing, Growth Rate, Oysters, Ponds, ...**6.0267**

GROWTH, CONDITION, AND SURVIVAL OF SHELLFISH ...Adaptation, Environmental Physiology, Oysters, Water Quality-general, Water Salinity, ...**6.0269**

Mass Transfer

DISPOSAL OF BRINE BY SOLAR EVAPORATION ...Desalination, Evaporation, Heat Transfer, Solar Still, Vapor Pressure, ...**3.0333**

MASS TRANSFER AND CHEMICAL REACTION IN TWO PHASE FLOW ...Close Channel, Mathematical Analysis, Model Studies, Phase Relationship, Waste Water Treatment-general, ...**5.0225**

ROTATIONAL STABILITY OF DILUTE POLYMER SOLUTIONS ...Fluid Flow-other, Organic, Polymer Type-other, Solution, Transport, ...**1.0027**

AIR OXIDATION OF ORGANIC COMPOUNDS IN AQUEOUS SYSTEMS ...Chemical Treatment, Kinetics-other, Organic Wastes, Solution, Wet Oxidation, ...**5.0215**

PIPELINE TRANSPORT OF SLUDGE ...Disposal, Mining Activities, Pump, Sewage Treatment Plant, West Virginia, ...**5.0869**

AIR OXIDATION OF ORGANIC COMPOUNDS IN AQUEOUS SYSTEMS ...Aeration, Chemical Treatment, Continuous, Organics, Wet Oxidation, ...**1.0023**

CONTROLLED FREEZING DESALINATION ...Desalination, Freezing, Heat Transfer, Other, ...**3.0216**

FLOW FIELD IN A PACKED BED ...Fluid Flow-other, Packed Bed, Porous Media - Flow Through, Surface-other, ...**1.0045**

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Creep

RAINWASH AND SOIL CREEP IN WESTERN NORTH DAKOTA ...Environmental Effects-geologic, Erosion-general, Morphology-general, North Dakota, Slopes, ...**2.0848**

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Land and Rock Slides

DEVELOPMENT OF A PRACTICAL METHOD OF LOCATING AND TRACING SEEPAGE WATER IN UNSTABLE SLOPES ...Electric Logging, Kentucky, Loss, Seepage, Slopes, ...**2.0519**

FLUCTUATION OF RESERVOIR LEVELS AND THE RELATED CAUSE OF LANDSLIDES (THE OHIO RIVER VALLEY) ...Force, Reservoirs and Impoundments, Slopes, Soil Stability Analysis, Water Level Fluctuation, ...**8.0191**

FLOOD AND SEDIMENT REDUCTION IN THE CONIFEROUS TIMBER ZONE OF CALIFORNIA ...Creep, Floods, Management, Pulp, Paper , and Logging, Sediment Yield, ...**2.0078**

Snowslide-avalanche

WATER YIELD IMPROVEMENT, AND SNOW AND AVALANCHE PREDICTION AND PREVENTION, IN THE ALPINE REGIONS OF THE CENTRAL ROCKY MOUNTAINS ...Alpine, Colorado, Water Loss Control, Water Yield, ...**3.0146**

Features

MATHEMATICAL GEOMORPHOLOGY ...Erosion, Geomorphology-quantitative, Model Studies, Processes, Terrain Analysis, ...**2.0425**

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DISTRIBUTION AND ABUDANCE OF JUVENILE AMERICAN SHAD, ALOSA SAPIDISSIMA (WILSON), IN THE CONNECTICUT RIVER ABOVE HOLYOKE DAM, MASSACHUSETTS ...Alewife,menhaden,shad,herring, Connecticut River, Engineering Structures-general, Migration, Number Or Density, ...**3.0271**

FOOD HABITS OF LARVAL AND JUVENILE SHAD IN THE CONNECTICUT RIVER ...Alewife,menhaden,shad,herring, Aquatic Ecology, Connecticut River, Food Supply, Recreation Sites, ...**3.0272**

THE EFFECTS OF PESTICIDE RESIDUES ON LARVAL AND JUVENILE WINTER FLOUNDER IN THE WEWEANTIC RIVER ESTUARY, MASSACHUSETTS ...Estuaries, Pollution - Effects of , Righteye Flounders, Wildlife, ...**5.0509**

SOME ASPECTS OF THE MARINE SPORT FISHERY OF MASSACHUSETTS WITH SPECIAL EMPHASIS ON SURVEY DESIGN AND BASIC ECONOMIC ATTRIBUTES ...Censusing, Fishing, Survey, ...**7.0054**

INVESTIGATION OF RELATIONSHIP OF CUNNER, TAUTOGOLABRUS ADSPERSUS -(WALBAUM), TO WEWEANTIC RIVER ESTUARY, WAREHAM, MASSACHUSETTS ...Aquatic Ecology, Estuaries, Fish -other, Swamps-marshes, Water Environment -other, ...**5.0511**

THE ECOLOGY OF THE YOUNG FISHES OF THE WEWEANTIC RIVER ESTUARY ...Aquatic Ecology, Estuaries, Pesticides - non-specific, Pollution - Effects of , Population Dynamics, ...**2.0607**

OPTIMUM UTILIZATION AND MANAGEMENT OF WATER IN FORMATIONS HYDROLOGICALLY-CONNECTED TO A STRETCH OF THE CONNECTICUT RIVER ...Aquifers-general, Artificial Recharge, Baseflow, Connecticut River, Water Yield, ...**4.0134**

THE ROLE OF AQUATIC VASCULAR PLANTS IN THE EUTROPHICATION OF SELECTED LAKES IN WESTERN MASSACHUSETTS ...Bioindicators, Eutrophication, Lakes, Nutrients, Water Properties-general, ...**2.0609**

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IMPROVEMENTS IN MASS CONCRETE MIXTURE PROPORTIONING ...Aggregates, Extenders, Fillers, Cement, Concrete, Composition Parameters-other, Costs, Homogeneity, ...8.0260

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EFFECT OF AGGREGATE PROPERTIES AND CEMENT CONTENT ON THE TENSILE STRENGTH OF CONCRETE ...Aggregates, Extenders, Fillers, Cement, Concrete, Composition Parameters-other, Tensile, ...**8.0110**

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POURBAIX DIAGRAM FOR CORROSION EVALUATION ...Soil Chemical Properties, Soils, Water, ...**8.0022**

SCREENING TESTS ON NEW ASPHALTIC, PLASTIC, AND RUBBER PRODUCTS ...Bituminous, Elastomers Rubber, Standards, Specifications, ...**8.0079**

INSULATING MINERAL OILS AND SYNTHETIC LIQUIDS AND LUBRICATING OILS ...Electrical Materials, Liquid Lubricants, Lubricants and Fluids - Other, Oxidation, Standards, Specifications, ...**8.0059**

ALLOY SELECTION FOR CAVITATION RESISTANCE ...Cavitation, Cavitation-other, Metallic Alloys, Turbine-other, ...**8.0025**

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Bonding

Bonding - Other

DEVELOPMENT AND EVALUATION OF TEST PROCEDURES FOR DETERMINING REACTIVE EXPANSION, AIR AND WATER PERMEABILITY, AND BONDING EFFICIENCY ...Adhesives , Cement, Concrete, Porosity, Permeability, Repairing, Test Methods, ...**8.0112**

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EVALUATION OF POLYVINYL CHLORIDE (PVC) AND VINYL CLAD ALUMINUM PIPE USED FOR CARRYING IRRIGATION WATER WHEN BURIED WITHIN THE FROST ZONE ...Aluminum, Cladding, Irrigation-general, Pipe, Tube, Polyvinyls-other, Soils, ...**8.0271**

DEVELOPMENT AND DEMONSTRATION OF MATERIALS TO REDUCE OR ELIMINATE WATER INFILTRATION INTO SEWERAGE ...Groundwater Movement, Linings-pavings, Other, Pipe-other, Sealant Materials, ...**5.1186**

SHEAR EVALUATION OF WEAK ROCK FOUNDATIONS ...Cement, Concrete, Foundations, Ohio River, Shear Strength, Soil Test - Insitu, ...**8.0273**

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CROP AND SOIL MANAGEMENT OVER SHALLOW PLASTIC-LINED MOLE DRAINS ...Management , Plastics - General, Soil and Rock Leaching, ...**4.0262**

Repairing

EPOXY RESINS FOR CIVIL WORKS PROJECTS ...Concrete-other, Construction-other, Epoxies, Fracture Mechanics, Maintenance, ...**8.0248**

DEVELOPMENT AND EVALUATION OF TEST PROCEDURES FOR DETERMINING REACTIVE EXPANSION, AIR AND WATER PERMEABILITY, AND BONDING EFFICIENCY ...Adhesives, Bonding - Other, Cement, Concrete, Porosity, Permeability, Test Methods, ...**8.0112**

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POLYMERIC COATINGS FOR PROTECTION ON CONCRETE EXPOSED TO AQUEOUS SALINE ENVIRONMENTS ...Cement, Concrete, Depolymerization, Organic-general, Plastics - General, Salinity, Water, ...**3.0405**

Dimensions, Expansion

PREPARATION OF SMALL TUBES AND THE DETERMINATION OF THEIR PROPERTIES FOR REVERSE OSMOSIS ...Mechanical Properties-general, Permeability, Pipe, Tube, Reverse Osmosis, Stretch Forming, Cryoform, ...**3.0387**

RESEARCH AND DEVELOPMENT OF ULTRATHIN FILM MEMBRANES FOR REVERSE OSMOSIS DESALINATION ...Brackish Water, Cellulosics, Desalination, Membranes-other, Reverse Osmosis, ...**3.0298**

CEMENT - AGGREGATE REACTION ...Aggregates, Extenders, Fillers, Alkali Metals-general, Cement, Concrete, Reaction-general, ...**8.0236**

INVESTIGATION OF CREEP IN CONCRETE ...Cement, Concrete, Creep, Water, ...**8.0240**

Electromagnetic Radiation

Color

INFLUENCE OF WATER QUALITY IN MAINTAINING WHITENESS WHEN LAUNDERING WHITE FABRICS ...Cleansing Agents, Cotton, Hardness-minerals, Laundering, Pollution - Effects of , Strength, Cohesion, ...**3.0382**

Physical Properties-general

RESEARCH ON PROPERTIES OF CEMENTITIOUS MATERIAL ...Cement, Concrete, Mechanical Properties-general, Standards, Specifications, Test Methods, ...**8.0249**

INVESTIGATION OF SHOTCRETE ...Cement, Concrete, Mechanical Properties-general, Test Methods, ...**8.0261**

REVIBRATION OF CONCRETE AND MASONRY ...Cement, Concrete, Concrete-other, Mechanical Vibrations-other, Standards, Specifications, Vibration, ...**8.0108**

Porosity, Permeability

RESEARCH ON POROUS GLASS MEMBRANES FOR REVERSE OSMOSIS ...Desalination, Fiber, Filament, Whisker, Glass, Membranes-other, Reverse Osmosis, Waste Water Treatment-other, ...**3.0068**

STORAGE AND CONVEYANCE OF IRRIGATION WATER ...Biological, Irrigation-general, Leekage, Linings-pavings, Stability, Weathering, ...**2.1071**

DEVELOPMENT AND EVALUATION OF TEST PROCEDURES FOR DETERMINING REACTIVE EXPANSION, AIR AND WATER PERMEABILITY, AND BONDING EFFICIENCY ...Adhesives, Bonding - Other, Cement, Concrete, Repairing, Test Methods, ...**8.0112**

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Mathematical Analysis

MODEL RIVER SYSTEM STUDIES ...Flume Studies, Model Studies, Radioactivity-general, Streams, Turbidity, ...**2.1010**

MOVEMENT OF RADIONUCLIDES IN THE COLUMBIA RIVER ESTUARY ...Columbia River, Estuaries, Pollutants - Path of , Radioactivity-general, Water Sampling, ...**5.0986**

DYNAMIC GROUND-WATER STORAGE ...Groundwater Movement, Storage of Water, Unsteady Flow, ...**2.0765**

THE PREDICTION AND OPTIMIZATION OF STREAM RESPONSES TO POLLUTANT WASTES ...Forecasting-prediction, Model Studies, Physical Parameters, Pollution - Effects of , Streams, ...**5.0743**

MATHEMATICAL SIMULATION OF CYCLIC SEDIMENTATION ...Deposition-other, Model Studies, Simulation Theory, ...**2.0131**

STUDIES OF THE PHYSICAL CHEMISTRY OF ELECTROLYTE SOLUTIONS ...Conductivity, Desalination, Electrolytes, Model Studies, Nuclear Magnetic, ...**1.0085**

OPTIMAL DESALINATION BY GEOMETRIC PROGRAMMING AND MATHEMATICAL DECOMPOSITION ...Cost Analysis, Decompositions, Desalination, Optimal Statistics, Other Programming, ...**3.0077**

THE DEVELOPMENT OF AN ANALYTICAL MODEL OF A FLASH STAGE ...Desalination, Flash Distillation, Model Studies, ...**3.0156**

INFLUENCE OF TOPOGRAPHIC FEATURES ON RAINFALL IN WEST VIRGINIA ...Forecasting, Patterns, Topographic Influences, Weather Charts-maps, West Virginia, ...**2.1140**

RECESSION CHARACTERISTICS OF IOWA STREAMS ...Iowa, Low Flow, Streams, Variation in Time, ...**5.0413**

DEVELOPMENT OF DRAINAGE ASSESSMENT PROCEDURES BASED ON PHYSICAL FEATURES IN ILLINOIS ...Benefit-cost Analysis, Drainage, Drainage Engineering, Illinois, Terrain Analysis, ...**6.0207**

EFFECTS OF AREAL AND TIME DISTRIBUTION OF RUNOFF SUPPLY ON WATERSHED HYDROGRAPHS ...Hydrographs, Model Studies, Other Model Modif, Runoff, Watersheds-general, ...**2.0666**

SEDIMENTATION AND IN-PLACE FILTRATION DURING FLOW THROUGH EARTH FRACTURES ...Analog Computers, Filtration, Joints-fractures, Model Studies, Sedimentology-general, ...**4.0018**

SOLAR HEATING OF WATER TO VERY HIGH TEMPERATURES ...Conductivity, Desalination, Medium Temperature - 300-1000k, Sunshine, Water, ...**3.0331**

GROUND WATER BASIN DYNAMICS ...Dispersion -water, Groundwater Basins, Model Studies, Natural Recharge, Ohio, ...**2.0851**

MASS TRANSFER AND CHEMICAL REACTION IN TWO PHASE FLOW ...Close Channel, Mass Transfer, Model Studies, Phase Relationship, Waste Water Treatment-general, ...**5.0225**

DEVELOPMENT OF A MATHEMATICAL MODEL TO PREDICT THE ROLE OF SURFACE RUNOFF AND GROUND WATER FLOW IN OVERFERTILIZATION OF SURFACE WATERS ...Eutrophication, Minnesota, Nutrients, Runoff, Surface Water, ...**5.0606**

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UNSTEADY FLOW TOWARD PARTIALLY PENETRATING ARTESIAN WELLS ...Artesian Flow, Groundwater Movement, Seepage, Unsteady, Unsteady Flow, ...**2.0522**

PLANT SOIL MOISTURE ENVIRONMENT AND ITS EFFECT ON WATER MOVEMENT INTO PLANT ROOTS ...Moisture Levels, Moisture Tension, Soil Environment, Soil-water-plant Relationships, ...**2.0521**

WATER QUALITY CRITERIA FOR SELECTED RECREATION USES ...Illinois, Pollution-water, Recreation Sites, User Characteristics -other, Water Quality-general, ...**5.0381**

STOCHASTIC ANALYSIS OF HYDROLOGIC SYSTEMS ...Computers-general, Model Studies, River Basins, Stochastic Models, Systems Analysis, ...**6.0203**

DECISION MODELS FOR MINIMIZING COST OF INFORMATION OR ERROR IN ESTIMATING BENEFIT-WATER RELATIONSHIPS IN IRRIGATION. (ABBREV) ...Benefit-cost Analysis, Irrigation-general, Model Studies, Reliability, Systems Analysis, ...**6.0359**

TIME DISTRIBUTION OF RAINFALL INTENSITIES ...Atmosphere Disturbance, Patterns, ...**2.0920**

FLOW ANALYSIS OF HYDRAULIC CONNECTORS IN ARTIFICIAL RECHARGE SYSTEMS ...Artificial Recharge, Flow Characteristics -water, Model Studies, ...**2.0859**

THE STORAGE COEFFICIENT AS A FUNCTION OF WATER TABLE CELERITY ...Drainage, Permeability, Storage of Water, Unsteady Flow, Water Table Fluctuation, ...**2.1121**

EFFECT OF PHYSICAL PROPERTIES OF POROUS MEDIA ON WATER MOVEMENT ...Permeability, Porosity, Porous Media - Flow Through, Size, Subsurface Flow, ...**2.0391**

QUANTIFICATION AND PREDICTION OF THE INFILTRATION PHASE OF THE HYDROLOGIC CYCLE ...Hydrographs, Infiltration, Internal Water Movement, Soil Environment, ...**2.0468**

DYNAMICS OF WATER INFILTRATION INTO SOIL AS GOVERNED BY SURFACE CRUSTING AND SEALING ...Infiltration, Moisture Tension, ...**2.0469**

DEVELOPMENT OF A MATHEMATICAL MODEL FOR THE SIMULATION OF FLAT-LAND WATERSHED HYDRAULICS ...Development of Models, Hydraulics-general, Model Studies, Technique Development, Wetlands, ...**4.0102**

MATHEMATICAL MANAGEMENT MODEL UNCONFINED AQUIFER ...Carbonate Aquifers, Groundwater, Management, Model Studies, Water Movement-general, ...**4.0246**

HYDROLOGIC ANALYSIS OF GROUNDWATER BASINS BY DIGITAL COMPUTER SIMULATION ...Aquifers-general, Digital Computers, Groundwater Basins, Groundwater Movement, Model Studies, ...**4.0043**

SYSTEM IDENTIFICATION AND MULTI-LEVEL OPTIMIZATION OF INTEGRATED GROUND WATER SYSTEMS ...Aquifers-general, Model Studies, Systems Analysis, ...**6.0062**

MODELING AND OPTIMIZATION OF WATER RESOURCES SYSTEMS ...Management, Model Studies, Multiple-purpose Projects, Optimization, Reservoirs and Impoundments, ...**6.0234**

THE INTERFLOW PROCESS ON SLOPING WATERSHED AREAS ...Forecasting-prediction, Groundwater Movement, Physical Properties-general, Rain-general, Tracers-general, ...**2.0961**

DELAWARE ESTUARY AND BAY WATER QUALITY SAMPLING AND MATHEMATICAL MODELING PROJECT ...Data Analysis - General, Delaware Bay, Model Studies, Pollution Abatement, Technique Development, ...**5.0749**

USE OF NEW ANALYTICAL METHODS FOR WATER RESOURCES DEVELOPMENT ...Optimization, Optimization Technique, Planning, Reservoirs and Impoundments, Water Resources Development, ...**6.0545**

A MATHEMATICAL MODEL FOR REGIONAL TREATMENT OF WATER POLLUTION SYSTEMS ...Estuaries, Public Utilities, Public Works, Regional Areas, Sewerage Systems-other, Value Analysis, ...**5.0114**

THERMAL STRATIFICATION IN RESERVOIRS ...Forecasting-prediction, Model Studies, Reservoirs and Impoundments, Stratification, Temperature, ...**2.0616**

INDUCED AIR MIXING OF LARGE BODIES OF POLLUTED WATER ...Aeration, Injector, Mixing, Model Studies, Organic Matter, ...**5.0477**

FORMULATION OF A GENERAL MATHEMATICAL MODEL FOR THE PREDICTION OF THERMAL ENERGY CHANGES IN IMPOUNDMENTS ...Columbia River, Forecasting-prediction, Model Studies, Reservoirs and Impoundments, Thermal Pollution, ...**5.0163**

MATHEMATICAL MODEL OF THE ELECTRODIALYSIS PROCESS FOR ADVANCED WASTE TREATMENT ...Electrodialysis, Process Design, Waste Water Treatment-general, ...**5.0531**

CHARACTERIZATION OF THE ACTIVATED SLUDGE PROCESS AT THE HYPERION TREATMENT PLANT ...Activated, California, Model Studies, Waste Water Treatment-general, Water Purification Plants, ...**5.0107**

DEVELOPMENT OF MATHEMATICAL MODEL OF SEWAGE SLUDGE FLUIDIZED BED INCINERATORS ...Computers-general, Disposal, Fluidized Bed, Model Studies, ...**5.0344**

MECHANICS OF DISPERSION IN ESTUARY POLLUTION ...Dispersion -water, Estuaries, Model Studies, Pollutants - Path of , Tides, ...**5.0528**

AMMONIA STRIPPING MATHEMATICAL MODEL FOR WASTE WATER TREATMENT ...Aeration, Ammonia, Finance, Model Studies, Waste Treatment-economics, ...**5.0337**

SNOW HYDROLOGY ...Arizona, Energy Budgets, Forest Watersheds, Snow, Snowmelt, ...**2.0064**

HYDRAULICS OF SURFACE IRRIGATION ...Channel Roughness, Flow Characteristics -water, Irrigation, Irrigation Engineering, Soils -general, Surface Irrigation -general, ...**2.0215**

HYDROLOGIC CHARACTERIZATION OF SMALL WATERSHEDS ...Aerial, Area, Illinois, Slopes, Small Watersheds, ...**6.0206**

MOVEMENT OF WATER AND GASES IN SOIL ...Density, Internal Water Movement, Physical Properties-general, Water Table Fluctuation, ...**2.0480**

HYDROLOGIC CHARACTERIZATION OF SMALL WATERSHEDS ...Flow Characteristics -water, Gaging, Model Studies, Small Watersheds, Topographic, ...**4.0104**

HYDROLOGIC CHARACTERIZATION OF SMALL WATERSHEDS ...Cold - Climates, Model Studies, Peak Flow, Runoff, Small Watersheds, ...**4.0143**

HYDRAULICS OF SURFACE IRRIGATION ...Model Studies, Surface Flow, Surface Irrigation -general, ...**3.0307**

BASE FLOW ANALYSIS OF SELECTED DRAINAGE BASINS. ...Baseflow, New Hampshire, Seasonal, Small Watersheds, ...**2.0742**

HYDROLOGIC CHARACTERIZATION OF SMALL WATERSHEDS ...Hydrology-general, Model Studies, Runoff, Small Watersheds, Stochastic Models, ...**4.0197**

HYDRAULICS OF SURFACE IRRIGATION ...Model Studies, Other Models, Surface Flow, Surface Irrigation -general, Unsteady Flow, ...**4.0268**

HYDRAULICS OF FLOOD MOVEMENTS ...Analog Computers, Floods, Open Channel Flow, Partial, Routing, Unsteady Flow, ...**2.0348**

STOCHASTIC ANALYSIS OF RAINFALL-RUNOFF RELATIONSHIP ...Amount, North Carolina, Runoff, Stochastic Processes, ...**2.0428**

SYSTEMS METHODOLOGY FOR WATER-RESOURCE PLANNING IN A REGIONAL DEVELOPMENT CONTEXT ...Economics-general, Regional Areas, Social Aspects, Systems Analysis, Water Resources Development, ...**6.0288**

ESTUARINE ECOLOGY ...Aquatic Ecology, Contamination - Water, Estuaries, Washington, Water Quality-general, ...**6.0620**

FLOW IN HETEROGENEOUS POROUS MEDIA ...Model Studies, Porous Media - Flow Through, Statistical Models, Two-phase-other, ...**8.0190**

GENERALIZED ANALYSIS OF SMALL WATERSHED RESPONSES ...Rain-general, Sequences - Series, Small Watersheds, Water Yield, ...**2.0085**

MATHEMATICAL MODELING OF SMALL WATERSHED FLOODS ...Floods, Model Studies, Rain-general, Runoff, Small Watersheds, ...**4.0073**

PILOT-STUDY OF SMALL WATERSHED HYDROLOGY ...Data Analysis - General, Floods, Instrumentation-general, Rain-general, Runoff, Small Watersheds, ...**2.0379**

THEORETICAL ANALYSIS OF REGIONAL GROUND-WATER FLOW IN THE HAVANA AREA ...Groundwater Movement, Illinois, Model Studies, Subsurface Flow, Water Table Fluctuation, ...**2.0410**

LAKE MICHIGAN WATER QUALITY MODEL ...Discharge-general, Hardness-minerals, Lake Michigan, Management, Water Quality-general, ...**6.0198**

MATHEMATICAL SIMULATION OF HYDROLOGIC EVENTS ON UNGAGED WATERSHEDS ...Hydrographs, Hydrology-general, Model Studies, Research - Development, Runoff, Watersheds-general, ...**2.0462**

HYDROLOGIC BEHAVIOR OF SELECTED WATERSHEDS IN THE NORTHERN APPALACHIAN REGION ...Clouds-precipitation, Forecasting-prediction, Model Studies, Runoff, Valley and Ridge Province, Watersheds-general, ...**2.0922**

WATERSHED WATER BUDGET ...Agricultural Watersheds, Evapotranspiration, Moisture Content, Runoff, Water Balance-budget, ...**2.1157**

SIMULATED OPEN CHANNEL HYDRAULICS ...Cumberland River, Model Studies, Numerical Analysis-other, Open Channel Flow, Tennessee, ...**2.0983**

TEMPERATURE DISTRIBUTION IN THE VICINITY OF WASTE HEAT DISCHARGES ...Electric Power Plants, Mixing, Stratification, Temperature, Thermal Pollution, ...**5.1120**

TRANSPORT PROCESSES IN FLUID FLOWS ...Clastic Aquifers, Dispersion -water, Dyes, Model Studies, Porous Media - Flow Through, ...**2.0368**

A TEST OF CERTAIN EVALUATION DESIGNS FOR CLOUD-SEEDING EXPERIMENTS ...Clouds-precipitation, Forecasting, Model Studies, Oklahoma, Weather Charts-maps, ...**2.0180**

DEVELOPMENT AND REFINEMENT OF METHODS FOR PREDICTING FIELD RUNOFF AND SOIL LOSS ...Conservation, Erosion-general, Forecasting-prediction, Runoff, Sediment Yield, Soil Environment, Soil Erosion -non-specific, ...**2.0477**

OPTIMUM UTILIZATION OF SURFACE AND SUBSURFACE WATER FACILITIES ...Aquifers-general, Conjunctive Use, Operations Research, Storage of Water, Survey Studies, ...**4.0110**

Analytical Methods

Decompositions

OPTIMAL DESALINATION BY GEOMETRIC PROGRAMMING AND MATHEMATICAL DECOMPOSITION ...Cost Analysis, Desalination, Mathematical Analysis, Optimal Statistics, Other Programming, ...**3.0077**

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Dynamic

WATER QUALITY MODELING AND PREDICTION ...Pollutants - Path of , Prediction Models, Quality Control, Waste Water Treatment-other, ...**5.0432**

DYNAMIC SYSTEM MODELING AND SIMULATION OF A RIVER BASIN ...Hybrid Computers, Michigan, Model Studies, River Basins, Stochastic Models, ...**6.0301**

Non-autonomous

SYSTEMS APPROACH TO FLOW PREDICTION IN WATER RESOURCE PLANNING ...Fourier Transform, Hydrology-general, Monte Carlo Methods, Prediction Models, Regression Analysis, Spectral Analysis, ...**2.0915**

THE FINITE ELEMENT METHOD IN FLUID MECHANICS ...Degradation, Finite Differences, Fluid Dynamics, Groundwater Movement, Saturated Flow, ...**5.0302**

Nonlinearity

WATER RESOURCE SYSTEM OPTIMIZATION BY GEOMETRIC PROGRAMMING ...Algorithms, Design of Experiments, Optimization, Optimization Technique, Research - Development, ...**6.0552**

Differential Equations

Ordinary

SIMULATION OF MULTISTAGE FLASH TEST MODULI (9-STAGE SAN DIEGO PLANT) ...Desalination, Development of Models, Digital Computers, Flash Distillation, Hybrid Computers, ...**3.0328**

SYSTEM ANALYSIS OF RAINFALL-RUNOFF RELATIONSHIP ...Amount, Digital Computers, Digital Computers, Runoff, Systems Analysis, ...**2.0427**

TRANSPORT MECHANISMS IN WATER FILTRATION ...Development of Models, Filtration, Flow of Dispersed Solids, Model Studies, Transport, ...**5.0811**

Partial

FREE-STREAMLINE FLOW OVER DISCONTINUITIES IN A BOUNDARY LAYER ...Boundary-layer-other, Differential Equations, Rotating Fluids, Supercavitating Flow, ...**2.0658**

LAMINAR AND TURBULENT FLOW OF FLUIDS THROUGH POROUS MEDIA ...Compressible Fluid, Incompressible Fluid, Porous Media - Flow Through, Statistics-general, ...**2.0227**

STUDY OF LOCAL WATER CONTAMINATION PROBLEMS ...Forecasting-prediction, Model Studies, Pollutants - Path of , Potable Water, Radioactivity-general, ...**5.0535**

HYDRAULICS OF FLOOD MOVEMENTS ...Analog Computers, Floods, Mathematical Analysis, Open Channel Flow, Routing, Unsteady Flow, ...**2.0348**

CONVECTIVE INSTABILITY IN TRANSIENT SYSTEMS ...Approximations, Stability, Transport-other, ...**1.0048**

NUMERICAL ANALYSIS OF TIME-DEPENDENT FREE SURFACE FLOWS ...Capillarity, Dimension-three, Finite Differences, Open Channel, Unsteady, ...**2.0441**

SOIL MOISTURE FLOW PROBLEMS AND SOLUTIONS IN THE CORN BELT REGION ...Corn Belt, Flow Characteristics -water, Internal Water Movement, Management-general, ...**2.0440**

Elasticity

ARCH DAM ANALYSES BASED ON THE MATHEMATICAL THEORY OF ELASTICITY ...Analysis Structural, Arch Dams, Development of Models, Engineering Structures-general, Foundations-general, ...**8.0089**

Integral Transforms

Fourier Transform

SYSTEMS APPROACH TO FLOW PREDICTION IN WATER RESOURCE PLANNING ...Hydrology-general, Monte Carlo Methods, Non-autonomous, Prediction Models, Regression Analysis, Spectral Analysis, ...**2.0915**

Laplace Transform

FLOW OF WATER INTO TILE DRAINS ON STRATIFIED SOILS ...Drainage Systems, Percolation, Seepage, ...**2.0486**

Measure - Integration

Integrals

TURBULENT BOUNDARY LAYERS IN PRESSURE GRADIENTS ...Analysis-other, Laminar - Turbulent, Pressure Gradient, Separation, ...**8.0181**

Sequences - Series

GENERALIZED ANALYSIS OF SMALL WATERSHED RESPONSES ...Mathematical Analysis, Rain-general, Small Watersheds, Water Yield, ...**2.0085**

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Models of Biological Systems

Physico - Chem - Metab

OXYGEN TRANSFER IN CONCENTRATED MICROBIAL SYSTEMS ...Degradation, Microbial-bacterial, Mixed Culture, Model Studies, Oxygen, ...**5.0801**

Mathematical Models

Development of Models

SIMULATION OF MULTISTAGE FLASH TEST MODULI (9-STAGE SAN DIEGO PLANT) ...Desalination, Digital Computers, Flash Distillation, Hybrid Computers, Ordinary, ...**3.0328**

EVAPORATION FROM SOIL SURFACES AS AFFECTED BY SALT, STRUCTURE AND TEXTURE ...Boundary Process (moisture), Computers-general, Evaporation, Saline Properties, Soil Morphology, Profiles, Water Movement-general, ...**2.0216**

STUDY OF FACTORS AFFECTING THE CHANNEL PHASE OF RUNOFF FROM SMALL WATERSHEDS BY MATHEMATICAL MODELING ...Finite Differences, Flow Characteristics - water, Runoff, Small Watersheds, Streams, ...**2.0665**

OPTIMIZATION OF STEP AERATION WASTE TREATMENT PROCESSES ...Aeration, Dynamic Programming, Optimization, Process Design, Systems Analysis, ...**5.0426**

THE DETERMINATION OF ZONES OF INTENSE CONTRIBUTION TO STREAM FLOW AS RELATED TO THE CONCEPT OF PARTIAL AREA CONTRIBUTIONS ...Digital Computers, Model Studies, Runoff, Synthetic Hydrology-general, Watersheds-general, ...**2.0580**

COMPUTER MODELS FOR WATER DISTRIBUTION SYSTEMS ...Algorithms, Laminar Flow, Model Studies, Water Allocation, Water Transfer, ...**8.0286**

DEVELOPMENT OF A STATE WATER PLANNING MODEL ...Application, Model Studies, Montana, Planning, River Basins, ...**6.0325**

THE DEVELOPMENT OF A SIMULATION MODEL FOR THE BEAR RIVER BASIN ...Analog Computers, Model Studies, Planning, River Basins, Utah, ...**6.0586**

EFFECTS OF FOREST COVER MANIPULATION ON WATER YIELD AS STUDIED BY AN ELECTRIC ANALOG ...Analog Computers, Forest Watersheds, Soils and Fertilizer, Washington, Water Yield, ...**3.0484**

DEVELOPMENT OF A MATHEMATICAL MODEL FOR THE SIMULATION OF FLAT-LAND WATERSHED HYDRAULICS ...Hydraulics-general, Mathematical Analysis, Model Studies, Technique Development, Wetlands, ...**4.0102**

DEVELOP A COMPUTERIZED METHODOLOGY FOR EVALUATION OF MUNICIPAL WATER CONSERVATION RESEARCH PROGRAMS ...Conservation-general, Cost Analysis, Digital Computers, Urban Environments, ...**3.0253**

STOCHASTIC BASIS FOR COMPREHENSIVE RIVER BASIN PLANNING ...Digital Computers, Monte Carlo Methods, New York, Planning, Stochastic Processes, Systems Analysis, ...**6.0374**

HYBRID COMPUTER SIMULATION OF GROUND-WATER BASINS ...Groundwater, Groundwater Basins, Hybrid Computers, Model Studies, Water Quality Control-general, ...**2.0106**

WATER UTILIZATION ASPECTS OF WEATHER MODIFICATION AS APPLIED TO KANSAS ...Amount, Clouds-precipitation, Kansas, Model Studies, Water Harvesting, ...**2.0505**

COMPUTER SIMULATION OF AQUIFERS OF COASTAL PLAIN OF NORTH CAROLINA ...Analog Computers, Carbonate Aquifers, Digital Computers, Model Studies, North Carolina, ...**2.0822**

DEVELOPMENT OF LAND USE EQUATIONS FOR THE SLOPING SOILS OF INDIANA ...Erosion-general, Indiana, Land Use, Slopes, Tillage, Cropping Systems, ...**2.0464**

COMPUTER-ORIENTED MATHEMATICAL MODEL FOR CONTINUOUS STREAMFLOW PREDICTION ...Amount, Computers-general, Discharge-general, Prediction Models, ...**2.0985**

ARCH DAM ANALYSES BASED ON THE MATHEMATICAL THEORY OF ELASTICITY ...Analysis Structural, Arch Dams, Elasticity, Engineering Structures-general, Foundations-general, ...**8.0089**

HIGH-VOLTAGE A-C TRANSMISSION ...Analog Computers, Digital Computers, Electrical Engineering-general, Power Transmission, Switching, ...**8.0056**

ENGINEERING ANALYSIS OF WASTE TREATMENT ...Activated Carbon, Digital Computers, Electrodialysis, Optimization, Sewerage Systems-other, ...**5.0861**

COMPUTERIZED DESIGN AND SYSTEMS ANALYSIS OF WASTEWATER TREATMENT PLANTS ...Application, Digital Computers, Forecasting-prediction, Systems Analysis, Waste Water Treatment-general, ...**6.0421**

TRANSPORT MECHANISMS IN WATER FILTRATION ...Filtration, Flow of Dispersed Solids, Model Studies, Ordinary, Transport, ...**5.0811**

Modification of Models

Applications

FLOW REGIMES IN POROUS MEDIA ...Flow Characteristics - water, Model Studies, Porosity, Porous Media - Flow Through, Viscous, ...**8.0189**

NUMERICAL PREDICTION OF CLOUDINESS AND PRECIPITATION ...Forecasting, Prediction Models, ...**2.0266**

Other Model Modif

EFFECTS OF AREAL AND TIME DISTRIBUTION OF RUNOFF SUPPLY ON WATERSHED HYDROGRAPHS ...Hydrographs, Mathematical Analysis, Model Studies, Runoff, Watersheds-general, ...**2.0666**

INTRODUCTION OF RISK AND UNCERTAINTY CONCEPTS TO OPTIMIZATION OF WATER RESOURCE SYSTEM DESIGN ...Application, Optimization, Optimization Technique, Risk & Uncertainty, Water Resources Development, ...**6.0548**

Other Models

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THE GROUND-WATER FLOW SYSTEM IN THE DELMARVA PENINSULA ...Aquifers-general, Delaware, Flow Characteristics -water, Groundwater, Water Balance-budget, ...**2.0254**

A LEGAL-ECONOMIC ANALYSIS OF ADMINISTRATIVE AND MARKET PROCEDURES USED IN THE TRANSFER OF WATER RIGHTS ...Administrative Structures, Economic Efficiency, Production - Supply, State Government, Water Allocation, Water Transfer, ...**2.0726**

THE EFFECT OF URBANIZATION ON RUNOFF IN SMALL WATERSHEDS ...Indiana, Land Use, Runoff, Small Watersheds, Urban Environments, ...**2.0458**

STORAGE OF FRESH WATER IN UNDERGROUND RESERVOIRS CONTAINING SALINE WATER ...Artificial Recharge, Flow Characteristics -water, Mixing, Recharge Pits - Wells, Storage of Water, ...**4.0115**

APPLICATION OF RADIOISOTOPO TECHNIQUES TO A CRITICAL WATER RESOURCES PROBLEM AREA (NUTRITIONAL POLLUTION) ...Algae, Nutrients, Phosphorus, Radioisotopes, ...**5.0919**

INVESTIGATION OF THE CIRCULATION OF LAKE SUPERIOR ...Circulation -water, Stratified Flow, Temperature, Velocity -water, ...**2.1161**

EVALUATION OF RESOURCE USE AND ECONOMIC EFFECTS DUE TO IRRIGATION WATER AVAILABILITY IN TEXAS ...Agriculture Industry, Economic Impact, Planning, Projections and Estimations, Texas, ...**6.0558**

SIMULATION OF WATER RESOURCE REGIMES ...Analog Computers, Estuaries, Groundwater, Surface Water, ...**7.0047**

MATHEMATICAL SIMULATION OF RAINFALL RUNOFF PROCESSES ...Computers-general, Hydrographs, Optimization, Other Computers, Runoff, Storms-general, ...**2.1015**

ECONOMIC IMPLICATIONS OF WATER POLICY IN ARIZONA ...Arizona, Economic Efficiency, Economic Impact, Legal Review, Water Resources Development, ...**6.0011**

EFFECTS OF AREAL AND TIME DISTRIBUTION OF RUNOFF SUPPLY ON WATERSHED HYDROGRAPHS ...Hydrographs, Mathematical Analysis, Other Model Modif, Runoff, Watersheds-general, ...**2.0666**

EFFECT OF RAINDROP IMPACT AND SURFACE ROUGHNESS ON SHEET FLOW ...Flow Characteristics -water, Rain-other, Rainfall Simulators, Roughness, Sheetflow, ...**2.0447**

ECONOMIC ANALYSIS OF ALTERNATIVE WATER POLLUTION CONTROL MEASURES ...Alternative Planning, Economics-general, Waste Water Treatment-general, Water Quality Control-general, ...**6.0231**

SEDIMENTATION AND IN-PLACE FILTRATION DURING FLOW THROUGH EARTH FRACTURES ...Analog Computers, Filtration, Joints-fractures, Mathematical Analysis, Sedimentology-general, ...**4.0018**

PREDICTION MODEL FOR WATER USE BY POPULATION STRUCTURE ...Florida, Forecasting-prediction, Other, Projections & Forecasting, Water Utilization -domestic, ...**6.0150**

PREDICTION MODELS FOR WATER QUALITY PARAMETERS ...Oxygen, Projections and Estimations, Social Aspects, Systems Analysis, Temperature, Water Standards, ...**6.0164**

INTERNAL CURRENTS RESULTING FROM INTERMEDIATE DENSITY INFLOWS INTO STRATIFIED RESERVOIRS ...Inflow, Reservoirs and Impoundments, Stratification, Stratified Flow, Temperature, ...**5.1264**

MAXIMIZING PRODUCTIVITY OF WATER USED FOR IRRIGATION OF AGRICULTURAL LANDS ...Irrigation-general, Optimization, Water - Alternative Uses, Water Allocation, ...**6.0610**

ECONOMIC IMPACT OF WATER IMPOUNDMENT - VALIDITY TESTING OF A COMPARATIVE- PROJECTION MODEL ...Economic Impact, Projections and Estimations, Recreation Sites, Reservoirs and Impoundments, Texas, ...**6.0554**

APPLICATION OF AN ELECTRONIC ANALOG COMPUTER TO THE SIMULATION OF THE TOTAL HYDROLOGIC-ECONOMIC FLOW SYSTEM ...Analog Computers, Economics-general, Hydrology-general, River Basins, ...**6.0585**

GROUND WATER BASIN DYNAMICS ...Dispersion -water, Groundwater Basins, Mathematical Analysis, Natural Recharge, Ohio, ...**2.0851**

THE USE OF SYSTEMS ANALYSIS IN THE DEVELOPMENT OF WATER RESOURCES MANAGEMENT PLANS FOR NEW YORK STATE ...Management, New York, Planning, Systems Analysis, ...**6.0373**

A CONTINUATION OF THE STUDY TO DETERMINE THE COSTS OF WATER IN INDUSTRIAL USES ...Benefit-cost Analysis, Computers-general, Industrial-general, Water Costs, Water Demand, ...**6.0468**

BENEFITS FROM INTEGRATED WATER MANAGEMENT IN THE NEW YORK METROPOLITAN REGION ...Administrative Structures, Management, New York, Urban Environments, Water Sources -general, ...**6.0393**

MULTISTRUCTURAL DEMAND MODELS FOR WATER REQUIREMENT FORECASTING ...Industrial-general, Projections and Estimations, Social Aspects, Water Demand, ...**6.0442**

DECISION MAKING UNDER UNCERTAINTY - ECONOMIC EVALUATION OF STREAMFLOW FORECASTS ...Benefit-cost Analysis, Flow Characteristics -water, Forecasting-prediction, Projections and Estimations, Water Supply-general, ...**6.0296**

SYSTEMS APPROACH TO WATER RESOURCE MANAGEMENT ...Administrative Structures, Economics-general, Legal Review, Social Aspects, Systems Analysis, Water Allocation, ...**6.0080**

DEVELOPMENT OF COMPUTER MODELS & METHODOLOGY FOR FORECASTING & EVALUATING MUNICIPAL & INDUSTRIAL WATER REQUIREMENTS ...Digital Computers, Maryland, Projections and Estimations, Urban Environments, Water Demand, ...**6.0252**

URBAN WATER POLITICS AND DECISION MAKING IN THE DETROIT METROPOLITAN REGION ...Decision Theory, Optimization Technique, Politics, Urban Environments, ...**6.0298**

UTILIZATION OF PHYSICAL AND MATHEMATICAL MODELS IN ESTUARINE WATER RESOURCES RESEARCH AND MANAGEMENT ...Computers-general, Estuaries, Management, Shoreline - Coastline, Tides, ...**6.0607**

ADAPTING THE WATER RESOURCE PLANNING PROCESS TO PROBLEMS AND NEEDS OF METROPOLITAN AREAS ...Planning, River Basins, Systems Analysis, Urban Environments, Water Resources Development, ...**6.0402**

A THREE DIMENSIONAL STUDY OF PARAMETERS RELATED TO THE CURRENT DISTRIBUTION IN LAKE ROOSEVELT ...Currents -water, Reservoirs and Impoundments, Stratification, Temperature, Water Quality-general, ...**5.1245**

HORIZONTAL DISPERSION IN SHALLOW ESTUARIES OF IRREGULAR SHAPE ...Circulation -water, Dispersion -water, Estuaries, Gulf of Mexico, Water Quality-general, ...**2.1013**

APPLICATION OF SIMULATION THEORY TO WATER RESOURCES PLANNING AND MANAGEMENT ...Management, Optimization, Planning, River Basins, ...**6.0340**

THEORETICAL AND EMPIRICAL STUDIES OF STOCHASTIC MODELS FOR THE ANALYSIS OF FLOOD CONTROL AND RELIEF POLICIES ...Alternative Planning, Floodproofing, Intergovernmental Relations, Other, Policy Making, ...**6.0047**

EXPERIMENTAL AND THEORETICAL STUDY OF THE HYDRODYNAMICS OF DISPERSION IN RIVERS AND ESTUARIES ...Dispersion -water, Estuaries, Flow Characteristics -water, Streams, Velocity -water, ...**2.0584**

PROGRAMMED SELECTION OF OPTIMUM USES OF A SMALL WATER RESOURCE SUBJECTED TO COMPLEX SIMULTANEOUS DEMAND STRESSES ...Computers-general, Optimization, Water - Alternative Uses, Water Demand, Water Supply-general, ...**6.0281**

PROCESS CONTROL MODEL FOR OXYGEN REGENERATION OF POLLUTED RIVERS ...Aeration, Automatic, Chemical Oxygen Demand, Detectors and Sensors, Oxygen, Streams, ...**5.0727**

DYNAMIC BEHAVIOR OF SOILS ...Deformation, Shear Strength, Soil Dynamics, Soil Environment, Soil Liquefaction, ...**8.0284**

NUMERICAL MODELING OF GROUND WATER FLOW ...Aquifers-general, Artificial Recharge, Groundwater Movement, Subsurface Flow, ...**2.0506**

SPATIAL BEHAVIOR OF ROUGHNESS IN LABORATORY WATERSHED, PHASE II ...Energy Loss -water, Roughness, Runoff, Structure-size, Surface Flow, Synthetic Hydrology-general, ...**2.0703**

COMPUTER SIMULATION OF THE HYDROLOGIC SYSTEM OF A MOUNTAIN WATERSHED ...Digital Computers, Groundwater, Hydrology-general, Mountains-alpine, Surface Water, Watersheds-other, ...**2.0707**

EVALUATION OF GROUNDWATER RESOURCES, LIVERMORE VALLEY, CALIFORNIA ...Data Acquisition-general, Groundwater Basins, Management, Subsurface Flow, Water Yield, ...**4.0025**

THE DETERMINATION OF ZONES OF INTENSE CONTRIBUTION TO STREAM FLOW AS RELATED TO THE CONCEPT OF PARTIAL AREA CONTRIBUTIONS ...Development of Models, Digital Computers, Runoff, Synthetic Hydrology-general, Watersheds-general, ...**2.0580**

DEVELOPMENT AND EVALUATION OF HYDROLOGIC SIMULATION MODELS ...Runoff, South Carolina, Synthetic Hydrology-general, Technique Development, Watersheds-general, ...**2.0954**

COMPUTER MODELS FOR WATER DISTRIBUTION SYSTEMS ...Algorithms, Development of Models, Laminar Flow, Water Allocation, Water Transfer, ...**8.0286**

MASS TRANSFER AND CHEMICAL REACTION IN TWO PHASE FLOW ...Close Channel, Mass Transfer, Mathematical Analysis, Phase Relationship, Waste Water Treatment-general, ...**5.0225**

PARAMETERIZATION OF THE OBSERVED HYDROGRAPH AS A MEANS OF UNDERSTANDING RUNOFF PHENOMENA FROM SMALL WATERSHEDS ...Forecasting-prediction, Hydrographs, Runoff, Small Watersheds, Vermont, ...**2.1085**

INVESTIGATION OF A LINEAR MODEL TO DESCRIBE THE HYDROLOGIC PHENOMENON OF DRAINAGE BASINS ...Amount, Hydrographs, Runoff, Small Watersheds, Testing of Models, ...**2.1041**

TIDAL EFFECTS ON GROUND WATER HYDRAULICS IN HAWAII ...Analog Computers, Groundwater, Hawaii, Hydraulics-general, Tides, ...**2.0378**

PHYSICAL, CHEMICAL AND MICROBIOLOGICAL FACTORS AFFECTING THE DISCHARGE OF WATER INTO DRAIN TILE ...Drainage, Drainage Engineering, Water Properties-general, ...**2.0145**

INVESTIGATION OF THE INFLUENCE OF VALENCE STATES OF IRON AND MANGANESE UPON THE BIOTA OF THE HYPOLIMNION ...Biological-general, Chemical-general, Electron Spin, Ions and Gases, Reservoirs and Impoundments, ...**5.0298**

ECONOMICS OF WATER QUALITY CONTROL IN THE UPPER MISSISSIPPI RIVER (MINNESOTA) ...Minnesota, Mississippi River, Optimization, Water Quality Control-general, Water Standards, ...**6.0311**

DYNAMIC SYSTEM MODELING AND SIMULATION OF A RIVER BASIN ...Dynamic, Hybrid Computers, Michigan, River Basins, Stochastic Models, ...**6.0301**

A SYSTEMATIC TREATMENT OF THE PROBLEM OF INFILTRATION ...Hysteresis, Infiltration, Moisture Content, Patterns, Soil Profile, ...**2.0219**

PHASE TWO - EXPERIMENTAL INVESTIGATION OF SMALL WATERSHED FLOODS ...Floods, Mathematical Analysis, Rain-general, Runoff, Small Watersheds, ...**2.0233**

A METHODOLOGY FOR PLANNING OPTIMAL REGIONAL WASTE MANAGEMENT SYSTEMS ...Effluents-waste Water, Management, Optimization, Regional Areas, Waste Water Treatment-general, ...**6.0280**

STOCHASTIC ANALYSIS OF HYDROLOGIC SYSTEMS ...Computers-general, Mathematical Analysis, River Basins, Stochastic Models, Systems Analysis, ...**6.0203**

SIMULATION MODEL FOR EVALUATION OF INTERCEPTION FROM FOREST TREES ...Digital Computers, Environment, Forests, Interception, Snow-general, ...**2.0390**

DECISION MODELS FOR MINIMIZING COST OF INFORMATION OR ERROR IN ESTIMATING BENEFIT-WATER RELATIONSHIPS IN IRRIGATION. (ABBREV) ...Benefit-cost Analysis, Irrigation-general, Mathematical Analysis, Reliability, Systems Analysis, ...**6.0359**

MODEL STUDY TO PREDICT SALT DISTRIBUTION AND CONCENTRATION OF WATER IN SOIL PROFILES ...Arid and Desert, Irrigation-general, Moisture Content, Saline Properties, Soil Chemical Properties, ...**5.0750**

EVALUATION OF SELECTED COMPUTER PROGRAMS IN HYDROLOGY ...Hydrology-general, Routing, Runoff, Spillways, Storm Water, ...**2.0659**

DEVELOPMENT OF A STATE WATER PLANNING MODEL ...Application, Development of Models, Montana, Planning, River Basins, ...**6.0325**

FLOW ANALYSIS OF HYDRAULIC CONNECTORS IN ARTIFICIAL RECHARGE SYSTEMS ...Artificial Recharge, Flow Characteristics -water, Mathematical Analysis, ...**2.0859**

EXPERIMENTAL INVESTIGATION OF HYDRAULIC TRANSIENTS IN RIVER-RESERVOIR SYSTEMS ...Hydraulics-general, Open Channel, Reservoirs, Streams, Transition Sections, ...**2.0993**

VERIFICATION OF MODELS USED IN THE MANAGEMENT AND CONTROL OF WATER QUALITY ...Disposal Wastes, Management, Washington, Water Quality Control-general, ...**5.1261**

THE DEVELOPMENT OF A SIMULATION MODEL FOR THE BEAR RIVER BASIN ...Analog Computers, Development of Models, Planning, River Basins, Utah, ...**6.0586**

LOSS COEFFICIENT IN A CHANNEL BEND WITH NATURALLY DEFORMED BED ...Energy Losses-other, Open Channel, Surface Phenomena, Transition Sections, Velocity, ...**2.0934**

PARTIAL AREA CONTRIBUTION TO STREAM FLOW ...Digital Computers, Flow Characteristics -water, Runoff, Water Yield, Watersheds-general, ...**2.0581**

EFFECT OF FORMATION DIP ON THE MOVEMENT OF FRESH WATER STORED IN SALINE AQUIFERS ...Aquifers-other, Artificial Recharge, Fresh Water, Local Structure, Storage of Water, ...**4.0122**

RELATIONSHIP OF ACTIVATED SLUDGE BULKING TO ORGANIC LOADING, OXYGEN AVAILABILITY, AND HYDRAULIC CHARACTERISTICS OF THE AERATION TANK ...Activated, Aeration, Organics, Process Design, ...**5.0879**

SORPTION AND DESORPTION OF CHLORINATED HYDROCARBON PESTICIDES IN AQUATIC SEDIMENT MINERALS ...Absorption, Fixation, Exchange, Adsorption Capacity, Adsorption-desorption, Equilibrium-other, Pesticides, ...**5.0690**

DEVELOPMENT OF A MATHEMATICAL MODEL FOR THE SIMULATION OF FLAT-LAND WATERSHED HYDRAULICS ...Development of Models, Hydraulics-general, Mathematical Analysis, Technique Development, Wetlands, ...**4.0102**

SYSTEMATIC ANALYSIS OF MANAGEMENT EFFECTIVENESS OF THE WATER QUALITY CONTROL BOARD SYSTEM OF CALIFORNIA ...California, Management, Operations Research, State-local Government, Water Quality Control-general, ...**6.0035**

MATHEMATICAL MANAGEMENT MODEL UNCONFINED AQUIFER ...Carbonate Aquifers, Groundwater, Management, Mathematical Analysis, Water Movement-general, ...**4.0246**

RESEARCH ON DATA AND ANALYTICAL SYSTEMS FOR PREPARING NATIONAL WATER ASSESSMENTS ...Data & Statistics Info Storage, Data Acquisition-general, Statistics-general, Water Quality-general, Water Quantity-general, ...**6.0397**

A GENERALIZED, PROBABILISTIC APPROACH TO REGIONAL WATER SUPPLY ASSESSMENT ...Available Water, Confidence Intervals, Patterns, Regional Areas, Runoff, ...**6.0059**

HYDROLOGIC ANALYSIS OF GROUNDWATER BASINS BY DIGITAL COMPUTER SIMULATION ...Aquifers-general, Digital Computers, Groundwater Basins, Groundwater Movement, Mathematical Analysis, ...**4.0043**

ECONOMIC EVALUATION OF WATER, A DYNAMIC INTER-REGIONAL INPUT-OUTPUT PROGRAMMING MODEL OF CALIFORNIA AND THE WESTERN STATES WATER ECONOMY ...Economics, Economics-general, Input - Output Analysis, Regional Areas, ...**6.0045**

SYSTEM IDENTIFICATION AND MULTI-LEVEL OPTIMIZATION OF INTEGRATED GROUND WATER SYSTEMS ...Aquifers-general, Mathematical Analysis, Systems Analysis, ...**6.0062**

MODELING AND OPTIMIZATION OF WATER RESOURCES SYSTEMS ...Management, Mathematical Analysis, Multiple-purpose Projects, Optimization, Reservoirs and Impoundments, ...**6.0234**

HYBRID COMPUTER SIMULATION OF GROUND-WATER BASINS ...Development of Models, Groundwater, Groundwater Basins, Hybrid Computers, Water Quality Control-general, ...**2.0106**

WATER UTILIZATION ASPECTS OF WEATHER MODIFICATION AS APPLIED TO KANSAS ...Amount, Clouds-precipitation, Development of Models, Kansas, Water Harvesting, ...**2.0505**

PLANNING ANALYSIS FOR THE NON-MARKET VALUES OF WATER RESOURCES WITH PARTICULAR EMPHASIS ON RECREATION ...Lakes, New York, Projected Demand, Recreation Sites, ...**6.0391**

RESERVOIR WATER QUALITY PREDICTION BASED ON LIMNOLOGICAL PARAMETERS ...Nutrients, Primary Productivity, Reservoirs and Impoundments, Water Properties-general, ...**5.1102**

A MODEL RELATING WATER QUALITY VEGETATIONAL STRUCTURE AND URBANIZATION IN THE SAN JACINTO RIVER BASIN ...Land Use, River Basins, Texas, Urban Environments, Water Quality-general, ...**4.0242**

A COMPUTER PROGRAM FOR FORECASTING POLLUTION AND DISSOLVED OXYGEN IN STREAMS ...Distributions, Forecasting-prediction, Oxygen, Stochastic Models, Water Quality-general, ...**5.1210**

UNSTEADY FLOW OF GROUNDWATER--DISPERSION AND SALT WATER INTRUSION IN NON-HOMOGENEOUS MEDIA ...Dispersion -water, Saline Water Intrusion, Unsteady, Unsteady Flow, ...**2.1159**

-MULTIPURPOSE RESERVOIRS AND URBAN DEVELOPMENT ...Land Use, Reservoirs and Impoundments, Urban Environments, ...**2.0823**

COMPUTER SIMULATION OF AQUIFERS OF COASTAL PLAIN OF NORTH CAROLINA ...Analog Computers, Carbonate Aquifers, Development of Models, Digital Computers, North Carolina, ...**2.0822**

ANALOG MODELING TO DETERMINE FRESH WATER AVAILABILITY ON THE OUTER BANKS OF NORTH CAROLINA ...Analog Computers, Groundwater, Groundwater Movement, North Carolina, Water Yield, ...**3.0375**

A WATER QUALITY COMPUTER MODEL OF COOK INLET (PHASE ONE - THE HYDRAULIC MODEL) ...Alaska, Computers-general, Estuaries, Hydraulics-general, Water Quality-general, ...**7.0002**

EXPLORATORY STUDY OF SOCIOLOGICAL ASPECTS OF WATER RESOURCES RESEARCH ...Methodology, Social Aspects, Social Change, ...**6.0405**

THE ECONOMICS OF WATER SUPPLY AND QUALITY ...Benefit-cost Analysis, Delaware River, Flow Augmentation, Pollution Abatement, Urban Environments, Water Allocation, ...**6.0286**

OXYGEN TRANSFER IN CONCENTRATED MICROBIAL SYSTEMS ...Degradation, Microbial-bacterial, Mixed Culture, Oxygen, Physico - Chem - Metab, ...**5.0801**

DYNAMIC MODEL STUDY OF LAKE ERIE ...Hydraulics-general, Inflow, Lake Erie, Synthetic Hydrology-general, ...**5.0766**

ECONOMIC EVALUATION OF WATER QUALITY ...Benefit-cost Analysis, Computers-general, Management, Systems Analysis, Waste Water Treatment-general, ...**6.0046**

VERTICAL CURRENT STRUCTURE IN THE GREAT LAKES ...Buoys, Currents -water, Forecasting-prediction, Great Lakes-general, Wind-water Interaction, ...**2.0632**

A MODEL FOR QUANTIFYING FLOW AUGMENTATION BENEFITS ...Flood Control, Flow Augmentation, Other Methods, River Basins, Systems Analysis, Water Distribution Systems, ...**6.0152**

DISPERSION DURING FLOW IN HETEROGENEOUS POROUS MEDIA ...Differential Equations General, Dispersion -water, Porous Media - Flow Through, Seepage, Statistical Models, ...**5.0394**

TURBULENT DIFFUSION AND REAERATION IN NATURAL RIVERS ...Aeration, Flow of Gas in Liquid, Mixing, Tracers-general, Turbulent Flow, ...**5.1136**

EUTROPHICATION FACTORS IN NORTH CENTRAL FLORIDA LAKES ...Administrative Structures, Eutrophication, Florida, Lakes, Systems Analysis, ...**5.0258**

EVALUATION OF AN OXIDATION-DITCH WASTEWATER TREATMENT PLANT IN SUBARCTIC ALASKA ...Chemical Oxygen Demand, Dilution-other, Sub - Polar, Waste Treatment-economics, ...**5.0038**

DELAWARE ESTUARY AND BAY WATER QUALITY SAMPLING AND MATHEMATICAL MODELING PROJECT ...Data Analysis - General, Delaware Bay, Mathematical Analysis, Pollution Abatement, Technique Development, ...**5.0749**

SEQUENTIAL USE WITHIN A HYDROLOGIC COMPLEX ...Hydrology-general, Management, Other Data Analysis, Systems Analysis, Water Quality-general, ...**5.1189**

A STOCHASTIC MODEL FOR POLLUTION IN ESTUARIES ...Estuaries, Ions and Gases, Oxygen, Water Quality Control-general, Water Quality-general, ...**5.1211**

MINERAL-WATER CHEMISTRY, GREAT LAKES ...Chemical Reactions, Great Lakes-general, Mineral Equilibra, Mineral Genesis, Phase Relationships, Solution Chemistry, ...**5.0552**

KINETICS OF ALGAL SYSTEMS IN WASTE TREATMENT ...Algae, Biological, Nutrients, Pilot Plant, Process Design, ...**5.0069**

THERMAL STRATIFICATION IN RESERVOIRS ...Forecasting-prediction, Mathematical Analysis, Reservoirs and Impoundments, Stratification, Temperature, ...**2.0616**

WATER-QUALITY REGIMEN OF TAHOE-TRUCKEE SYSTEM ...California, Digital Computers, Lakes, Nevada, Water Quality-general, ...**5.0706**

BIOLOGICAL TREATMENT OF ACID MINE WATER ...Acid Mine Wastes, Acidity, Anaerobic, Iron, Mining Activities, Process Design, ...**5.0795**

ENTERIC BACTERIAL DEGRADATION OF STREAM DETRITUS ...Bacterial Pollutant Sources, Intestinal Bacteria, Organic-general, Sanitation, Self-purification, ...**5.0291**

INDUCED AIR MIXING OF LARGE BODIES OF POLLUTED WATER ...Aeration, Injector, Mathematical Analysis, Mixing, Organic Matter, ...**5.0477**

COMPLEMENTARY - COMPETITIVE ASPECTS OF WATER STORAGE ...Benefit-cost Analysis, Computers-general, Reservoirs and Impoundments, Storage of Water, Water - Alternative Uses, ...**5.0144**

BIOLOGICAL MODELS OF FRESHWATER COMMUNITIES ...Aquatic Ecology, Fresh Water, Freshwater Ecology, Nutrients, Urban Environments, ...**5.1270**

MATHEMATICAL MODELS OF HYDROLOGIC SYSTEMS ...Economics-general, Hydraulic Structures, Open Channel, Unsteady, Unsteady Flow, Water Quality-general, ...**6.0382**

RENOVATION OF MUNICIPAL WASTEWATER BY REVERSE OSMOSIS SYSTEMS ...Depolymerization, Membranes-other, Process Design, Reverse Osmosis, Urban Environments, ...**5.0092**

MANAGEMENT OF INDUSTRIAL WASTE DISCHARGES IN COMPLEX ESTUARINE SYSTEMS ...Estuaries, Industrial Wastes, Management, Texas, Water Standards, ...**5.1156**

INVESTIGATION FOR CONTROL OF WATER POLLUTION FROM COMBINED SEWERS IN ROANOKE, VIRGINIA ...Alternative Planning, Combined Sewer, Rain Fall Intensity, Runoff, Sanitary Sewage Quantity-other, Storm Water, Water Quality Control-general, ...**5.1220**

FORMULATION OF A GENERAL MATHEMATICAL MODEL FOR THE PREDICTION OF THERMAL ENERGY CHANGES IN IMPOUNDMENTS ...Columbia River, Forecasting-prediction, Mathematical Analysis, Reservoirs and Impoundments, Thermal Pollution, ...**5.0163**

RESEARCH AND FIELD ENGINEERING STUDIES FOR OPTIMIZING LIPID BIOSTABILIZATION PROCESSES ...Anaerobic, Destratification, Fats -non-specific, Microorganisms (non-specific), Process Design, ...**5.0684**

CHARACTERIZATION OF THE ACTIVATED SLUDGE PROCESS AT THE HYPERION TREATMENT PLANT ...Activated, California, Mathematical Analysis, Waste Water Treatment-general, Water Purification Plants, ...**5.0107**

DEVELOPMENT OF A MATHEMATICAL MODEL FOR SEPARATION COAGULATION AND SEDIMENTATION PROCESS USING ADDITION OF CHEMICALS ...Coagulation, Lime Treatment, Process Design, Sedimentation, Waste Treatment-economics, ...**5.0343**

DEVELOPMENT OF MATHEMATICAL MODEL OF SEWAGE SLUDGE FLUIDIZED BED INCINERATORS ...Computers-general, Disposal, Fluidized Bed, Mathematical Analysis, ...**5.0344**

MECHANICS OF DISPERSION IN ESTUARY POLLUTION ...Dispersion -water, Estuaries, Mathematical Analysis, Pollutants - Path of , Tides, ...**5.0528**

AMMONIA STRIPPING MATHEMATICAL MODEL FOR WASTE WATER TREATMENT ...Aeration, Ammonia, Finance, Mathematical Analysis, Waste Treatment-economics, ...**5.0337**

PREDICTING THE EFFECT OF WATER QUALITY AND GYPSUM ON THE CHEMICAL AND PHYSICAL PROPERTIES OF SALINE AND ALKALI SOILS ...Calcium, Forecasting-prediction, Hydrated Acid and Norm, Pollution - Effects of , Soil Chemical Properties, ...**3.0013**

FACTORS INFLUENCING THE FLOW OF SUBSOIL WATER IN THE IMMEDIATE PROXIMITY OF, AND INTO DRAINAGE FACILITIES ...Capillarity, Drainage Systems, Grain Size and Distribution, Methods, Seepage, ...**2.0212**

EFFECT OF EXTERNAL AIR PRESSURE ON LIQUID FLOW THROUGH A POROUS MEDIUM ...Canals, Permeability, Physical Properties -other, Pressure-density, Seepage, ...**2.0392**

FACTORS INFLUENCING THE FLOW OF SUBSOIL WATER IN THE IMMEDIATE PROXIMITY OF AND INTO DRAINAGE FACILITIES ...Design Criteria, Drainage Systems, Flow Characteristics -water, Other, Seepage, ...**4.0088**

HYDROLOGIC CHARACTERIZATION OF SMALL WATERSHEDS ...Flow Characteristics -water, Gaging, Mathematical Analysis, Small Watersheds, Topographic, ...**4.0104**

HYDROLOGIC CHARACTERIZATION OF SMALL WATERSHEDS ...Cold - Climates, Mathematical Analysis, Peak Flow, Runoff, Small Watersheds, ...**4.0143**

DISTRIBUTION, APPLICATION AND USE OF WATER ...Furrow Irrigation, Irrigation Engineering, Moisture Content, Soil-water-plant Relationships, Water Yield, ...**3.0304**

HYDRAULICS OF SURFACE IRRIGATION ...Mathematical Analysis, Surface Flow, Surface Irrigation -general, ...**3.0307**

THE ECONOMICS OF WATER TRANSFER - AN APPRAISAL OF INSTITUTIONS ...Administrative Structures, Alternative Planning, Economic Efficiency, Legal Review, Water Transfer, Welfare Economics, ...**4.0169**

FLOW OF COLLOIDAL SUSPENSIONS IN POROUS MEDIA ...Colloidal Phenomena, Porous Media - Flow Through, Radioisotopes, Suspension, ...**2.0871**

HYDROLOGIC CHARACTERIZATION OF SMALL WATERSHEDS ...Hydrology-general, Mathematical Analysis, Runoff, Small Watersheds, Stochastic Models, ...**4.0197**

LAND AND WATER USE, CONSERVATION, AND DEVELOPMENT IN OKLAHOMA WATERSHEDS ...Administrative Structures, Agriculture, Floodplains, Floodproofing, Land, Land Use, ...**6.0443**

HYDRAULICS OF SURFACE IRRIGATION ...Irrigation Engineering, Math Models, Surface Flow, Surface Irrigation -general, Water Application Methods, ...**4.0252**

HYDRAULICS OF SURFACE IRRIGATION ...Mathematical Analysis, Other Models, Surface Flow, Surface Irrigation -general, Unsteady Flow, ...**4.0268**

ECONOMIC AND LEGAL FACTORS IN PROVIDING, USING AND MANAGING WATER RESOURCES IN AGRICULTURE ...Administrative Structures, Economic Impact, Impact, Policy Making, Recreation Sites, Social Aspects, Water Rights-general, ...**6.0646**

THE EFFECT OF HETEROGENEITIES OF THE SOIL UPON INFILTRATION ...Infiltration, Physical Properties -other, ...**2.1165**

WATER IN RELATION TO ECONOMIC GROWTH IN AN ARID ENVIRONMENT ...Arid and Desert, Arizona, Economic Impact, Groundwater, Water Costs, ...**6.0013**

TREATING AN INADEQUACY OF THE UNIT HYDROGRAPH HYPOTHESIS BY STORAGE ROUTING WITH VARIABLE EMPIRICAL VALUES OF LAG AND STORAGE ...Amount, Arizona, Hydrographs, Runoff, Storage of Water, ...**2.0063**

DESIGN OF INSTRUCTIONAL EQUIPMENT FOR LABORATORY DEMONSTRATIONS IN FLUID MECHANICS ...Tanks, Water Tunnels Tables, Wind Tunnels, ...**8.0194**

FREE SURFACE FLOW AND WAVE PROPAGATION THROUGH CHANNEL-FLOOD PLAIN GEOMETRIES ...Channels, Conduit Flow-other, Floodplains, Flow Characteristics -water, Free Surface Waves, ...**8.0196**

THE CHARACTERIZATION OF OVERLAND FLOW ON VERY ROUGH SURFACES ...Channel Roughness, Channels, Data Analysis Applications, Flow Characteristics -water, Surface Flow, ...**8.0192**

WATER POLLUTION STUDY OF THE WABASH RIVER ...Data Acquisition-general, Indiana, Low Flow, Oxygen, Water Quality-general, ...**5.0390**

SYSTEMATIC ANALYSIS OF THE MOISTURE-TEMPERATURE INTERACTIONS ON CORN YIELD ...Corn, Moisture Content, Yield, ...**2.0442**

COMPUTER SIMULATION AND EVALUATION OF CLIMATOLOGICAL MODELS ...Computers-general, Patterns, Statistics-general, ...**7.0044**

A REGIONAL STUDY OF THE CHANGING OCCUPANCY AND DEVELOPMENT OF AN ALLUVIAL LOWLAND ...Alluvial Deposits, Land Use, Management, Mississippi, Regional Areas, ...**7.0031**

FEASIBILITY OF RATING CURRENT METERS IN A VELOCITY FIELD ...Currents -water, Gaging, Mass, Velocity -water, ...**7.0107**

FLOW IN HETEROGENEOUS POROUS MEDIA ...Mathematical Analysis, Porous Media - Flow Through, Statistical Models, Two-phase-other, ...**8.0190**

PROJECTING THE DEMAND FOR AND SUPPLY OF WATER ...Projections and Estimations, Regional Areas, River Basins, Water Demand, Water Quality Control-general, Water Supply-general, ...**6.0357**

MATHEMATICAL MODEL OF STORM AND SANITARY INTERCEPTOR SYSTEM ...Design-other, Inflow, Peak Flow, Rain Fall Intensity, Storm Water, ...**5.0597**

HYDRAULIC STUDIES AND RESEARCH ON CALIFORNIA WATER FACILITIES ...Flow Characteristics -water, Fluid Flow-general, Irrigation, Irrigation-general, Synthetic Hydrology-general, ...**7.0010**

SACRAMENTO-SAN JOAQUIN DELTA ANALOG MODEL STUDIES ...Analog Computers, Deltas, Electronics - Applied, Instrumental Services, Sacramento River, ...**7.0008**

IRRIGATION IN RELATION TO CROPPING SYSTEMS ...Irrigation-general, Water Allocation, Water Costs, Water Sources - general, Water Yield, ...**6.0053**

A STUDY OF THE SOCIAL MECHANISM OF RURAL-URBAN WATER TRANSFERS WITH SPECIAL REFERENCE TO EXTERNAL EFFECTS ...Administrative Structures, Agriculture, Base Studies, Economic Efficiency, Fiscal, Social Aspects, Water Allocation, Water Transfer, Welfare Economics, ...**6.0105**

GROUND WATER RESOURCES ...Colorado, Groundwater, Management, Technique Development, Water Resources Development, ...**4.0067**

MATHEMATICAL MODELING OF SMALL WATERSHED FLOODS ...Floods, Mathematical Analysis, Rain-general, Runoff, Small Watersheds, ...**4.0073**

DEVELOPMENT OF COST CRITERIA FOR WATER SUPPLY ...Reservoirs and Impoundments, Water - Alternative Uses, Water Costs, Water Supply-general, Water Transfer, Water Wells, ...**4.0098**

THEORETICAL ANALYSIS OF REGIONAL GROUND-WATER FLOW IN THE HAVANA AREA ...Groundwater Movement, Illinois, Mathematical Analysis, Subsurface Flow, Water Table Fluctuation, ...**2.0410**

WATER RESOURCE DEVELOPMENT AND MANAGEMENT MODEL ...Alternative Planning, Available Water, State-local Government, Systems Analysis, Water Resources Development, ...**6.0201**

WATER QUALITY MODEL DERIVED FROM SYSTEM ANALYSES ...Management, Optimization, Systems Analysis, Water Quality-general, ...**6.0200**

MATHEMATICAL SIMULATION OF HYDROLOGIC EVENTS ON UNGAGED WATERSHEDS ...Hydrographs, Hydrology-general, Mathematical Analysis, Research - Development, Runoff, Watersheds-general, ...**2.0462**

AGRICULTURAL AND INDUSTRIAL DEVELOPMENT IN RELATION TO IOWAS ECONOMIC GROWTH ...Agriculture, Base Studies, Economics-general, Income, Iowa, Requirement and Resources, Water Resources Development, ...**7.0043**

IOWA ECONOMETRIC MODEL ...Economics-general, Iowa, Planning, Projections and Estimations, River Basins, ...**6.0225**

APPLICATION OF OPTIMIZATION TECHNIQUES TO PROBLEMS TO AGRICULTURE ...Analog Computers, Animal Waste Removal-treatment, Digital Computers, Optimization, Solid Waste, Waste Water Treatment-general, ...**5.0427**

EVALUATION OF MAGOTHY AQUIFER - ANNAPOLIS AREA ...Atlases-maps, Available Water, Clastic Aquifers, Maryland, Saline Water Intrusion, ...**2.0564**

A PHYSICAL AND ECONOMIC ANALYSIS OF ALTERNATIVE IRRIGATION METHODS IN A SUB-HUMID CLIMATE ...Applied Climatology, Evapotranspiration, Irrigation-general, Sub - Humid, Water Balance-budget, ...**3.0384**

THE EXTENT OF IRRIGATION DEVELOPMENT IN NORTH DAKOTA AND ITS ECONOMIC IMPACT ...Economic Impact, Impact, Irrigation-general, Production & Processing, Water - Alternative Uses, Water Resources Development, ...**3.0380**

HYDRAULICS OF WELLS ...Aquifers-other, Drawdown, Hydraulic Engineering-other, Unsteady Flow, Water Wells, ...**7.0077**

SUPPLY AND DEMAND FOR WATER ...Projections and Estimations, Water Costs, Water Demand, Water Supply-general, Water Transfer, ...**6.0385**

AN ECONOMIC EVALUATION OF WATER POLLUTION CONTROL, YAQUINA BAY, ORE ...Alternative Planning, Bays, Benefit-cost Analysis, Oregon, Systems Analysis, Water Quality Control-general, ...**6.0454**

SIMULATION AS A MEANS OF STUDYING RESOURCE ALLOCATIONS ...Alternative Planning, Economics-general, River Basins, Simulation Theory, Water Allocation, ...**6.0456**

DEVELOPMENT OF A MODEL RESOURCE ANALYSIS FOR RANGE WATERSHEDS ...Mapping, Quality and Utilization, Species and Species Evaluation, ...**6.0460**

HYDROLOGIC BEHAVIOR OF SELECTED WATERSHEDS IN THE NORTHERN APPALACHIAN REGION ...Clouds-precipitation, Forecasting-prediction, Mathematical Analysis, Runoff, Valley and Ridge Province, Watersheds-general, ...**2.0922**

METHODOLOGY FOR DETERMINING VALUATIONS OF WATER FOR ALTERNATIVE USES ...Economic Efficiency, Input - Output Analysis, Water - Alternative Uses, Water Allocation, Water Costs, ...**6.0592**

ELECTRONIC ANALOG MODEL STUDIES OF RIVER BASINS ...Analog Computers, Groundwater, Management, Precipitation-general, River Basins, Runoff, Water Cycle, Water Resources Development, ...**2.1059**

A STUDY OF THE INTEGRATION OF THE WATER RESOURCES OF THE BEAR, WEBER, AND JORDAN RIVERS IN NORTHERN UTAH ...Analog Computers, Analog Computers Math, Planning, Utah, Water Transfer, ...**6.0587**

INVESTIGATION OF RAINFALL DISTRIBUTION ON URBAN RUNOFF FOR IMPERVIOUS AREAS ...Drainage, Hydrographs, Patterns, Runoff, Urban Environments, ...**2.0306**

HYDROLOGIC MODEL FOR STREAMFLOW FORECASTING ...Flow Characteristics -water, Forecasting-prediction, Hydrographs, Peak Flow, Precipitation-general, Runoff, ...**2.0600**

ANALYSIS OF MIXING PHENOMENA ASSOCIATED WITH THE RISE OF GASEOUS BUBBLES THRU A STRATIFIELD LIQUID ...Bubbles, Destratification, Mixing, Salinity, Stratification, ...**1.0072**

SIMULATED OPEN CHANNEL HYDRAULICS ...Cumberland River, Mathematical Analysis, Numerical Analysis-other, Open Channel Flow, Tennessee, ...**2.0983**

DEVELOPMENT OF HYDROLOGIC ANALYSIS TECHNIQUES ...Computers-general, Data Analysis - General, Hydrology-general, Land Use, Technique Development, ...**2.0988**

EFFECTS OF TEMPERATURE ON AQUATIC LIFE ...Aquatic Ecology, Fish -non-specific, Productivity - Food Chain, Temperature, Warm Water, ...**5.1121**

GENERAL COASTAL INLET STUDIES ...Coastal Engineering-other, Coastlines-shorelines, Discharge-other, Synthetic Hydrology-general, Tides, Velocity -water, ...**2.0689**

GREAT LAKES RESEARCH - COASTAL AREA SEDIMENTATION ...Beach, Development, General Transport Effects, Great Lakes-general, Lakeshores-inlets, ...**2.0651**

GREAT LAKES RESEARCH - WATER-LEVEL DISTURBANCES ...Lake Erie, Lake Michigan, Seiches, Tides, Water Level Fluctuation, ...**2.0640**

GREAT LAKES RESEARCH - HARBOR CURRENTS ...Currents - water, Great Lakes-general, Harbors, Pressure-density, Water Level Fluctuation, Wind-general, ...**2.0642**

MECHANICS OF SAND MOVEMENT BY WAVES ...Ocean Waves - Currents, Shoreline Structures, Size, Wave Motion in Fluids-other, Waves, ...**2.0259**

HYDRAULIC INSTRUMENTATION ...Instrumentation-general, Technique Development, Turbulent Flow, Water Level Fluctuation, ...**7.0063**

HYDROLOGIC EFFECT OF VEGETATION MODIFICATION ...Hydrology-general, Modified Water Use, Water Development, Water Movement, Velocity, Water Yield, ...**3.0009**

TRANSPORT PROCESSES IN FLUID FLOWS ...Clastic Aquifers, Dispersion -water, Dyes, Mathematical Analysis, Porous Media - Flow Through, ...**2.0368**

SPATIAL DISTRIBUTION OF CHEMICAL CONSTITUENTS IN GROUND WATER ...Carbonates, Chemical-general, Groundwater, Sedimentary Petrogenesis, Solution Chemistry, Statistical, ...**1.0120**

ANALYTICAL MODEL OF THE LAND PHASE OF THE HYDROLOGIC CYCLE ...Hydrology-general, Water Cycle, ...**2.0117**

MATHEMATICAL GEOMORPHOLOGY ...Erosion, Features, Geomorphology-quantitative, Processes, Terrain Analysis, ...**2.0425**

ELECTRICAL ANALOG MODELS OF HYDROLOGIC SYSTEMS ...Analog Computers, Flow Characteristics -water, Groundwater, Groundwater Movement, Surface Water, ...**2.0037**

UNSTEADY FLOW AND SALINE INTRUSION IN ESTUARIES ...Channels, Estuaries, Open Channel Flow, Saline Water Intrusion, Unsteady Flow, ...**2.1091**

EVALUATION OF VARIABLES IN ALLUVIAL CHANNEL FLOW ...Bed Load, Channels, Flow Characteristics -water, Morphology-general, Velocity -water, ...**2.0237**

MILL CREEK VALLEY ANALOG MODEL STUDY, OHIO ...Analog Computers, Aquifers-general, Artificial Recharge, Ohio, Recharge Pits - Wells, ...**4.0195**

WATER RESOURCES, COLUMBUS, INDIANA AREA ...Alternative Planning, Clastic Aquifers, Groundwater, Indiana, Water Development, ...**2.0456**

ELECTRICAL-ANALOG ANALYSIS OF HYDROLOGIC DATA, ARVA VALLEY, ARIZ ...Analog Computers, Arizona, Groundwater, Pumping, Water Table Fluctuation, ...**2.0044**

NUMERICAL SIMULATION OF HYDRODYNAMIC PHENOMENA BY DIGITAL COMPUTER ...Groundwater, Open Channel Flow, Porous Media - Flow Through, Subsurface Flow, Waves, ...**2.1096**

RESERVOIR AND RIVER OPERATION PROCEDURES ...Available Water, Management, Optimization, Reservoirs and Impoundments, River Basins, ...**6.0095**

ENERGY DISSIPATORS ...Energy Dissipators, Fluid Dynamics, Technique Development, ...**8.0114**

DEVELOPMENT OF STANDARD DESIGNS FOR CANAL STRUCTURES ...Canals, Construction, Design Criteria, Energy Losses-general, Open Channel, ...**8.0064**

AQUIFERS AND DRAINAGE ...Aquifers-other, Brackish Water, Drainage, Groundwater Movement, Irrigation-general, ...**2.0166**

MODEL STUDY OF UNDERGROUND OPENINGS ...Dams-general, Foundations-general, Geology - Engineering, Rock Mechanics, Structural Analysis-general, Tunnel, ...**8.0067**

SOIL PRESSURES ON FLEXIBLE STEEL PIPE ...Pipes, Pressure-general, Soil-structure Interaction, Triaxial, ...**8.0072**

QUALITY OF WATER AS AFFECTED BY STRATIFIED FLOW (RESERVOIRS) ...Ions and Gases, Reservoirs and Impoundments, Stratification, Stratified Flow, Turbidity, ...**5.0185**

BEHAVIOR OF STRUCTURAL ELEMENTS OR MODELS UNDER TEMPERATURE AND DYNAMIC LOADS ...Dynamic-other, Earthquakes, Engineering Structures-general, Mechanical Vibrations-other, Structures-other, ...**8.0100**

SKYWATER--PARK RANGE FOREST HYDROLOGY ...Colorado, Forest Watersheds, Mountains-alpine, Topographic Influences, Weather Modification-general, ...**2.0172**

CONVECTIVE CLOUD SYSTEMS, NORTHERN GREAT PLAINS, ATMOSPHERIC WATER RESOURCES ...Cloud Structure, Clouds-precipitation, Convection, Cumulus, Great Plains Province, ...**2.0193**

PRODUCTION AND DETECTION OF ARTIFICIAL ICE NUCLEI ...Cloud Physics, Formation, Modification, Nucleation Physics, Precipitation Instruments, ...**2.0173**

HYDROLOGIC BEHAVIOR OF SELECTED WATERSHEDS IN THE NORTHERN APPALACHIAN REGION ...Appalachian Highlands-other, Clouds-precipitation, Flow Characteristics - water, Modification, Watersheds-general, ...**2.0184**

COASTAL DIFFUSION OF POLLUTANTS ...Currents-other, Ocean, Oregon, Outlet, Pulp and Paper Wastes, ...**5.0973**

HYDRAULIC DESIGN OF STRUCTURES FOR WATER USE AND CONTROL IN THE CORN BELT ...Construction, Corn Belt, Design Criteria, Routing, Water Control Works-general, ...**8.0216**

PRINCIPLES, FACILITIES, AND SYSTEMS FOR WATER HARVEST ...Rainfall Simulators, Runoff, Stabilization-other, Storage of Water, Water Harvesting, ...**3.0006**

IRRIGATION SYSTEMS FOR EFFICIENT WATER USE ...Evapotranspiration, Infiltration, Irrigation-general, Water Application Methods, Water Loss Control, ...**8.0003**

SURFACE AND SPRINKLER IRRIGATION SYSTEM DESIGN AND OPERATION FOR EFFICIENT WATER USE IN THE PACIFIC NORTHWEST ...Evapotranspiration, Irrigation, Sprinkler Irrigation, Surface Irrigation -general, Technique Development, ...**3.0204**

APPLICATIONS OF ANALOG COMPUTER SIMULATION TECHNIQUES FOR RUNOFF PREDICTIONS WITHIN THE REYNOLDS CREEK WATERSHED ...Analog Computers, Forecasting-prediction, Idaho, Runoff, Simulation Theory, ...**7.0106**

THE SIMULATION OF HYDROLOGIC EVENTS IN ARID REGIONS ...Analog Computers, Arid and Desert, Hydrology-general, Management, Surface Water, ...**2.1075**

LABORATORY CATCHMENT INVESTIGATIONS RELATING TO HYDROLOGIC SYSTEMS ANALYSIS ...Gaging, Hydrology-general, Morphology-general, Systems Analysis, ...**6.0574**

ECONOMICS OF ALTERNATIVE ROUTINES FOR DELIVERING IRRIGATION WATER ...Agriculture Industry, Economic Efficiency, Irrigation-general, Legal Review, Water - Alternative Uses, ...**6.0101**

THE ECONOMIC ANALYSIS OF WATER POLLUTION BY PESTICIDES AND OTHER AGRICULTURAL WASTES ...Agricultural Watersheds, Benefit-cost Analysis, Economic Impact, Pesticides -non-specific, Pollution, Pollution Abatement, ...5.0238

TRANSPORT MECHANISMS IN WATER FILTRATION ...Development of Models, Filtration, Flow of Dispersed Solids, Ordinary, Transport, ...5.0811

Model Studies-general

SOIL CHARACTERISTICS AFFECTING SUBSURFACE DRAINAGE ...Computers-general, Permeability, Void Ratio and Porosity, ...4.0194

PREDICTING NITRATE CONTENT OF AGRICULTURAL DRAIN WATER ...Agricultural Watersheds, Computers-general, Drainage, Moisture Content, Nitrate, Nitrite, Nitrogen, ...5.0181

Rheological

SOIL STRUCTURE - TILLAGE INTERACTIONS ...Deformation Mechanics, Other Water Conditions, Soil Environment, Soil-water-plant Relationships, Stability, ...2.0499

Models

Math Models

HYDRAULICS OF SURFACE IRRIGATION ...Irrigation Engineering, Measurement, Porous Media - Flow Through, Surface Flow, Surface Irrigation -general, ...2.0047

HYDRAULICS OF SURFACE IRRIGATION ...Irrigation Engineering, Model Studies, Surface Flow, Surface Irrigation -general, Water Application Methods, ...4.0252

Moisture Content -plants

WATER REQUIREMENTS BY SUGARCANE UNDER IRRIGATION ...Consumptive Use, Irrigation, Requirements for Water, Sugar Cane, ...3.0424

EFFECT OF WATER AVAILABILITY ON PHOTOSYNTHESIS OF PLANTS ...Available Water, Corn, Drought, Irrigation-general, Photosynthesis, Soybean, ...2.0426

WATER REQUIREMENT BY SUGARCANE UNDER IRRIGATION ...Evapotranspiration, Irrigation, Percolation, Requirements for Water, Sugarcane, ...2.0933

Moisture Meters

DEVELOPMENT AND EVALUATION OF IMPROVED TECHNIQUES TO MEASURE WATER-CONTENT OF SNOW ...Composition, Instrumental Services, Other Telemetry, Technique Development, Transducers, ...7.0103

SOIL WATER MOVEMENT ...Conservation-general, Groundwater Movement, Management, Moisture Tension, Movement, Availability, ...3.0245

THE USE OF WATER IN THE PRODUCTION OF HORTICULTURE CROPS ...Drought, Modified Water Use, Quality -non-specific, Soil-water-plant Relationships, ...2.0695

IMPROVING IRRIGATION WATER SUPPLY FORECASTS AND THEIR USE ...Forecasting-prediction, Frost and Permafrost, Irrigation-general, Moisture Content, Runoff, Water Yield, ...3.0401

INVESTIGATION OF BLOSSOM-END ROT OF PEAR TOMATOES ...Antitranspirants, Blossom End Rot, Modified Water Use, Tomatoes, Water-borne, ...2.1044

SOIL MOISTURE SURVEY FOR SOUTH PLAINS OF NORTHWEST TEXAS ...Moisture Content, Moisture Tension, Soil Depth, Texas, ...2.1051

Molecular Collisions

SCATTERING MEASUREMENTS ON ALKALI - WATER SYSTEMS ...Alkali Metals-general, Atomic Collisions, Other, Water, ...1.0022

Mollusks

Clams

RADIONUCLIDE METABOLISM IN AQUATIC ANIMALS ...Contamination - Water, Fish -non-specific, Metabolism, Radiation Effects-non-specific, Reactor Sites & Rad Waste, ...5.0101

ECOLOGY AND DISTRIBUTION OF OYSTERS AND CLAMS ...Chesapeake Bay, Commercial Fishing, Food Supply, Food Webs, Oysters, ...6.0268

HISTOPATHOLOGIC EFFECTS OF POLLUTANTS ON CELLS AND TISSUES OF MARINE INVERTEBRATES ...Computer Matching Code, Contamination - Water, Invertebrate Pathology, Pollution - Effects of , Pollution Effects, Pollution-other, ...5.1081

THE NORMAL ANATOMY AND HISTOLOGY OF SOME MARINE INVERTEBRATES ...Histology and Cytology, Invertebrate Anatomy, Pollution Effects, Water Quality-general, ...5.1095

THE DEVELOPMENT OF OPERATIONAL SHELLFISH DEPURATION AND RELAYING SYSTEMS ...Bacterial Pollutant Sources, Salmonella Typhimurium, Thermal Pollution, Trace Elements, ...5.1068

PURIFICATION OF HARD CLAMS FROM POLLUTED WATERS ...Animal Viruses (non-specific), Contamination - Water, Estuaries, Intestinal Bacteria, New Jersey, ...5.0729

ORGANISMS RESPONSIBLE FOR TOXICITY OF ALASKAN CLAMS ...Alaska, Biological Pollutants -general, Food Spoilage Detection, Microbiological, Pollutants-general, ...5.0032

MICROBIOLOGY OF ESTUARINE AND SHELLFISH POLLUTION ...Bioindicators, Estuaries, Oysters, Pollution Effects, Shellfish Depuration, Waste Water Treatment-general, ...5.0719

BACTERIAL DEPURATION OF WEST COAST SHELLFISH ...Oysters, Pilot Plants, Salinity, Shellfish Depuration, Turbidity, ...5.1229

Freshwater Mussels, Scallops

THE UPTAKE OF DIELDRIN IN THE THREE RIDGED NAIAD, AMBLEMA PLICATA ...Bioindicators, Dieldrin, Metabolism, Ohio River, Pollution Effects, ...5.0886

RELATIONSHIP OF THE SOURCE TO LEVELS OF TOXIC CHEMICALS IN SHELLFISH ...Heavy Elements, Industrial Wastes, Legal Standards, Pollutants - Path of , Pollution - Effects of , ...5.1073

EPIZOOTICS IN EXPERIMENTAL MARINE SHELLFISH POPULATIONS ...Epizootic, Mortality Rates, Oysters, Pathology, ...6.0631

Gastropods -slugs,conch,snails

CORRELATION OF STRUCTURE VS. ACTIVITY OF POLLUTANTS OF FRESH WATER ...Bioindicators , Molluscicides - non-specific, Pesticide-other, Screening Potential Pesticides, Thiocarbamate, N.s. , ...5.1050

EFFECT OF WATER TEMPERATURE AND/OR DISSOLVED OXYGEN REQUIREMENTS ON SELECTED MOLLUSKS ...Environmental Physiology, Freezing & Below, Gases, Dissolved - water, Oxygen, Warm Water, ...5.0555

ECOLOGICAL STUDIES OF LARVAL TREMATODES AND THEIR SNAIL-HOSTS IN THE LAKE CHAMPLAIN WATERSHED ...Aquatic, Aquatic Ecology, Digenea -other, Effect of Parasite on Host, Survey Studies, ...6.0396

Mollusks -non-specific & Other

A STUDY OF A POLLUTED RIVER, THE ILLINOIS ...Aquatic Ecology, Bioindicators, Contamination - Water, Fish -non-specific, Illinois River, ...2.0408

DISTRIBUTION AND ECOLOGY OF RIVER MOLLUSKS IN CENTRAL AND WESTERN NORTH DAKOTA ...Aquatic Ecology, North Dakota, Pollution - Effects of , Pollution Effects, Streams, ...6.0416

ECOLOGY OF COLORADO MOLLUSKS ...Colorado, Pollution - Effects of , Pollution -non-specific, Pollution Effects, Range Or Territorial Distr. , ...5.0178

THERMAL EFFECTS ON MARINE AND ESTUARINE SHELLFISH ...Aquatic Ecology, Crustacea -non-specific, Environmental Physiology, Pollution - Effects of , Water Temperature-non-specific, ...5.1251

VIBRIO PARAHAEMOLYTICUS IN THE ESTUARINE ENVIRONMENT ...Crustacea -non-specific, Estuaries, Isolation From Nat. environ. , Temporal Distribution, Vibrio N S, ...2.1115

TOXIC AND OTHER CHEMICALS IN MARINE BIOTA ...Bioassay, Dibrom, Diquat, Paraquat, ...5.1074

INVESTIGATIONS ON CIGUATERA-LIKE BIOTOXINS IN SHELLFISH ...Algal Culture, Algal Toxins, Bulk Culture -other, Crustacea -non-specific, Gymnodinium, ...5.0018

COOPERATIVE STUDIES WITH FEDERAL AND STATE AGENCIES ...Bioassays, Crustacea -non-specific, Public Health Ecology, Survey Studies, Water Quality-general, ...7.0111

GENERAL TECHNICAL ASSISTANCE ...Committee-support, Crustacea -non-specific, Shellfish Depuration, Water Quality-general, ...**5.1075**

Oysters

COLUMBIA RIVER STUDIES ...Columbia River, Contamination - Water, Invertebrates, Pollution Effects, Radioactivity-general, Reproductive System, ...**5.1268**

MASS MORTALITY OF PACIFIC OYSTERS ALONG THE WASHINGTON COAST ...Bays, Environmental Ecology, Mortality Rates, Pathology, Puget Sound, ...**5.1230**

MASS MORTALITY OF OYSTERS ALONG THE OREGON COAST ...Bays, Invertebrate Pathology, Mortality Rates, Oregon, Pathology, ...**5.0985**

CHARTING OF SUBTIDAL OYSTER BEDS AND EXPERIMENTAL TRANSPLANTING OF SEED OYSTERS FROM POLLUTED SEED OYSTER BEDS ...Captive Rearing, Commercial Fishing, Estuaries, South Carolina, Stocking of Fish & Shellfish, ...**5.1101**

OYSTER LEASE CONTROL MONUMENTS - BAY ADAM, BASTIAN BAY AND SANDY POINT BAY AREAS ...Commercial Fishing, Gulf of Mexico, Louisiana, Plane, Tides, ...**6.0249**

A FIELD AND LABORATORY STUDY OF FLUORIDE UPTAKE BY OYSTERS ...Estuaries, Fluoride, Laboratory, Metabolism, Mining Activities, Phosphate, Phosphite, ...**6.0407**

ENTERIC BACTERIA AND VIRUSES IN SEWAGE, WATER, AND SHELLFISH ...Bacterial Pollutant Sources, Coliforms (non-specific), Pollution Effects, Sewage, Viral Pollutant Sources, ...**5.0718**

STUDIES IN OYSTER PATHOLOGY ...Histology and Cytology, Mortality Rates, Pathology, ...**6.0630**

OIL CONTAMINATION OF OYSTERS FROM OIL WELL DRILLING MUDS ...Industrial Wastes, Oil, Petroleum Industry, Pollution Effects, ...**5.0449**

ECOLOGICAL FACTORS AFFECTING REPRODUCTION OF SHELLFISH (PHYSIOECOLOGY OF SHELLFISH PROGRAM) ...Connecticut, Environmental Ecology, Reproductive System, Spawn Or Nesting Sites, Water Properties-general, ...**6.0114**

CULTURE OF SHELLFISH IN ARTIFICIAL AND NATURAL SALT PONDS ...Captive Rearing, Commercial Fishing, Growth Rate, Maryland, Ponds, ...**6.0267**

POTENTIAL OYSTER SETTING CAPACITY - LOCAL AREAS ...Chesapeake Bay, Commercial Fishing, Other, Spawn Or Nesting Sites, Streams, ...**5.0507**

ECOLOGY AND DISTRIBUTION OF OYSTERS AND CLAMS ...Chesapeake Bay, Clams, Commercial Fishing, Food Supply, Food Webs, ...**6.0268**

SHELLFISH MORTALITY - CHESAPEAKE BAY ...Chesapeake Bay, Computer Matching Code, Mortality Rates, Pathology, Protozoa, ...**6.0264**

PESTICIDE MONITORING PROGRAM ...Bioindicators, Estuaries, Gas, Monitoring Systems, ...**5.0268**

MICROBIOLOGY OF MARINE AND ESTUARINE INVERTEBRATES ...Estuaries, Marine Bacteria (non-specific), Microbiological Analysis, ...**2.0586**

PACIFIC OYSTER MORTALITY STUDIES ...Invertebrate Pathology, Invertebrates, Mortality Rates, Pathology, ...**6.0266**

GROWTH, CONDITION, AND SURVIVAL OF SHELLFISH ...Adaptation, Environmental Physiology, Maryland, Water Quality-general, Water Salinity, ...**6.0269**

FREQUENCY DISTRIBUTION OF BIOLOGICAL POLLUTANTS IN SHELLFISH AND THE MARINE ENVIRONMENT ...Biology, Coliforms (non-specific), Enteroviruses of Humans, Gulf of Mexico, Pollution-water, ...**5.0016**

EPIZOOTICS IN EXPERIMENTAL MARINE SHELLFISH POPULATIONS ...Epizootic, Freshwater Mussels, Scallops, Mortality Rates, Pathology, ...**6.0631**

EFFECT OF ANTIBIOTICS ON FUNGUS PARASITES IN OYSTERS ...Antibiotics, Chemicals - Fungicides, Dermocystidium, Fungal Culture, Host Specificity, ...**5.1171**

BIOLOGICAL ACTIVITIES OF MARINE FUNGI ...Endoparasites - other, Host-parasite Interactions, Invertebrate Pathology, Marine Fungi (non-specific), Pathological Physiolog, Plant Developmental Biology, ...**5.0289**

CONTAMINATION OF OYSTERS BY PESTICIDES ...Dieldrin, Endrin, Mode of Action -animal, Residues in Foods, ...**5.0462**

MICROBIOLOGY OF ESTUARINE AND SHELLFISH POLLUTION ...Bioindicators, Clams, Estuaries, Pollution Effects, Shellfish Depuration, Waste Water Treatment-general, ...**5.0719**

DEPURATION OF CHEMICAL POLLUTANTS IN SHELLFISH ...Chromium, Contamination - Water, Metabolism, Pesticides - non-specific, Shellfish Depuration, ...**5.0020**

DEPURATION OF MICROBIAL POLLUTANTS IN SHELLFISH ...Microbiological, Shellfish Depuration, Ultra Violet, Viral Pollutant Sources, ...**5.0019**

OCEANOGRAPHIC DATA COLLECTION - MIDDLE PUGET SOUND ...Data Acquisition, Puget Sound, Salinity, Temperature, Trace Elements, ...**7.0112**

ACCUMULATION AND ELIMINATION OF VIRUSES BY SHELLFISH ...Enteroviruses of Humans, Pathology, ...**5.1227**

BACTERIAL DEPURATION OF WEST COAST SHELLFISH ...Clams, Pilot Plants, Salinity, Shellfish Depuration, Turbidity, ...**5.1229**

Monitoring (long Term Studies)

LAKE ERIE ENVIRONMENTAL STUDIES PROGRAM ...Biological , Biological-general, Chemical, Chemical-general, Deltas, Eutrophication, Lake Erie, Meteorological Studies-general, Physical-general, Sedimentology-general, ...**2.0783**

DEVELOPMENT OF A METHOD FOR CHRONIC TOXICITY BIOASSAY USING MARINE PLANKTONIC ALGAE ...Algal Culture, Bioassays, Marine Plants, Microbiological Analysis, Phytoplankton, Technique Development, Toxicology, ...**5.1088**

Monocots

Asparagus

INFLUENCE OF SOIL MOISTURE AND SOIL FERTILITY LEVELS ON ASPARAGUS YIELD AND QUALITY ...Coastal Plain, Moisture Content, Moisture Levels, Rates Or Levels of Application, ...**2.0760**

Elodea, Waterweed, Thalassia

THE ECOLOGY OF SELECTED SUBMERSED AQUATIC WEEDS ...Mineral Nutrition, of Aquatic Plants, Potamogeton, Ruppia, Zostera.., Submerged Plants, Water Milfoil, Waterweed... , ...**2.0764**

THE ECOLOGY OF SELECTED SUBMERSED AQUATIC WEEDS ...of Aquatic Plants, Potamogeton, Ruppia, Zostera.., Submerged Plants, Water Properties-general, ...**2.0805**

Grasses

Bahia Grass, Dallisgrass

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A STUDY OF BIOLOGICAL SYSTEMS IN THE SCIOTO RIVER AS INDICES TO WATER QUALITY ...Bioindicators, Chemical-general, Physical-general, Systems Analysis, Water Sampling, ...5.0875

RAPID-FLOW COMBUSTIBLE FILTER FOR TREATMENT OF COMBINED SEWER OVERFLOW ...Combined Sewer, Combustible, Rapid, Sewage Treatment Plant, Waste Treatment-economics, ...5.0871

MODIFICATION OF WHITTIER STREET STORM STANDBY TANKS ...Appurtenances, Combined Sewer, Pump, Runoff, Storm Water, ...5.0873

EFFECTS OF SOIL MANAGEMENT TREATMENTS ON ERODIBILITY AND INFILTRATION CHARACTERISTICS ...Infiltration, Management Effects, ...2.0860

FLORISTIC AND FAUNISTIC SURVEY IN THE CUYAHOGA RIVER WATERSHED ...Aquatic Ecology, Freshwater Ecology, Physical-general, Pollution - Effects of , Survey Studies, ...6.0436

A SURVEY OF PHYTOPLANKTON IN AND OLD AND A NEW RESERVOIR ...Algal Pollutant Sources, Phytoplankton, Reservoirs and Impoundments, ...6.0434

THE ROLE OF TEMPERATURE AND ILLUMINATION IN THE BIOLOGY OF OSCILLATORIA RUBESCENS ...Lakes, Optical Properties, Temperature, Temporal Distribution, ...6.0435

TROPHIC TYPOLOGY OF OHIO LAKES ...Eutrophication, Freshwater Ecology, Lakes, Nutrients, Plant Succession, ...5.0893

ECOLOGICAL SUCCESSION IN A NORTHEASTERN OHIO RESERVOIR ...Eutrophication, Nutrients, Plankton (non-specific), Plant Succession, Reservoirs and Impoundments, ...5.0894

THE ALGAE AND ZOOPLANKTON OF PROTECTED AND EXPLOITED LENTIC HABITATS IN NORTHEASTERN OHIO ...Algae- General, Aquatic Ecology, Freshwater Ecology, Habitat Studies, Zooplankton, ...6.0431

DAILY HEAT BUDGETS IN ENVIRONMENTAL FLUIDS ...Heat Budget, Heat Flow, Illinois, Temperature Or Heat Budgets, ...2.0405

EFFICIENT SYSTEM OF WATER QUALITY MANAGEMENT FOR THE MIAMI BASIN ...Alternative Planning, Economic Efficiency, Management, River Basins, Water Quality Control-general, ...5.1015

ACCUMULATION OF CLIMATOLOGICAL DATA ...Ash Trees, Flowering, Soil Depth, Soil Temp. -non-specific, ...7.0090

MILL CREEK VALLEY ANALOG MODEL STUDY, OHIO ...Analog Computers, Aquifers-general, Artificial Recharge, Model Studies, Recharge Pits - Wells, ...4.0195

SPRINGFIELD AREA INFILTRATION STUDY, OHIO ...Artificial Recharge, Clastic Aquifers, Flow Characteristics -water, Induced Infiltration, Water Yield, ...4.0196

Ohio River

DOCTORAL DISSERTATION RESEARCH IN GEOGRAPHY ...Data Analysis - General, General Synoptic Observations, Geography-physical, Humidity, Water Balance-budget, ...3.0392

THE UPTAKE OF DIELDRIN IN THE THREE RIDGED NAIAD, AMBLEMA PLICATA ...Bioindicators, Dieldrin, Freshwater Mussels, Scallops, Metabolism, Pollution Effects, ...5.0886

A STUDY OF THE QUALITY OF INDIANA SURFACE WATERS ...Indiana, Ions and Gases, Lake Michigan, Surface Water, Water Quality-general, ...5.0389

SHEAR EVALUATION OF WEAK ROCK FOUNDATIONS ...Cement, Concrete, Foundations, Joining, Bonding-general, Shear Strength, Soil Test - Insitu, ...8.0273

PROTOTYPE ANALYSIS-STRUCTURAL BEHAVIOR ...Gravity Dams, Mass, Piezometers, Seepage, Uplift, ...8.0149

Oil - Technological Testing

MARINE OIL-WATER MONITORING INSTRUMENTATION SYSTEM SUBGROUP V ...Detectors, Industrial Waste-other, Infrared, Infrared Radiation, Instrumental Services, Oil, ...5.0336

USE OF COAGULATION IN THE FLOTATION OF WASTEWATER ...Biochemical Oxygen Demand, Coagulation, Flotation, Industrial Wastes, Primary Treatment, ...5.0338

FILTRATION OF AQUEOUS EFFLUENTS CARRYING EMULSIFIED OILS ...Coagulation, Effluents-waste Water, Emulsion, Filter-other, ...1.0008

Oil and Natural Gas - Sulfur

Drilling Operation

DRILL PERFORMANCE MONITOR ...Borehole Geophysics, Foundations-general, Pressure, Soil Exploration, Temperature, ...8.0097

Fluid Properties

ANALYTICAL METHODS - OILFIELD WATER CHEMISTRY ...Brines, Chemical Analysis (water), General, Technique Development, ...2.0874

SOLUBILITIES OF THE SULFATES OF BARIUM AND STRONTIUM IN OILFIELD WATERS ...Barium, Brines, Radioisotopes, Solution Chemistry, Strontium, Thermal Properties-other, ...1.0097

Recovery - Production

General

ANALYTICAL METHODS - OILFIELD WATER CHEMISTRY ...Brines, Chemical Analysis (water), Fluid Properties, Technique Development, ...2.0874

Primary Recovery

CHEMISTRY OF SUBSURFACE OILFIELD BRINES ...Brines, Chemical-general, Fresh Water, ...2.0873

Secondary Recovery

REUSE OF WASTE IRRIGATION WATER TO RECOVER ADDITIONAL PETROLEUM BY WATERFLOODING ...Chemical Analysis (water), D.t.a. , Irrigation-other, Petroleum Industry, Spectroscopy-general, Water Reuse, ...5.0154

MINING-POLLUTION CONTROL TECHNOLOGY - OIL PRODUCTION GROUND-WATER RECLAMATION BY SELECTIVE PUMPING ...Brines, Groundwater, Mine Drainage Control, Petroleum Industry, Pumping, Saline Water Intrusion, ...5.0913

Oklahoma

INVESTIGATION AND ANALYSIS OF FLOODS FROM SMALL WATERSHEDS IN OKLAHOMA ...Floods, Flow Characteristics -water, Gaging, Peak Flow, Small Watersheds, ...2.0278

SUMMER RESEARCH AT THE UNIVERSITY OF OKLAHOMA BIOLOGICAL STATION ...Personnel, Research Facilities, Training Grants, Fellowships, Water Resources - General, ...9.0011

ASSESSMENT OF ENVIRONMENT FACTORS INFLUENCING THE DISTRIBUTION OF BOTTOM FISHES IN RESERVOIRS ...Nets, Organic, Physical Properties-general, Reservoirs and Impoundments, Turbidity & Suspended Matter, ...5.0924

WATER RESOURCES PLANNING STUDIES - ARKANSAS AND OKLAHOMA ...Arkansas, Daily, River Basins, Water Allocation, Water Quality-general, ...6.0028

COMPARISON OF ENERGY FLOW PARAMETERS OF MIDGE POPULATIONS IN BIOLOGICAL OXIDATION PONDS ...Bloodworms, Aquatic Midges, Energy Budgets, Pollution Effects, Productivity - Food Chain, Sewage Lagoons, ...5.0929

A PRELIMINARY ANALYSIS OF THE IMPACT OF THE ARKANSAS WATERWAY ON LAND TENURE AND VALUE IN OKLAHOMA ...Economic Impact, Engineering Structures-general, Land, ...6.0446

STUDIES OF THE SOIL-MOISTURE-PLANT REGIME FOR THE CONDITIONS OF WESTERN OKLAHOMA ...Analog Computers, Climate-general, Consumptive Use, Evapotranspiration, Soil-water-plant Relationships, ...2.0880

RADIO METHODS FOR DETERMINING WATER VAPOR CONTENT OF AIR ...Evaporation, Heat Budget, Humidity, Humidity Instruments, Reservoirs and Impoundments, Transmission Characteristics, Velocity, Water Loss Control, ...3.0114

A TEST OF CERTAIN EVALUATION DESIGNS FOR CLOUD-SEEDING EXPERIMENTS ...Clouds-precipitation, Forecasting, Mathematical Analysis, Model Studies, Weather Charts-maps, ...2.0180

A STUDY OF NATURAL EVAPORATION FROM FREE WATER SURFACES ...Boundary Layer Studies, Evaporation, Patterns, Water Loss Control, Waves, ...3.0129

EFFECT OF IMPOUNDMENTS ON WATER QUALITY ...Optimization, Pre-impoundment Sites, Reservoirs and Impoundments, Water Quality Control-general, Water Sampling, ...5.0904

DYNAMICS OF RESERVOIR DESTRATIFICATION ...Aeration, Destratification, Diffuser, Reservoirs and Impoundments, Rotating Fluids, ...5.0911

Operations Research

WATER SUPPLY-DEMAND ...New York, Planning, Projections and Estimations, Water Demand, Water Supply-general, ...2.0795

WATER RESOURCE OPERATIONS STUDY ...Conjunctive Use, Planning, Water Cycle, Weather Modification-general, Wyoming, ...6.0652

OPERATIONS RESEARCH STUDY OF WATER RESOURCES DEVELOPMENT AND MANAGEMENT IN THE TUCSON AREA ...Arizona, Management, Optimization Technique, Research - Development, Simulation Theory, Water Resources Development, ...6.0015

DEVELOPEMNT AND IMPLEMENTATION OF A MANAGEMENT STRATEGY FOR WATER RESOURCES RESEARCH ...Management, Planning, Projections and Estimations, Systems Analysis, Water Resources Development, ...6.0112

A STUDY OF WATER RESOURCES RESEARCH NEEDS IN MONTANA ...Montana, Projections and Estimations, Water Resources Development, ...6.0326

APPLICATION OF OPERATIONS RESEARCH TECHNIQUES FOR ALLOCATION OF COLORADO RIVER WATERS IN UTAH ...Colorado River, Optimization, Utah, Water Allocation, ...6.0575

THE DECISION SEQUENCE IN WATER RESOURCE PLANNING ...Decision Making, Decision Theory, Planning, ...6.0069

SYSTEMATIC ANALYSIS OF MANAGEMENT EFFECTIVENESS OF THE WATER QUALITY CONTROL BOARD SYSTEM OF CALIFORNIA ...California, Management, Model Studies, State-local Government, Water Quality Control-general, ...6.0035

RESEARCH ON DECISION MAKING AND RELATED MANAGERIAL ASPECTS OF BRITISH WATER RESOURCES PROGRAMS ...Administrative Structures, British Isles, Management, Water Law-general, ...6.0381

OPERATIONS RESEARCH IN WATER QUALITY MANAGEMENT ...Channel Regulation-other, Control and Protection, Engineering Structures-general, Management, Water Quality Control-general, ...5.0526

DATA COLLECTION ECONOMICS FOR WATER POLLUTION STUDIES ...Data Acquisition-general, Economic Efficiency, Water Quality Control-general, ...7.0055

DEVELOPMENT OF METHODS FOR PLANNING AND TIMING OF WATER RESOURCES INVESTMENTS ...Finance, Multiple-purpose Projects, Planning, Risk & Uncertainty, Water Resources Development, ...6.0065

WATER RESOURCES SYSTEM ANALYSIS ...Water Resources Development, ...6.0204

REGIONAL UTILITIES STUDY-WATER SUPPLY, SEWERAGE, DRAINAGE AND REFUSE DISPOSAL ...Connecticut, Municipal-waste-other, Planning, Sewage, Water Supply-general, ...5.0207

RESERVOIR WATER QUALITY INVESTIGATION ...Forecasting-prediction, Planning, Reservoirs and Impoundments, Storage of Water, Water Quality Control-general, ...5.0237

OPTIMUM UTILIZATION OF SURFACE AND SUBSURFACE WATER FACILITIES ...Aquifers-general, Conjunctive Use, Mathematical Analysis, Storage of Water, Survey Studies, ...4.0110

Optical Devices

OIL SLICK ANALYSES ...Aircraft, Instrumental Services, Oil, Satellites, Transducers, ...6.0275

Optical Techniques

Colorimetric

DEVELOPMENT OF FIELD TEST FOR FREE CHLORINE ...Bromine, Chlorine, Membranes-other, Sterilants, Technique Development, ...5.0808

(U) DETERMINATION OF FREE BROMINE IN WATER (US 14) ...Amines, Analysis and Detection, Bromine, Chlorine, ...5.0372

AN ANALYSIS OF PHOSPHORUS AND NITROGEN COMPOUNDS IN TIDAL MARSHLAND DRAINAGE - LABORATORY PROCEDURES ...Computers-general, Conductrometry, Management, Nitrogen, Phosphate, Phosphite, Swamps-marshes, ...1.0024

LIGAND EXCHANGE REAGENTS ...Complexes, Compound, Dyes and Coloring, Ion Exchange-other, Spectroscopy-other, ...5.0431

FIELD TECHNIQUES FOR CHEMICAL ANALYSIS OF WETLAND CRITERIA ...Chemical Analysis (water), Chromatography-other, Translation Grants, Wetlands, ...1.0091

METHODS OF ANALYSIS FOR INSECT-CONTROL CHEMICALS ...Chemical Analysis, Extraction-other, Gas, Reaction-general, Spectroscopy-other, ...5.0491

Light Scattering

THE MECHANISM FOR FORMATION OF A SKINNED TYPE MEMBRANE ...Desalination, Evaporation, Interface, Membranes-other, Solvent-other, ...3.0265

COMPARISON OF OPTICAL PROPERTIES WITH DIRECT MEASUREMENTS OF CONCENTRATION AND SIZE DISTRIBUTION OF SUSPENDED MATERIALS ...Chesapeake Bay, Fluorometry, Optical Properties, Size, Turbidity, ...2.0559

Refractometry

SOLAR REFLECTANCE OF MONOLAYER-COVERED WATER SURFACES AS RELATED TO EVAPORATION SUPPRESSION ...Evaporation, Evaporation Control, Monolayers, Organics-general, Water Loss Control, ...2.1110

Optics

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Optical Systems

MEASUREMENT OF WATER VAPOR FLUX ABOVE A LAKE SURFACE BY MEANS OF OPTICAL TECHNIQUES ...Absorption Spectra, Humidity Instruments, Infrared, Infrared Radiation, Water, ...2.0811

Oregon

CRATER LAKE VERTICAL TEMPERATURE PROFILES ...Electronics - Applied, Lakes, Radioactive Fallout, Temperature, Water Sampling, ...2.0101

ECOLOGICAL-PHYSIOLOGICAL INVESTIGATIONS OF LITTORAL DIATOM COMMUNITIES OF THE YAQUINA RIVER ESTUARY ...Algae- Diatoms, Environment, Intertidal Areas, Physiological Ecology, ...5.0949

INVESTIGATE THE FEASIBILITY OF INTRODUCING SOCKEYE SALMON INTO RESERVOIRS ...Reservoirs and Impoundments, Salmon -coho,chinook,sockeye.., Stocking of Fish & Shellfish, ...6.0464

MASS MORTALITY OF OYSTERS ALONG THE OREGON COAST ...Bays, Invertebrate Pathology, Mortality Rates, Oysters, Pathology, ...5.0985

A CLASSIFICATION OF THE LAKES OF THE STATE OF OREGON ...Data Acquisition-general, Lakes, Survey Studies, Water Properties-general, ...2.0891

SOCIO-CULTURAL IMPACTS OF WATER RESOURCE DEVELOPMENT IN THE SANTIAM ...Attitudes & Attitude Change, Economic Impact, Reservoirs and Impoundments, Social Aspects, Water Resources Development, ...6.0457

SEDIMENT-WATER-BACTERIA INTERACTIONS IN EUTROPHICATION ...Deposits-other, Eutrophication, Lakes, Nutrients, Water Bacteria, ...5.0953

NATIONAL SYMPOSIUM ON THERMAL POLLUTION ...Management, Meetings, Pollution - Effects of , Tennessee, Thermal Pollution, ...5.1138

MATHEMATICAL AND COMPUTER SERVICES FOR THE ANALYSIS OF DATA AND DESIGN OF EXPERIMENTS FOR CERTAIN FWPCA PROGRAMS ...Computers-general, Data Analysis - General, Facilities, Instrumental Services, ...5.0934

BIONOMICS OF FISHES AND SHELLFISHES ...Aquaculture & Fish-farming, Bays, Economics-general, Environmental Ecology, Productivity - Food Chain, ...2.0896

EPIDEMIOLOGICAL RELATIONSHIPS OF PESTICIDE APPLICATION TO PESTICIDE RESIDUES IN WILDLIFE TISSUES AND HABITATS ...Aquatic Ecology, Habitat Studies, Terrestrial -other, Wildlife -non-specific, ...5.0960

EVALUATION OF UPSTREAM AND DOWNSTREAM ANADROMOUS FISH PASSAGE AT RIVER MILL AND FARADAY DAMS ON THE CLACKAMAS RIVER, OREGON ...Engineering Structures-general, Management -other, Migration, Rainbow Trout, Steelhead Trout, Reservoirs and Impoundments, ...8.0279

OREGON FISHES - THEIR CLASSIFICATIONS, DISTRIBUTIONS AND LIFE HISTORIES ...Animal Taxonomy, Fresh Water, Life History Studies, Vertical Distribution, ...6.0450

VEGETABLE CROPS FERTILIZER, PLANT NUTRITION, AND IRRIGATION PROBLEMS ...Aerial, Irrigation, Irrigation-general, Root, Soil Fertility -non-specific, ...2.0895

AN ECONOMIC EVALUATION OF WATER POLLUTION CONTROL, YAQUINA BAY, ORE ...Alternative Planning, Bays, Benefit-cost Analysis, Model Studies, Systems Analysis, Water Quality Control-general, ...6.0454

ECOLOGY OF SPRING CHINOOK SALMON ...Aquatic Ecology, Life History Studies, Productivity - Food Chain, Salmon - coho,chinook,sockeye.., Streams, ...6.0447

RELATIONS OF NUISANCE ALGAE TO FISH IN KLAMATH LAKE ...Algal Toxins, Bioassays, Cyanophyta (non-specific & Ot), Fish -non-specific, Lakes, ...5.0937

FACTORS INFLUENCING THE FRESHWATER RESIDENCE OF JUVENILE FALL CHINOOK SALMON ...Aquatic Ecology, Fresh Water, Life History Studies, Salmon -coho,chinook,sockeye.., Streams, ...6.0448

GENERAL SOIL MAPS OF REGIONS IN OREGON WITH POTENTIAL FOR IRRIGATION ...Aerospatial, Irrigation-general, Mapping, Saline Properties, Soil Morphology, Profiles, ...6.0463

ECOLOGY OF RECREATIONALLY IMPORTANT ESTUARINE FISHES IN OREGON ...Aquatic Ecology, Environmental Ecology, Estuaries, Fishing, Migration, Population Dynamics, ...6.0458

NUTRITIONAL AND SOIL MOISTURE REQUIREMENTS OF PEAR ORCHARDS OF SOUTHERN OREGON ...Pears, Quality -non-specific, Requirements for Water, Trees, Yield, ...2.0899

EVALUATION OF ANADROMOUS FISH PASSAGE FACILITIES AT FALL CREEK DAM, BIG FALL CREEK, OREGON ...Aquatic Ecology, Engineering Structures-general, Migration, Rainbow Trout, Steelhead Trout, Salmon & Trout - Non-specific, ...8.0280

ESTIMATION OF RECREATION WATER REQUIREMENTS - ULTIMATE NEEDS STUDY (OREGON) ...Consumptive Use, Projected Demand, Recreation Sites, Water Demand, ...6.0612

SEDIMENTATION IN SMALL FORESTED DRAINAGE BASINS ...Forest Watersheds, Logging, Transport, Equipment, Runoff, Soil Erosion -non-specific, ...2.0901

COASTAL DIFFUSION OF POLLUTANTS ...Currents-other, Model Studies, Ocean, Outlet, Pulp and Paper Wastes, ...5.0973

ESTUARINE DIFFUSION OF POLLUTANTS ...Dilution-other, Estuaries, Pollutants - Path of , Salinity, Stratification, ...5.0974

IRRIGATED PASTURE AND MEADOW ESTABLISHMENT AND MANAGEMENT ...Flood Irrigation, Grasses -non-specific, Irrigation, Legume-grass Mixtures, Legumes -other..mesquite... , Montana, North Dakota, ...3.0472

Organ Sampling Devices

ECOLOGICAL STUDIES OF RADIOACTIVITY IN THE COLUMBIA RIVER ESTUARY AND ADJACENT PACIFIC OCEAN ...Columbia River, Contamination - Water, Pacific Ocean-north, Pollutants - Path of , Radioactivity, ...6.0452

Organic Evolution

Biochemical

PHYTOCHEMISTRY OF NARCOTIC PRINCIPLES IN CAULERPA ...Biochemical Analysis, Caulerpa, Cyclopropane, Medicinal Plants, Phaeophyta (non-specific & Ot), ...6.0172

Ecological

EVOLUTION OF ALLOPATRIC POPULATIONS ...Captive Rearing, Lake Trout, Brook Trout, Maine, Population Dynamics, ...5.0464

Organic Fertility -soil

Manure

FARM ANIMAL WASTE DISPOSAL ...Animal Waste Removal-treatment, Animal Wastes - Feed Lots, Management, Pollution - Effects of , ...5.0736

LIVESTOCK WASTE MANAGEMENT AND SANITATION ...Aerobic, Animal Waste Removal-treatment, Computer Methods -other, General Sanitation Methods, ...5.0360

Organic Fertility -other

COMPARISON OF VARIOUS FORAGES FOR AGRICULTURAL WASTE WATER DISPOSAL ...Infiltration, Sprinkler Irrigation, Use of Impaired Water, Waste Disposal -underground, ...5.0494

APPLICATION OF SEWAGE SLUDGE TO FIELD CROPS ...Disposal, Fertilizing, Planting & Cult, Methods of Application, Sewage, Source of Fertilizer, Waste Disposal -underground, ...**5.0363**

Plant Residues, Humus, Compost

SOIL SURFACE MANAGEMENT PROCEDURES FOR SOIL AND WATER CONSERVATION ...Conservation , Conservation-general, Tillage, Cropping Systems, Yield, ...**2.0878**

THE ROLE OF SOIL STRUCTURE IN CROP PRODUCTION AND METHODS FOR IMPROVING SOIL PHYSICAL CONDITIONS ...Groundwater Movement, Management Effects, Soil Environment, Soil Structure, Texas, ...**2.1055**

MANAGEMENT PRACTICES FOR SALINE AND SODIC SOILS IN IMPERIAL VALLEY ...California, Management, Tillage, Cropping Systems, ...**3.0037**

Organic Matter -soil

Characterization

PEAT BOG WASTE STABILIZATION ...Drying-dewatering, Industrial Wastes, Minnesota, Pulp and Paper Wastes, Waste Water Treatment-general, ...**5.0611**

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MEADOW SOD MAT ACCUMULATION AND DECOMPOSITION ...Ecology - Soil, High Organic Soils, Microbiology -soil, Soil Depth, Soil Physical Properties, ...**2.0238**

Physical Property Effects

SOILS, PESTICIDES AND THE QUALITY OF WATER ...Movement, Leaching, Organic Matter, Organophosphorous Cpds. , Soil and Rock Leaching, Soil Environment, ...**5.0325**

CHARACTERISTICS OF FARM ANIMAL MANURES AFFECTING DESIGN OF DISPOSAL FACILITIES ...Animal Waste Removal-treatment, Farm Wastes, Waste Disposal -underground, Waste Disposal-general, ...**3.0300**

IRRIGATION REQUIREMENTS, PRINCIPLES AND PRACTICES FOR EFFICIENT USE OF WATER IN THE PACIFIC NORTHWEST ...Evapotranspiration, Irrigation, Irrigation-general, Management, Southern, ...**3.0203**

Osmoregulation

STUDY OF BIOLOGICAL DESALINATION PHENOMENA AND SALT TRANSPORT MECHNAISMS OF SELECTIVE AVIAN SALT GLANDS ...Active Transport, Anseriformes -other, Chemical Analysis, Ion Selective, Transport, ...**3.0479**

STUDY OF EXCRETORY PATTERNS IN CRAYFISHES ...Crayfish, All, Metabolism, Nitrogen, Stress, Urea, ...**6.0376**

SURVIVAL REQUIREMENTS OF JUVENILE AND ADULT BLUE CRABS ...Biological Rhythms, Crabs, All, Environmental Physiology, Laboratory, Water Properties-general, ...**6.0401**

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SPORT FISHERY POTENTIAL IN RECLAIMED WASTEWATER ...Channel Catfish, Growth Rate, Salmon & Trout - Non-specific, Stream Rehabilitation, Tilapia, Cichlids, ...**5.0050**

THE EFFECT OF WATER STRUCTURE ON BIOLOGICAL ACTIVITY ...Bacteria (non-specific), Corn, Molecular Interaction, Water, Water Movement, ...**1.0047**

EFFECTS OF POSSIBLE POLLUTANTS ON ENERGY PRODUCTION BY BLUEGILL LIVER MITOCHONDRIA ...Bluegills, Bream, Metallic Ions, Mineral, Mineral Origin, Respiration, ...**5.0348**

DEVELOPMENT OF NX BOREHOLE INSTRUMENT FOR DEFORMATION MODULUS ...Borehole Geophysics, Deformation, Drilling and Coring, ...**8.0047**

PHYSIOLOGICAL STUDIES OF ALFALFA AS RELATED TO COLD AND HEAT TOLERANCE, DROUGHT RESISTANCE, AND FORAGE QUALITY AND YIELD ...Alfalfa, Blood Albumin, Cold Resistance and Hardiness, Drought, Respiration, ...**2.0572**

MARINE TOXINS OF THE TROPICAL PACIFIC ...Algal Metab.(non-specific &ot), Animal Origin, Fish -non-specific, Polynesia, Toxicology, ...**5.0315**

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LIGAND EXCHANGE REAGENTS ...Colorimetric, Complexes, Dyes and Coloring, Ion Exchange-other, Spectroscopy-other, ...**5.0431**

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CHEMISTRY OF THE HYPOLIMNION OF LAKE ERIE ...Chemical-general, Ions and Gases, Lake Erie, Oxygen, Stratification, ...**2.0625**

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STUDY OF LIGHT ISOTOPES IN LACUSTRINE ENVIRONMENTS ...Gaseous Atmosphere, Lakes, ...**2.0242**

DEVELOPMENT OF A COULOMETRIC METHOD FOR THE MEASUREMENT OF DISSOLVED OXYGEN IN SEA WATER ...Analysis and Detection, Coulometry, Electrolytic, Gases, Technique Development, ...**2.0914**

STABLE CARBON AND OXYGEN ISOTOPE RATIO VARIATIONS IN THE FLOW TO CARBON AND OXYGEN THROUGH NORMAL AND POLLUTED AQUATIC SYSTEMS ...Analysis and Detection, Carbon, Element Ratios, Organic-general, Pollutants - Path of , Sewerage Systems-other, ...**5.1183**

DETERMINATION OF OXYGEN IN SEA WATER ...Chemical Analysis, Electroanalyses-other, Gases, Salt, ...**1.0009**

DEVELOPMENT OF A CALIBRATION MODULE FOR TRACE OXYGEN ANALYZERS ...Analyzing, Calibration Devices, Chemical Analysis (water), Inorganic, Technique Development, ...**3.0055**

ASSEMBLY AND EVALUATION OF AN IMPROVED PPB OXYGEN ANALYZER FOR SEA WATER ...Automatic, Calibration Devices, Gases, Inorganic, Technique Development, ...**3.0453**

EFFECTS OF DISSOLVED OXYGEN CONCENTRATION ON SURVIVAL OF LARGEMOUTH BASS EMBRYOS ...Basic Embryology, Gases, Dissolved -water, Largemouth Bass, Mortality Rates, Water Movement, Currents,, Water Temperature-non-specific, ...**5.0771**

EFFECTS OF SIMULTANEOUS VARIATION OF TEMPERATURE AND DISSOLVED OXYGEN ON THE RESISTANCE OF FISHES TO CONTROLLED POLLUTANTS ...Contamination - Water, Gases, Dissolved -water, Pollution - Effects of , Temperature, Water Temperature-non-specific, ...**5.0220**

THE EFFECT OF SURFACTANTS ON THE AQUEOUS SOLUBILITY OF OXYGEN AND HYDROGEN SULFIDE ...Micelle, Solubility, Sulfide, Surfactants, Wettability, ...**1.0001**

DIFFUSION OF OXYGEN AND HYDROGEN SULFIDE IN WATER AS EFFECTED BY DISSOLVED SURFACTANTS ...Diffusion-other, Sulfide, Surfactants, ...**1.0002**

PREDICTION MODELS FOR WATER QUALITY PARAMETERS ...Model Studies, Projections and Estimations, Social Aspects, Systems Analysis, Temperature, Water Standards, ...**6.0164**

PROCESS CONTROL MODEL FOR OXYGEN REGENERATION OF POLLUTED RIVERS ...Aeration, Automatic, Chemical Oxygen Demand, Detectors and Sensors, Model Studies, Streams, ...**5.0727**

OXYGEN STATUS OF SOIL AIR AND SOIL WATER AS INFLUENCED BY OXYGEN TRANSFER THROUGH THE SOIL PROFILE ...Activation Analysis, Moisture-other, Polarography, Soil Chemical Properties, Soil Environment, ...**2.0248**

PIGMENT INDICES OF ENVIRONMENTAL OXYGEN STRESS ...Environmental Physiology, Hemoglobin, Respiratory Or Blood, ...**5.0810**

DIFFUSIVITY OF OXYGEN AND SULFIDE SPECIES IN AQUEOUS SOLUTIONS ...Chemical Treatment, Gas/liquid, Solution, Sulfide, Surfactants, ...**1.0003**

MICROBIAL RELEASE OF SOLUBLE PHOSPHATE IN AN ACTIVATED SLUDGE ENVIRONMENT ...Cell. env.(non-specific & Ot.), Microorganisms (non-specific), Phosphate, Phosphite, ...**5.1213**

THE EFFECT OF DETERGENTS ON THE OXYGENATION OF WATER ...Absorption-other, Activated, Isotherm, Surfactants, ...**5.1207**

A COMPUTER PROGRAM FOR FORECASTING POLLUTION AND DISSOLVED OXYGEN IN STREAMS ...Distributions, Forecasting-prediction, Model Studies, Stochastic Models, Water Quality-general, ...**5.1210**

DISSOLVED OXYGEN DETERMINATION IN NATURAL AND WASTE WATERS ...Chemical Analysis (water), Ions and Gases, Potentiometry, Technique Development, Voltammetry, ...**5.0553**

OXYGEN TRANSFER IN CONCENTRATED MICROBIAL SYSTEMS ...Degradation, Microbial-bacterial, Mixed Culture, Model Studies, Physico - Chem - Metab, ...**5.0801**

DISSOLVED OXYGEN REQUIREMENTS OF FRESHWATER FISH ...Aquatic Ecology, Environmental Ecology, Fish -non-specific, Gases, Dissolved -water, Ions and Gases, ...**5.0962**

BENTHONIC INVERTEBRATES AS AN INDEX OF WATER QUALITY ...Benthic Fauna, Bioindicators, Gases, Dissolved - water, Water Quality Control-general, ...5.0601

EFFECT OF PAPER FIBER WASTES ON FISH EGGS AND JUVENILES ...Fish -non-specific, Minnesota, Pollution - Effects of , Pulp, Paper , and Logging, Sphaerotilus, ...5.0614

OXYGEN RELATIONSHIPS IN SMALL STREAMS ...Aeration, Ions and Gases, Self-purification, Streams, ...5.0357

OXYGEN REGENERATION OF POLLUTED RIVERS ...Aeration, Delaware River, Economic Efficiency, Instrumentation-general, Pollution Abatement, Streams, ...5.0740

A STOCHASTIC MODEL FOR POLLUTION IN ESTUARIES ...Estuaries, Ions and Gases, Model Studies, Water Quality Control-general, Water Quality-general, ...5.1211

OXYGENATION KINETICS OF REDUCED SULFUR SPECIES ...Order, Other, Oxidation-general, ...5.0496

WATER QUALITY REQUIREMENTS FOR AQUATIC INSECTS ...Growth Rate, ...5.0699

EFFECT OF WATER TEMPERATURE AND/OR DISSOLVED OXYGEN REQUIREMENTS ON SELECTED MOLLUSKS ...Environmental Physiology, Freezing & Below, Gases, Dissolved - water, Gastropods -slugs,conch,snails, Warm Water, ...5.0555

OXYGENATION OF AQUEOUS BODIES USING LIQUID OXYGEN ...Aeration, Diffusion-other, Solution, Waste Treatment-economics, ...5.0685

DIFFUSION OF OXYGEN ACROSS THE MUD-WATER INTERFACE IN AQUATIC ENVIRONMENTS ...Aquatic Environments, Diffusion-other, Electroanalyses-other, Ions and Gases, ...2.0797

WATER POLLUTION STUDY OF THE WABASH RIVER ...Data Acquisition-general, Indiana, Low Flow, Model Studies, Water Quality-general, ...5.0390

OXYGEN TRANSFER TO WATER DROPLETS ...Air-general, Diffusion-other, Water, ...1.0038

STRUCTURE OF CARBON-OXYGEN COMPLEXES ...Adsorption-other, Carbon, Complexes, Infrared, Surface-other, ...1.0082

THE PHYSICAL AND CHEMICAL PROPERTIES OF WATER AND SOILS AS RELATED TO THE SUCCESSFUL GROWTH OF WATERFOWL FOOD AND COVER PLANTS ...Flooding, Food Supply, Phytotoxic, Soil (wildlife) Cover, Soil Conditions, Water Fowl, N.s. , ...2.0799

REAERATION IN OPEN CHANNEL FLOW ...Aeration, Degradation, Freshwater Ecology, Open Channel Flow, Oxygen Content - water, ...2.0224

CHEMISTRY OF THE HYPOLIMNION OF LAKE ERIE ...Chemical-general, Ions and Gases, Lake Erie, Overturn, Stratification, ...2.0625

OXYGEN DEMAND OF LAKE ERIE SEDIMENT .. Aquatic Soils, Deposits-other, Transfer Processes, ...2.0627

STREAM REAERATION ...Aeration, Morphology-general, Organic-general, Photosynthesis, Streams, ...5.0905

PHYSIOLOGIC AND METABOLIC RESPONSE AS INDICATORS OF STRESS ...Environmental Physiology, Gases, Dissolved -water, Ions and Gases, Metabolism -animal, Stress, ...5.0592

DETERMINATION OF SELECTED ENVIRONMENTAL REQUIREMENTS OF IMPORTANT SPECIES OF MARINE ZOOPLANKTON ...Copepods, Water Salinity, Water Temperature-non-specific, Zooplankton, ...5.1097

Pacific Mountain System

Cascade - Sierra Mountains

STATE OF WASHINGTON DEPARTMENT OF WATER RESOURCES CASCADE ATMOSPHERIC WATER RESOURCES PROGRAM ...Augmentation-general, Clouds-precipitation, Nucleation Physics, Patterns, Washington, ...2.0195

Pacific Ocean-general

PACIFIC OCEAN INFLUENCE UPON CALIFORNIA RAINFALL ...California, Forecasting, Patterns, Rain-other, Temperature, ...2.0104

CLOSTRIDIUM OUTGROWTH AND TOXIN PRODUCTION DURING STORAGE OF SHELLFISH ...Bacterial Pollutant Sources, Clostridium Botulinum, Microbiological, Oysters, Shelf Life & Storage, ...5.1223

Pacific Ocean-north

ECOLOGICAL STUDIES OF RADIOACTIVITY IN THE COLUMBIA RIVER ESTUARY AND ADJACENT PACIFIC OCEAN ...Columbia River, Contamination - Water, Organ Sampling Devices, Pollutants - Path of , Radioactivity, ...6.0452

Pakistan

ORGANISMS WHICH ATTACK THE AQUATIC PLANT, EURASIAN WATERMILFOIL IN PAKISTAN ...Animal Taxonomy, Insects -non-specific, Life History Studies, Other, Water Milfoil, Waterweed... , ...4.0202

Paleobotany

Phylum Thallophyta

Algae

ECOLOGY OF DIATOMS IN HARDWATER HABITATS ...Algae-Diatoms, Environmental Changes, Habitat Studies, Paleoecology, Pollen, ...5.0406

Paleoenvironments

THE POST-PLEISTOCENE EPICYCLE SEQUENCE OF ALLUVIATION AND EROSION IN THE LOWER SAN JUAN DRAINAGE ...Alluvial Deposits, Archeology, Gullys - Arroyos, Paleohydrology, San Juan, ...2.1097

Paleohydrology

CARBON-14 CONTENT OF FRESH WATER CARBONATES ...Carbon-14, Carbonates-general, Chemical, Paleoclimatology, Playas, ...2.0048

MOLLUSK STUDIES ...Agricultural Watersheds, Forest Watersheds, Mollusca - General Studies, Percolation, Strontium, ...1.0114

THE POST-PLEISTOCENE EPICYCLE SEQUENCE OF ALLUVIATION AND EROSION IN THE LOWER SAN JUAN DRAINAGE ...Alluvial Deposits, Archeology, Gullys - Arroyos, Paleoenvironments, San Juan, ...2.1097

Paleontology

Microfossils

DIVERSITY AND ECOLOGICAL NICHES IN MULTI-SPECIES ASSOCIATIONS OF CHYORID CLADOCERA (CRUSTACEA) ...Cladocera, Environmental Ecology, Habitat Studies, Interbiotic Relat.(non-specif), Lakes, ...2.0911

Paleoecology

STUDIES OF NEAR-SURFACE SEDIMENTS IN LAKES, AND RELATIONSHIPS BETWEEN SURFACE SEDIMENT POLLEN SPECTRA AND VEGETATION ...Canada, Lakes, New England Province, ...2.0555

Pollen

STUDIES OF NEAR-SURFACE SEDIMENTS IN LAKES, AND RELATIONSHIPS BETWEEN SURFACE SEDIMENT POLLEN SPECTRA AND VEGETATION ...Canada, Lakes, New England Province, Paleoecology, ...2.0555

ECOLOGY OF DIATOMS IN HARDWATER HABITATS ...Algae, Algae- Diatoms, Environmental Changes, Habitat Studies, Paleoecology, ...5.0406

Paleontology - Invertebrate

Mollusca - General Studies

MOLLUSK STUDIES ...Agricultural Watersheds, Forest Watersheds, Paleohydrology, Percolation, Strontium, ...1.0114

Particle Size Tests

Distribution

ATOMIZATION AND DROP SIZE OF NON-NEWTONIAN FLUID ...Atomization, Non - Newtonian, Nozzles, Solution, Spray Devices, ...5.0796

PREPARATION OF MONODISPERSE EMULSIONS ...Emulsion, Kinetic-general, Nucleation, Precipitation, ...5.0064

ACCESSIBILITY OF PORES IN POROUS MEDIA ...Porosity, Porous Media - Flow Through, ...8.0017

Pennsylvania

FEEDING PATTERNS OF THE FRESHWATER ISOPOD LIRCEUS BRACHYURUS ...Aquatic Ecology, Behavioral Ecology, Food Supply, Isopods, Nutrition - Invertebrate, Streams, ...**7.0093**

THE DISTRIBUTION OF FISH IN PENNSYLVANIA AS RELATED TO MINE ACID DRAINAGE ...Acidity, Contamination - Water, Fish -non-specific, Mining Activities, Number Or Density, ...**5.1026**

CHANGES IN STREAM COMMUNITIES ASSOCIATED WITH EFFLUENT - INDUCED EUTROPHICATION ...Aquatic Plants (non-specific), Eutrophication, Invertebrates -non-specific, Number Or Density, Streams, ...**5.1029**

THE HYDROLOGIC SIGNIFICANCE OF CHEMICALLY DERIVED MEAN BASIN TEMPERATURES ...Air Temperature Instruments, Aldose and Ketose, Evaporation, Forecasting-prediction, Heat Measurement, ...**2.0924**

ANOMALOUS FLOOD RESPONSE IN REGIONS OF SIMILAR GEOMORPHIC CHARACTERISTICS ...Computers-general, Floods, Flow Characteristics -water, Morphology-general, ...**2.0927**

CRITERIA FOR DETERMINING ECONOMIC PRIORITIES IN AWARDING SEWAGE FACILITY CONSTRUCTION GRANTS ...Fiscal, Waste Treatment-economics, Water Quality Control-general, Welfare Economics, ...**6.0475**

STREAM QUALITY PRESERVATION THROUGH URBAN LAND USE ...Land Use, Management, Urban Environments, Water Quality Control-general, ...**5.1010**

STUDY OF THE USE OF INERT GASES TO ELIMINATE ACID POLLUTION FROM ABANDONED DEEP MINES ...Acid Mine Wastes, Air-general, Mine Atmosphere Conditions, Mine Hydrology, Underground Workings, ...**4.0203**

CATAWISSA CREEK MINE DRAINAGE POLLUTION ABATEMENT PROJECT ...Acidity, Mine Hydrology, Mining Industry, Pollution Abatement, ...**5.0998**

NEUTRALIZATION AND PRECOAT FILTRATION OF CONCENTRATION SLUDGES FROM MINE WATE ...Acid Mine Wastes, Disposal, Filtration, Neutralization, Waste Treatment-economics, ...**5.1001**

EVALUATION OF POLLUTION ABATEMENT PROCEDURES IN THE MORAINE STATE PARK, BULTER COUNTY, PENNSYLVANIA ...Pollution Abatement, Systems Analysis, Water Quality-general, Water Quantity-general, ...**5.1002**

INFLUENCE OF FOREST COVER AND TIMBER HARVESTING METHODS ON STREAMFLOW ...Canopy & Overstory, Forest Watersheds, Logging, Transport, Equipment, Streams, ...**2.0930**

ECONOMIC IMPACT OF WATER RESOURCE DEVELOPMENT ON LAND USE ...Economic Impact, Land Use, Reservoirs and Impoundments, Rural Areas, Water Resources Development, ...**6.0472**

FEED AND WASTE HANDLING IN THE DAIRY OPERATION ...Animal Waste Removal-treatment, Animal Wastes - Feed Lots, Management, Sprinkler Irrigation, ...**5.1023**

STUDY OF METHODS FOR CONTROLLING AQUATIC GROWTH AT PYMATUNING RESERVOIR AND CONNEAUT LAKE, PENNSYLVANIA ...Lakes, of Aquatic Plants, Plant Pollutants, Pollution Abatement, Reservoirs and Impoundments, ...**6.0470**

HYDROGEOLOGY OF PUBLIC GROUND WATER SUPPLIES IN PENNSYLVANIA ...Chemical-general, Groundwater, Management, Pollution Abatement, Water Yield, ...**2.0907**

TREATMENT OF COAL MINE WATERS TO MEET CURRENT COMMONWEALTH WATER DISCHARGE REQUIREMENTS ...Coal-general, Lagoon, Mining Activities, Waste Treatment-economics, Waste Water Treatment-general, ...**5.1038**

RAINFALL FREQUENCY RELATIONS FOR PENNSYLVANIA ...Amount, Design Flow-flood, Gages, Hydrographic, Weather Charts-maps, ...**2.0926**

EFFECT OF CONSERVATION PRACTICES ON HYDROLOGY AND SEDIMENTATION RATES ...Conservation, Land Use, Rate of Deposition, Small Watersheds, ...**4.0204**

POLLUTION OF SUBSURFACE WATER BY SANITARY LANDFILL ...Contamination, Forecasting-prediction, Landfill, Pollutants - Path of , Subsurface Flow, ...**5.1009**

Percolation

NITRATE ACCUMULATION IN KANSAS GROUND WATER ...Fertilizers, Groundwater, Ions and Gases, Kansas, Nitrate, Nitrite, ...**5.0434**

A SYSTEM FOR GEOLOGIC EVALUATION OF POLLUTION POTENTIAL AT MOUNTAIN DWELLING SITES ...Joints-fractures, Sewage, ...**5.0199**

FLOW OF WATER INTO TILE DRAINS ON STRATIFIED SOILS ...Drainage Systems, Laplace Transform, Seepage, ...**2.0486**

DEEP SEEPAGE ON PIEDMONT WATERSHEDS ...Physical Properties-general, Piedmont Province, Saturated Flow, Seepage, Unsaturated Flow, Water Table Fluctuation, ...**2.0955**

SPREADING TREATED SEWAGE FOR GROUNDWATER RECHARGE ...Artificial Recharge, Groundwater, Loading, Pilot Plant, Sewage, ...**3.0005**

WATER QUALITY IN RELATION TO PHYSICAL AND CHEMICAL PROPERTIES OF SOILS AND WASTE WATERS THEREFROM ...Physical Properties-general, Salinity, Soil and Rock Leaching, Soil Chemical Properties, Water Quality-general, ...**5.0081**

MICROBIOL ADSORPTION IN SOILS ...Adsorption Capacity, Biological Pollutants -general, Electrical Properties, Microbiology -soil, Soil Environment, ...**2.0213**

SUITABILITY FOR SEPTIC TANK DISPOSAL SYSTEMS AND PRODUCTIVITY POTENTIALS OF PENNSYLVANIA SOILS ...Animal Wastes - Feed Lots, Septic Tanks, Soil, Waste Water Treatment-general, Water Table Fluctuation, ...**5.1039**

WATER REQUIREMENT BY SUGARCANE UNDER IRRIGATION ...Evapotranspiration, Irrigation, Moisture Content -plants, Requirements for Water, Sugarcane, ...**2.0933**

WASTE DISPOSAL FROM FOOD PROCESSING PLANTS IN SOUTH CAROLINA ...Disposal Wastes, Food Processing Industry, Self-purification, Soil Environment, ...**5.1104**

SOIL AND CLIMATE EFFECTS ON IRRIGATION WATER REQUIREMENTS ...Consumptive Use, Evapotranspiration, Irrigation-general, Requirements for Water, ...**2.1080**

MOLLUSK STUDIES ...Agricultural Watersheds, Forest Watersheds, Mollusca - General Studies, Paleohydrology, Strontium, ...**1.0114**

TRANSPORT PROPERTIES OF NATURAL CLAYS ...Clay, Clays, Hydraulics-general, Permeability, Sampling, ...**2.1102**

IRRIGABLE LAND SUITABILITY STUDY ...Analog Computers, Irrigation-general, Saline and Alkaline Soils, Water Quality-general, ...**6.0092**

GROUND WATER RECHARGE AND MANAGEMENT IN CALIFORNIA ...Groundwater, Groundwater Basins, Recharge - general, Soil Environment, Storage of Water, ...**4.0033**

METHODS FOR WATER QUALITY IMPROVEMENT AND ITS STORAGE UNDERGROUND ...Computers-general, Denitrification, Groundwater Basins, Management, Natural Recharge, Underground Waste Disposal, Waste Water Treatment-general, ...**4.0005**

Periphyton

THE ECOLOGY OF STREAM BIOTA IN WASTE ASSIMILATION ...Degradation, Organic Matter, Self-purification, Streams, Water Bacteria, ...**5.0675**

STUDIES ON EFFECTS OF WATERSHED PRACTICES ON STREAMS ...Chemical-general, Discharge-general, Forest Watersheds, Organic Matter, Physical-general, Primary Productivity, ...**5.0948**

PLANKTON-PERIPHYTON STUDIES IN THE COLUMBIA RIVER ...Columbia River, Food Webs, Phytoplankton, Radioactivity-general, Radioecology, ...**2.1127**

Personnel

SUMMER RESEARCH AT THE UNIVERSITY OF OKLAHOMA BIOLOGICAL STATION ...Oklahoma, Research Facilities, Training Grants, Fellowships, Water Resources - General, ...**9.0011**

WATER RESOURCES RESEARCH, MANPOWER AND TRAINING NEEDS FOR INDIANA ...Indiana, Management, Requirement and Resources, Training Grants, Fellowships, ...**9.0007**

AN INVESTIGATION OF MANPOWER RESOURCES FOR WATER RESOURCES RESEARCH AND OTHER WATER-RELATED ACTIVITIES ...Forecasting-prediction, Optimization, Requirement and Resources, Water Resources - General, ...**9.0008**

IMPROVED METHODS FOR ESTIMATING MANPOWER NEEDS FOR WATER RESOURCES DEVELOPMENT ...Indiana, Management, Requirement and Resources, Water Resources Development, ...**6.0218**

SUPPLY OF AND DEMAND FOR TRAINED WATER RESOURCES PERSONNEL - A PILOT STUDY ...Requirement and Resources, Training Grants, Fellowships, Utilization, ...**9.0004**

AIDS FOR WASTEWATER SYSTEM PERSONNEL SAFETY AND ADVANCEMENT ...Consultants, Advisory Services, Safety, Waste Water Treatment-general, ...**9.0006**

Pesticidal Control Measures

Absorption and Translocation

Plant -other

FATE OF HERBICIDES IN WATER AND CROPS IRRIGATED WITH WATER CONTAINING HERBICIDES ...Herbicides -non-specific, Persistance of Residues, Pesticides, Residues in Foods, Sprinkler Irrigation, ...**5.1327**

FATE OF PESTICIDES ...Absorption, Fixation, Exchange, Aldrin, Biodegradation, DDT , 2,4-d, ...**5.0741**

Root

PHREATOPHYTE CONTROL - LAHONTAN AND HUMBOLDT BASINS ...Phenology, Phreatophytes, Reservoirs and Impoundments, Saltcedar, Tamarisk, Weed Control -other, ...**3.0317**

Anti-transpirants

PLANT-WATER-USE EFFICIENCY WITH GROWTH REGULATORS AND TRANSPIRATION SUPPRESSANTS ...Antitranspirants, Fruit-set, Growth Rate, Growth Regulators, Modified Water Use, ...**3.0160**

THE EFFECTS OF PLANT TRANSPIRATION RETARDANTS ON TRANSPIRATION, LEAF TEMPERATURE, STOMATAL BEHAVIOUS AND OSMOTIC PRESSURE ...Modified Water Use, Osmotic and Turgor Pressure, Temperature - Internal, Transpiration, Transpiration and Evap, ...**2.0403**

CONTROL OF EVAPORATION AND TRANSPIRATION THROUGH SOIL, PLANT AND AIR - WATER INTERFACE MODIFICATIONS ...Evaporation, Modified Water Use, Transpiration, Transpiration and Evap, Water Loss Control, ...**2.1040**

Aquatic Or Soil-aquatic Cycles

THE CYCLING OF C1-36 LABELED DDT IN NATURAL ECOSYSTEMS ...DDT , Monitoring Systems, Persistance of Residues, Pollution - Effects of , Radioisotopes, ...**5.0876**

OCCURRENCE OF PESTICIDES IN AQUATIC ENVIRONMENTS ...Food Chains, Animal And/or Man, Irrigation-general, Reservoirs and Impoundments, Runoff, ...**5.1237**

SOILS, PESTICIDES, AND THE QUALITY OF WATER ...Hawaii, Movement, Leaching, Soil Environment, Triazines -non-specific, Urea Cpds. -non-specific, ...**5.0044**

SOILS, PESTICIDES AND THE QUALITY OF WATER ...Absorption, Fixation, Exchange, Boundary Process (moisture), Groundwater Movement, Movement, Leaching, Pesticides -non-specific, ...**5.0079**

SOIL, PESTICIDES AND THE QUALITY OF WATER ...Atrazine, Monuron, Movement, Leaching, Pesticides, Soil Environment, ...**5.0196**

THE DISPOSITION OF PESTICIDES IN THE SOIL ...Atrazine, Groundwater Movement, Microbial Degradation, Movement, Leaching, Rhizosphere, Trifluralin, ...**5.0290**

RELATIONSHIPS BETWEEN PESTICIDES AND GEORGIA FARM POND ECOSYSTEMS ...Clay, DDT , Endrin, Farm Pond, Georgia, Pollution - Effects of , Soil Types, ...**5.0288**

DEGRADATION - DEPLETION OF HERBICIDES IN IRRIGATION WATER AND ACCUMULATION OF HERBICIDE RESIDUES IN CROPS FROM TREATED WATER ...Biodegradation, Degradation, Persistance of Residues, Persistence in Soils, ...**5.1326**

CHEMICAL BRUSH CONTROL - BIOCHEMISTRY AND TOXIC HAZARD ...Environmental Effects, Herbicides -non-specific, Other, Pesticides, Range, ...**5.0944**

BEHAVIOR OF POLLUTANTS IN WATER ...Decomposition-general, Infiltration, Movement, Leaching, Persistence in Soils, Pesticides -non-specific, Pollutants - Path of , ...**5.0190**

ESTUARINE ECOSYSTEMS ...Estuaries, Pesticides -non-specific, Pollution - Effects of , Pollution Effects, Water Properties-general, ...**2.0324**

PESTICIDE KINETICS ...Degradation -non-specific, Estuaries, Insecticides -non-specific, Marine Biology (non-specific), Pollutants - Path of , ...**5.0271**

DEGRADATION KINETICS OF VARIOUS ESTER FORMULATIONS OF 2%2,4,5 TRICHLOROPHENOXYROPRIONIC ACID %SILVEX..Biodegradation, Chemical Degradation, Degradation, Physical Degradation, Silvex, ...**5.0285**

PESTICIDE POLLUTION OF FARMSTEAD WATER SUPPLIES ...Handling & Application, Pollutants - Path of , Residues in Potable Water, Water Utilization -domestic, ...**5.0485**

Atmospheric Contamination

REDUCTION OF INSECTICIDAL HAZARDS ...Insecticides -non-specific, Movement, Leaching, Persistence in Soils, Pest Control, Pollution - Effects of , ...**5.0393**

INFORMATION PROCEDURES IN ENVIRONMENTAL CONTAMINATION ...Atmpopheric Pollution-general, General Information Services, Pesticides -non-specific, ...**7.0070**

Degradation

Biodegradation

KINETIC STUDIES OF THE OXIDATIVE DEGRADATION OF DETERGENT, AND RELATED CHEMICAL SPECIES IN AQUEOUS SOLUTION ...Biological, Chemical Degradation, Kinetic-general, Physical Degradation, Surfactants, Waste Water Treatment-general, ...**5.0495**

ANALYTICAL METHODS FOR PESTICIDES AND PESTICIDE DEGRADATION PRODUCTS ...Persistance of Residues, Residue Analysis -other, Soil Degradation -other, Technique Development, ...**5.1031**

MICROBIAL ECOLOGY OF LAKE CHAMPLAIN AS INFLUENCED BY PESTICIDES ...Freshwater Ecology, Lakes, Microorganisms (non-specific), Nitrogen Bacteria, ...**5.1202**

DEGRADATION - DEPLETION OF HERBICIDES IN IRRIGATION WATER AND ACCUMULATION OF HERBICIDE RESIDUES IN CROPS FROM TREATED WATER ...Aquatic Or Soil-aquatic Cycles, Degradation, Persistance of Residues, Persistence in Soils, ...**5.1326**

PESTICIDES AND WILDLIFE ...Food Chains, Animal And/or Man, Habitat Studies, Insecticides -non-specific, Preventative Measures, Wildlife -non-specific, ...**5.0138**

ROLE OF ENTERIC MICROORGANISMS IN DETOXIFICATION - INTERACTION BETWEEN MICROORGANISMS AND PESTICIDES ...Bacterial Culture, Fish -non-specific, Identification, Insecticides -non-specific, Intestinal Bacteria, ...**5.0641**

BIOTRANSFORMATION OF ALDRIN AND DIELDRIN BY BACTERIA - INTERACTION BETWEEN MICROORGANISMS AND PESTICIDES ...Aldrin, Cell. env.(non-specific & Ot.), Dieldrin, Other, Soil Bacteria, Water Bacteria, ...**5.0644**

BIOTRANSFORMATION OF HEPTACHLOR BY BACTERIA - INTERACTION BETWEEN MICROORGANISMS AND PESTICIDES ...Bacterial Pollutant Sources, Heptachlor, Other, Soil Bacteria, Water Bacteria, ...**5.0645**

SOURCE DISTRIBUTION AND FATE OF C14 LABELED AND CHLORINATION HYDROCARBON INSECTICIDE RESIDUES IN FISH ...Carbon, Food Chains, Animal And/or Man, Persistance of Residues, Wildlife, ...**5.0281**

DEGRADATION KINETICS OF VARIOUS ESTER FORMULATIONS OF 2%2,4,5 TRICHLOROPHENOXYROPRIONIC ACID %SILVEX..Aquatic Or Soil-aquatic Cycles, Chemical Degradation, Degradation, Physical Degradation, Silvex, ...**5.0285**

DETERMINATION OF RESIDUES OF INSECT CONTROL CHEMICALS IN PLANT AND ANIMAL PRODUCTS AND IN SOILS ...Insecticides -non-specific, Persistance of Residues, Residues in Foods, ...**5.0482**

FATE OF PESTICIDES ...Absorption, Fixation, Exchange, Aldrin, DDT , Plant -other, 2,4-d, ...**5.0741**

Chemical Degradation

BIOLOGICAL AND CHEMICAL OXIDATION OF SELECTED ORGANIC PESTICIDES ...Biological, Chlorinated Hydrocarbons, Chlorination, Degradation, Gas, Pesticides, ...**5.0010**

KINETIC STUDIES OF THE OXIDATIVE DEGRADATION OF DETERGENT, AND RELATED CHEMICAL SPECIES IN AQUEOUS SOLUTION ...Biodegradation, Biological, Kinetic-general, Physical Degradation, Surfactants, Waste Water Treatment-general, ...**5.0495**

DEGRADATION KINETICS OF VARIOUS ESTER FORMULATIONS OF 2%2,4,5 TRICHLOROPHENOXYROPRIONIC ACID %SILVEX..Aquatic Or Soil-aquatic Cycles, Biodegradation, Degradation, Physical Degradation, Silvex, ...**5.0285**

Degradation -non-specific

PESTICIDE KINETICS ...Aquatic Or Soil-aquatic Cycles, Estuaries, Insecticides -non-specific, Marine Biology (non-specific), Pollutants - Path of , ...**5.0271**

Degradation -other

FATE AND PERSISTENCE OF PESTICIDES AND PHYSIOLOGICALLY ACTIVE DEGRADATION PRODUCTS ...Chemical Identification, Decomposition-other, Infrared, Persistance of Residues, ...**5.1032**

Physical Degradation

KINETIC STUDIES OF THE OXIDATIVE DEGRADATION OF DETERGENT, AND RELATED CHEMICAL SPECIES IN AQUEOUS SOLUTION ...Biodegradation, Biological, Chemical Degradation, Kinetic-general, Surfactants, Waste Water Treatment-general, ...**5.0495**

FACTORS INFLUENCING INSECTICIDE RESIDUES ON OR IN FOOD AND FORAGE CROPS ...Environmental Effects, Kansas, Organophosphorous Cpds. , Persistance of Residues, Persistence in Soils, Pollution Effects, ...**5.0429**

DEGRADATION KINETICS OF VARIOUS ESTER FORMULATIONS OF 2%2,4,5 TRICHLOROPHENOXYROPRIONIC ACID %SILVEX..Aquatic Or Soil-aquatic Cycles, Biodegradation, Chemical Degradation, Degradation, Silvex, ...**5.0285**

Economics of Chemical Control

ECONOMIC ANALYSIS OF RESOURCE POLLUTION BY PESTICIDES AND OTHER WASTE MATERIALS ...Economic Impact, Pesticides, Production & Processing, ...**5.1204**

Endogenous Biological Extracts

Endogenous Cpds -plants

AQUATIC PLANT CHEMISTRY-ITS APPLICATION TO ECOLOGY ...Aquatic Plants (non-specific), Bacterial Pollutant Sources, Bactericides -non-specific, Water Quality Control-general, ...**5.0793**

BIOLOGICAL ALGICIDES ...Algacides -non-specific, Algal Virus, Cell Injury and Autolysis, Mixed Culture, ...**5.0226**

Environmental Effects

INVESTIGATIONS OF THE RELATION BETWEEN THE USE OF CHLORINATED HYDROCARBONS AND THEIR RESIDUES IN CHANNEL CATFISH ...Channel Catfish, Chlorinated Hydrocarbons, Missouri River, Nebraska, Wildlife, ...**5.0702**

STATEWIDE FISHERIES RESEARCH ...Bioindicators, Bluegills, Bream, Pollution - Effects of , Rotenone, Temperature, ...**5.0817**

FACTORS INFLUENCING INSECTICIDE RESIDUES ON OR IN FOOD AND FORAGE CROPS ...Kansas, Organophosphorous Cpds. , Persistance of Residues, Persistence in Soils, Physical Degradation, Pollution Effects, ...**5.0429**

AN EVALUATION OF WIDELY USED HERBICIDES ON AQUATIC PLANTS, FISH AND FISH-FOOD ORGANISMS ...Food Supply, Herbicides -non-specific, Wildlife, ...**5.0570**

INCREASING CHAPARRAL WATERSHED YIELD THROUGH IMPROVED USE OF PHENOXY-TYPE HERBICIDES ...Herbicides -non-specific, Moisture Tension, Temperature, Translocation, Water Yield, Watersheds-other, ...**3.0089**

CHEMICAL BRUSH CONTROL - BIOCHEMISTRY AND TOXIC HAZARD ...Aquatic Or Soil-aquatic Cycles, Herbicides -non-specific, Other, Pesticides, Range, ...**5.0944**

LABORATORY STUDY OF AQUATIC ENVIRONMENTAL FACTORS AND PLANT GROWTH STAGES ON AQUATIC WEED GROWTH AND HERBICIDAL RESPONSE ...Herbicides -non-specific, Light -other, Maturity & Growth Stages, of Aquatic Plants, Water Temperature -other, ...**3.0127**

INFLUENCE OF SALINITY AND TEMPERATURE ON TOXICITY OF SOME PESTICIDES TO BRINE SHRIMP ...Salinity, Shrimps - Brine Or Fairy, Temperature, ...**5.0663**

PRINCIPLES AND PRACTICES FOR THE CONTROL OF SUBMERSED, FLOATING, AND IMMERSED AQUATIC WEEDS ...Biocontrol, Canals, Evaluation, Herbicides -non-specific, of Aquatic Plants, ...**5.1329**

CONTROLLING UNDESIRABLE PHREATOPHYTES ...Evaluation, Herbicides -non-specific, Integrated Physical Control, Phreatophytes, ...**3.0496**

Evaluation

METHODS FOR CONTROLLING ALLIGATORWEED AND OTHER WEEDS IN CANALS, WATERWAYS, AND ADJACENT WATERS IN THE SOUTHEASTERN U. S. ...Canals, Herbicides -non-specific, Integrated Biological Control, of Aquatic Plants, Southeast, ...**8.0210**

CONTROL OF CANADA THISTLE AND WATER WEEDS ...Kentucky Bluegrass, Montana, of Aquatic Plants, Phenology, Reed Canary, ...**3.0308**

CHEMICAL CONTROL OF CREOSOTEBUSH AND MESQUITE ...Legumes -other..mesquite... , Management Effects, Phreatophytes, Range, Watersheds-general, Zygophyllaceae, ...**4.0177**

FISH TOXICANT STUDIES ...Ammonium, Control of Nuisance Species, Fish -non-specific, Piscicides -non-specific, Screening Potential Pesticides, ...**5.1147**

FACTORS INFLUENCING FREE-LIVING NEMATODES IN WATER SUPPLIES ...Aquatic Ecology, Chemical Treatment-general, Mode of Action -animal, Nematoda -other, Sand, ...**5.0368**

COOPERATIVE BIOLOGICAL PEST CONTROL RESEARCH ...Biological Pollutants -general, California, Canals, of Aquatic Plants, Reservoirs and Impoundments, ...**5.0087**

EVALUATION OF HERBICIDES FOR CONTROL OF AQUATIC WEEDS ...Application Rates, Floating Plants, Herbicides -non-specific, of Aquatic Plants, Submerged Plants, ...**5.0247**

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PESTICIDE RESISTANT FISH IN NATURAL ECOSYSTEMS ...Animal Resistance, Endrin, Food Chains, Animal And/or Man, Pollution Effects, Tolerance Rates, ...**5.0624**

Toxicity Or Residues -other

THE BIOASSAY OF WATER POLLUTANTS WITH CULTURED MAMMALIAN CELLS ...Bioassay, Bioassays, Herbicides -non-specific, ...**5.1055**

Toxicity Or Residues in Humans

Human Tox. or Residues -other

OCCUPATIONAL AND ENVIRONMENTAL HEALTH ...Food , Occupational Hazards, Pollution - Effects of , Pollution-atmosphere, Radiologic Health, ...**5.0518**

Residues in Foods

REDUCTION OF HAZARDS ASSOCIATED WITH INSECTICIDAL CHEMICALS IN THE ENVIRONMENT ...Insecticides -non-specific, Persistence in Soils, Pollution - Effects of , Pollution Effects, Removal of Residues, ...**5.0359**

REDUCTION OF HAZARDS ASSOCIATED WITH THE PRESENCE OF RESIDUES OF INSECTICIDAL CHEMICALS IN THE ENVIRONMENT ...Chlorinated Hydrocarbons, Organophosphorous Cpds. , Other, Persistence in Soils, Pesticides, ...**5.0404**

FATE OF HERBICIDES IN WATER AND CROPS IRRIGATED WITH WATER CONTAINING HERBICIDES ...Herbicides -non-specific, Persistance of Residues, Pesticides, Plant -other, Sprinkler Irrigation, ...**5.1327**

DETERMINATION OF RESIDUES OF INSECT CONTROL CHEMICALS IN PLANT AND ANIMAL PRODUCTS AND IN SOILS ...Biodegradation, Insecticides -non-specific, Persistance of Residues, ...**5.0482**

CONTAMINATION OF OYSTERS BY PESTICIDES ...Dieldrin, Endrin, Mode of Action -animal, Oysters, ...**5.0462**

Residues in Potable Water

IDENTIFICATION AND REMOVAL OF PESTICIDES FROM RURAL WATER SUPPLIES ...Pesticides -non-specific, Removal of Residues, Rural Areas, Waste Water Treatment-general, Water Utilization -domestic, ...**5.0448**

PESTICIDE POLLUTION OF FARMSTEAD WATER SUPPLIES ...Aquatic Or Soil-aquatic Cycles, Handling & Application, Pollutants - Path of , Water Utilization -domestic, ...**5.0485**

Pesticides

Aldrin

THE EFFECT OF DIELDRIN ON SURVIVAL AND DEVELOPMENT OF FISH EGGS ...Basic Embryology, Dieldrin, Mode of Action -animal, Ohio, Pollution - Effects of , ...**5.0885**

EFFECTS OF THE CHLORINATED HYDROCARBONS, ALDRIN AND DIELDRIN, ON FRESHWATER SEED SHRIMP (OSTRACODA) ...Contamination - Water, Dieldrin, Fresh Water, Laboratory Animals, Pollution - Effects of , Shrimps - Seed Or Mussel, ...**5.1117**

INTERACTION OF INORGANIC AND ORGANIC FERTILIZER MATERIALS WITH PESTICIDES AS RELATED TO WATER QUALITY IN SOILS ...Absorption, Fixation, Exchange, Chemical Degradation, Fertilizers, Other, Pesticides, ...**5.0052**

BIOTRANSFORMATION OF ALDRIN AND DIELDRIN BY BACTERIA - INTERACTION BETWEEN MICROORGANISMS AND PESTICIDES ...Biodegradation, Cell. env.(non-specific & Ot.), Dieldrin, Other, Soil Bacteria, Water Bacteria, ...**5.0644**

SCREENING FOR PESTICIDE DETOXIFICATION AGENTS - CHEMICAL AND PHYSICAL STUDIES ON REDUCTION OF PESTICIDE HAZARDS ...DDT , Dieldrin, Removal of Residues, Screening Potential Pesticides, ...**5.0636**

FATE OF PESTICIDES ...Absorption, Fixation, Exchange, Biodegradation, DDT , Plant -other, 2,4-d, ...**5.0741**

Algacides

Algacides -non-specific

CHEMICAL CONTROL OF WEEDS IN PONDS ...Herbicides -non-specific, of Aquatic Plants, Plant Pollutants, Ponds, Wildlife, ...**5.0009**

REVIEW OF ALGALCIDES ...Algal Pollutant Sources, Public Utilities, Residential, Survey Studies, Water Distribution Systems, ...**5.0358**

BIOLOGICAL ALGICIDES ...Algal Virus, Cell Injury and Autolysis, Endogenous Cpds -plants, Mixed Culture, ...**5.0226**

Copper Sulfate

EFFECT OF COPPER SULFATE ON AQUATIC WEEDS ...Alkalinity, Canals, Copper, Irrigation-general, of Aquatic Plants, ...**3.0108**

Azodrin

CURRENT FISH AND WILDLIFE PESTICIDE PROBLEMS ...Endrin, Guthion, Mercury, of Aquatic Plants, Seed Treatment, Thiodan, Wildlife, ...**4.0042**

Bactericides

Bactericides -non-specific

BACTERIDAL EFFECTS OF ALGAE ON ENTERIC ORGANISMS ...Algae- General, Algal Culture, Intestinal Bacteria, Sanitation, Sewage, ...**5.1151**

AQUATIC PLANT CHEMISTRY-ITS APPLICATION TO ECOLOGY ...Aquatic Plants (non-specific), Bacterial Pollutant Sources, Endogenous Cpds -plants, Water Quality Control-general, ...**5.0793**

Carbamates -non-specific

EFFECT OF PESTICIDE RESIDUES AND OTHER ORGANOTOXICANTS ON THE QUALITY OF SURFACE AND GROUNDWATER RESOURCES ...Groundwater, Movement, Leaching, Persistence in Soils, Removal of Residues, Water Quality Control-general, ...**5.0396**

PESTICIDE CONTAMINATION OF THE ENVIRONMENT AND ITS SIGNIFICANCE ...Louisiana, Monitoring Systems, Organophosphorous Cpds. , Persistance of Residues, ...**5.0451**

RELATIVE SUSCEPTIBILITIES OF FISH FAMILIES TO INSECTICIDES - ACUTE TOXICITY OF PESTICIDES TO FRESHWATER FISH AND OTHER VERTEBRATES ...Bioassay, Bioassays, Chlorinated Hydrocarbons, Organophosphorous Cpds. , Wildlife, ...**5.0653**

EFFECTS OF CHRONIC EXPOSURE TO SUBLETHAL LEVELS OF INSECTICIDES ON REPRODUCTION IN BROOK TROUT. CHRONIC TOXICITY OF PESTICIDES TO FISH ...Chlorinated Hydrocarbons, Lake Trout, Brook Trout, Organophosphorous Cpds. , Pollution - Effects of , Reproduction Studies (general), Wildlife, ...**5.0654**

MEASUREMENT OF THE EFFECTS OF PESTICIDES ON INVERTEBRATE RESPIRATION - ACUTE TOXICITY OF PESTICIDES TO FRESHWATER INVERTEBRATES ...Chlorinated Hydrocarbons, Organophosphorous Cpds. , Pollution - Effects of , Respiratory System, ...**5.0664**

HIGH RESOLUTION NUCLEAR MAGNETIC RESONANCE SPECTRA OF ORGANIC PESTICIDES ...Chlorinated Hydrocarbons, Concentration, Decomposition-general, Isotopic, Nuclear Magnetic Resonance, Organophosphorous Cpds. , Temperature-other, ...**5.0283**

Chlorinated Hydrocarbons

INVESTIGATIONS OF THE RELATION BETWEEN THE USE OF CHLORINATED HYDROCARBONS AND THEIR RESIDUES IN CHANNEL CATFISH ...Channel Catfish, Environmental Effects, Missouri River, Nebraska, Wildlife, ...**5.0702**

BIOLOGICAL AND CHEMICAL OXIDATION OF SELECTED ORGANIC PESTICIDES ...Biological, Chemical Degradation, Chlorination, Degradation, Gas, Pesticides, ...**5.0010**

ALTERNATE METHODS OF MOSQUITO CONTROL TO REDUCE CHEMICAL POLLUTION OF WATERS FOR RECHARGE OF THE OGALALLA FORMATION ...Alternative Planning, Aquifers-general, Insecticides -non-specific, Mosquitoes -non-specific, Playas, Pollution Abatement, ...**5.1180**

DEVELOPMENT OF ANALYTICAL METHODS FOR PESTICIDE CONTAMINANTS IN DOMESTIC, IRRIGATION AND POND WATERS ...Emission, Gas, Irrigation-general, Pollutants-general, Ponds, ...**5.0137**

LIMNOLOGICAL FACTORS AFFECTING PESTICIDE RESIDUES IN SURFACE WATERS ...Iowa, Persistance of Residues, Phytoplankton, Reservoirs and Impoundments, Runoff, Surface Water, ...**5.0416**

INTERACTION OF HERBICIDES AND SOIL MICROORGANISMS ...Degradation, Microbial Degradation, Removal of Residues, Water Quality Control-other, ...**5.0802**

REDUCTION OF HAZARDS ASSOCIATED WITH THE PRESENCE OF RESIDUES OF INSECTICIDAL CHEMICALS IN THE ENVIRONMENT ...Organophosphorous Cpds. , Other, Persistence in Soils, Pesticides, Residues in Foods, ...**5.0404**

THE PERSISTENCE, ACCUMULATION AND FATE OF PESTICIDES IN CRANBERRY SOILS AND RESERVOIRS ...Blueberries, Cranberries, Organophosphorous Cpds. , Persistence in Soils, Reservoirs and Impoundments, Swamps-marshes, ...**5.0533**

COMPARATIVE UPTAKE OF 10 CHLORINATED HYDROCARBON PESTICIDES BY FISH ...Fish -non-specific, Metabolism - animal, Residue Analysis -other, Wildlife, ...**5.0628**

RELATIVE SUSCEPTIBILITIES OF FISH FAMILIES TO INSECTICIDES - ACUTE TOXICITY OF PESTICIDES TO FRESHWATER FISH AND OTHER VERTEBRATES ...Bioassay, Bioassays, Carbamates -non-specific, Organophosphorous Cpds. , Wildlife, ...**5.0653**

EFFECTS OF CHRONIC EXPOSURE TO SUBLETHAL LEVELS OF INSECTICIDES ON REPRODUCTION IN BROOK TROUT. CHRONIC TOXICITY OF PESTICIDES TO FISH ...Carbamates -non-specific, Lake Trout, Brook Trout, Organophosphorous Cpds. , Pollution - Effects of , Reproduction Studies (general), Wildlife, ...**5.0654**

MEASUREMENT OF THE EFFECTS OF PESTICIDES ON INVERTEBRATE RESPIRATION - ACUTE TOXICITY OF PESTICIDES TO FRESHWATER INVERTEBRATES ...Carbamates - non-specific, Organophosphorous Cpds. , Pollution - Effects of , Respiratory System, ...**5.0664**

CHEMICAL ANALYSES ...Estuaries, Substances Or Chemicals, ...**1.0034**

MECHANISMS OF PESTICIDE ACCUMULATION IN AQUATIC ORGANISMS ...Food Chains, Animal And/or Man, Insecticides - non-specific, Pollution Effects, Productivity - Food Chain, ...**5.0546**

HIGH RESOLUTION NUCLEAR MAGNETIC RESONANCE SPECTRA OF ORGANIC PESTICIDES ...Carbamates -non-specific, Concentration, Decomposition-general, Isotopic, Nuclear Magnetic Resonance, Organophosphorous Cpds. , Temperature-other, ...**5.0283**

FATE OF POLLUTANTS IN GROUND WATER ...Aquifers-general, Artificial Recharge, Nitrate, Nitrite, Playas, Pollutants - Path of , ...**5.0917**

INTERACTIONS OF PESTICIDES AND SEDIMENTED OILS ...Chemical Treatment-other, Other, Pesticides, Pollutants - Path of , ...**5.0551**

SYNERGISM OF PESTICIDES AND DETERGENTS ...Fish -non-specific, Mode of Action -animal, Other, Surfactants - Wetting Agents, Synergism and Synergists, ...**5.0800**

DDT

THE CYCLING OF C1-36 LABELED DDT IN NATURAL ECOSYSTEMS ...Aquatic Or Soil-aquatic Cycles, Monitoring Systems, Persistance of Residues, Pollution - Effects of , Radioisotopes, ...**5.0876**

RELATIONSHIPS BETWEEN SUB-LETHAL PESTICIDES AND REPRODUCTION AND BEHAVIOR OF FISHES ...Behavior - animal, Killifishs - Cyprinodon, Pesticides -non-specific, Reproduction Studies (general), Wildlife, ...**5.0292**

EFFECTS OF CHRONIC SUBLETHAL DOSAGES OF DDT ON THE SWIMMING PERFORMANCE OF ATLANTIC SALMON PARR ...Atlantic Salmon, Sebago Salmon, Locomotion -animal, Mode of Action -animal, Stamina, Wildlife, ...**5.0472**

DESIGNING AND TESTING A WATER MONITORING SYSTEM FOR PESTICIDES IN NORTH CAROLINA ...Agricultural Watersheds, Chemical Identification, Endrin, Monitoring Systems, North Carolina, Technique Development, ...**7.0087**

INTERACTION OF PESTICIDE POLLUTANTS AND AQUATIC FOOD-CHAIN ORGANISMS ...Food Chains, Animal And/or Man, Persistance of Residues, Pollutants - Path of , Pollution - Effects of , ...**5.1107**

THE BEHAVIOR AND FATE OF DDT AND ZECTRAN IN A FOREST SOIL ...Persistence in Soils, Soils and Fertilizer, Zectran, ...**5.1205**

RELATIONSHIPS BETWEEN PESTICIDES AND GEORGIA FARM POND ECOSYSTEMS ...Aquatic Or Soil-aquatic Cycles, Clay, Endrin, Farm Pond, Georgia, Pollution - Effects of , Soil Types, ...**5.0288**

EFFECT OF PESTICIDES ON WILDLIFE.(SONGBIRDS, HERRING GULLS AND FISH) ...Pollution Effects, Wildlife, Wildlife - non-specific, Wisconsin, ...**5.1309**

SURVEY OF DDT AND DIELDRIN RESIDUES IN FISHES IN WISCONSIN WATERS ...Dieldrin, Survey Studies, Wildlife, Wisconsin, ...**5.1291**

DDT RESIDUE ACCUMULATION IN WISCONSIN FISH AND THE EFFECT ON REPRODUCTION ...Maturity & Growth Stages, Reproduction Studies (general), Walleyes, Wildlife, Wisconsin, ...**5.1292**

DDT AND DIELDRIN METABOLISM AND STORAGE BY CHINOOK SALMON UNDER LABORATORY CONDITIONS ...Dieldrin, Laboratory Animals, Metabolism -animal, Salmon - coho,chinook,sockeye.., ...**5.0660**

SCREENING FOR PESTICIDE DETOXIFICATION AGENTS - CHEMICAL AND PHYSICAL STUDIES ON REDUCTION OF PESTICIDE HAZARDS ...Aldrin, Dieldrin, Removal of Residues, Screening Potential Pesticides, ...**5.0636**

INVESTIGATION OF STRESS-INDUCED MOBILIZATION OF INSECTICIDE RESIDUES - CHRONIC TOXICITY OF PESTICIDES TO FISH ...Dieldrin, Metabolism -animal, Salmon - coho,chinook,sockeye.., Stress, Wildlife, ...**5.0655**

FATE AND EFFECTS OF PESTICIDES IN FOREST SOILS AND WATER ...Forests, Groundwater Movement, Movement, Leaching, Persistence in Soils, Soils and Fertilizer, ...**5.0968**

FATE OF PESTICIDES ...Absorption, Fixation, Exchange, Aldrin, Biodegradation, Plant -other, 2,4-d, ...**5.0741**

Dibrom

TOXIC AND OTHER CHEMICALS IN MARINE BIOTA ...Bioassay, Diquat, Mollusks -non-specific & Other, Paraquat, ...**5.1074**

Dieldrin

THE EFFECT OF DIELDRIN ON SURVIVAL AND DEVELOPMENT OF FISH EGGS ...Aldrin, Basic Embryology, Mode of Action -animal, Ohio, Pollution - Effects of , ...**5.0885**

THE UPTAKE OF DIELDRIN IN THE THREE RIDGED NAIAD, AMBLEMA PLICATA ...Bioindicators, Freshwater Mussels, Scallops, Metabolism, Ohio River, Pollution Effects, ...**5.0886**

THE EFFECTS OF DIELDRIN ON MALLARD DUCKLING BEHAVIOR ...Behavior -animal, Light Quality -non-specific, Mallard, Mode of Action -animal, Visual, ...**6.0580**

EFFECTS OF THE CHLORINATED HYDROCARBONS, ALDRIN AND DIELDRIN, ON FRESHWATER SEED SHRIMP (OSTRACODA) ...Aldrin, Contamination - Water, Fresh Water, Laboratory Animals, Pollution - Effects of , Shrimps - Seed Or Mussel, ...**5.1117**

EFFECTS OF PESTICIDES ON MARINE ANIMALS ...Laboratory Animals, Metabolism, Mode of Action -animal, Respiration, ...**5.0261**

SURVEY OF DDT AND DIELDRIN RESIDUES IN FISHES IN WISCONSIN WATERS ...DDT , Survey Studies, Wildlife, Wisconsin, ...**5.1291**

BIOTRANSFORMATION OF ALDRIN AND DIELDRIN BY BACTERIA - INTERACTION BETWEEN MICROORGANISMS AND PESTICIDES ...Aldrin, Biodegradation, Cell. env.(non-specific & Ot.), Other, Soil Bacteria, Water Bacteria, ...**5.0644**

DDT AND DIELDRIN METABOLISM AND STORAGE BY CHINOOK SALMON UNDER LABORATORY CONDITIONS ...DDT , Laboratory Animals, Metabolism -animal, Salmon - coho,chinook,sockeye.., ...**5.0660**

SCREENING FOR PESTICIDE DETOXIFICATION AGENTS - CHEMICAL AND PHYSICAL STUDIES ON REDUCTION OF PESTICIDE HAZARDS ...Aldrin, DDT , Removal of Residues, Screening Potential Pesticides, ...**5.0636**

INVESTIGATION OF STRESS-INDUCED MOBILIZATION OF INSECTICIDE RESIDUES - CHRONIC TOXICITY OF PESTICIDES TO FISH ...DDT , Metabolism -animal, Salmon - coho,chinook,sockeye.., Stress, Wildlife, ...**5.0655**

CONTAMINATION OF OYSTERS BY PESTICIDES ...Endrin, Mode of Action -animal, Oysters, Residues in Foods, ...**5.0462**

Endrin

CURRENT FISH AND WILDLIFE PESTICIDE PROBLEMS ...Azodrin, Guthion, Mercury, of Aquatic Plants, Seed Treatment, Thiodan, Wildlife, ...**4.0042**

EVALUATION OF EARTHY MATERIALS FOR USE IN DECONTAMINATION OF WATER ...Clay, Removal of Residues, Waste Water Treatment-general, ...**5.0002**

DESIGNING AND TESTING A WATER MONITORING SYSTEM FOR PESTICIDES IN NORTH CAROLINA ...Agricultural Watersheds, Chemical Identification, DDT , Monitoring Systems, North Carolina, Technique Development, ...**7.0087**

LONG-TERM EFFECTS OF PESTICIDES ON AQUATIC INVERTEBRATES ...Malathion, Parathion, Pollution - Effects of , Pollution Effects, Sevin, ...**5.0548**

RELATIONSHIPS BETWEEN PESTICIDES AND GEORGIA FARM POND ECOSYSTEMS ...Aquatic Or Soil-aquatic Cycles, Clay, DDT , Farm Pond, Georgia, Pollution - Effects of , Soil Types, ...**5.0288**

BIOCHEMISTRY OF FISH SEMEN ...Cutthroat Trout, Fertility, Male Gametes, Mode of Action -animal, ...**5.0627**

PROJECT 2203 EFFECTS ON PHYSIOLOGY WORK UNIT 53 CHRONIC EFFECTS OF ENDRIN ON BLUEGILLS ...Alabama, Bluegills, Bream, Computer Matching Code, Residue Analysis - other, Wildlife, ...**5.0022**

CHRONIC EFFECTS OF METYHL PARATHION AND ENDRIN ON CHANNEL CATFISH AND GOLDFISH IN PONDS. PESTICIDE-INDUCED CHANGES IN POND ECOLOGY ...Channel Catfish, Goldfish, Parathion, Ponds, ...**5.0648**

THE CONSTITUENTS AND PHVSICO-CHEMICAL PROPERTIES OF SERUM FROM GOLD-FISH EXPOSED CHRONICALLY TO MALATHION AND ENDRIN ...Blood Plasma and Serum, Endocrine -other, Goldfish, Malathion, Mode of Action -animal, ...**5.0630**

THYROID FUNCTION OF GOLDFISH AND RAINBOW TROUT EXPOSED CHRONICALLY TO MALATHION AND ENDRIN - PESTICIDE EFFECTS ON FISH ENDOCRINE FUNCTIONS ...Goldfish, Malathion, Mode of Action -animal, Rainbow Trout, Steelhead Trout, Thyroid, ...**5.0631**

BLOOD OXYGEN AND CO2 CARRYING CAPACITY OF 4 FISH EXPOSED TO MALATHION AND ENDRIN - PESTICIDE EFFECTS ON FISH ENDOCRINE FUNCTIONS ...Blood Cells, Laboratory Animals, Malathion, Mode of Action -animal, Sevin, ...**5.0632**

EFFECTS OF ENDRIN & MALATHION ON GONADAL HYDRATION RESPONSE OF MALE GOLDFISH & RAINBOW TROUT. PESTICIDE EFFECTS ON FISH ENDOCRINE FUNCTION ...Goldfish, Malathion, Male Gametes, Mode of Action - animal, Pesticides, Rainbow Trout, Steelhead Trout, ...**5.0634**

PESTICIDE RESISTANT FISH IN NATURAL ECOSYSTEMS ...Animal Resistance, Food Chains, Animal And/or Man, Pollution Effects, Tolerance Rates, Wildlife, ...**5.0624**

CONTAMINATION OF OYSTERS BY PESTICIDES ...Dieldrin, Mode of Action -animal, Oysters, Residues in Foods, ...**5.0462**

Fungicides

Fungicides -non-specific

ALTERATIONS OF THE PERSISTENCE AND MOVEMENT OF HERBICIDES IN SOIL, WATER, AND PLANTS ...Herbicides - non-specific, Movement, Leaching, Pollutants - Path of , Soil Degradation -other, ...**5.0486**

Guthion

CURRENT FISH AND WILDLIFE PESTICIDE PROBLEMS ...Azodrin, Endrin, Mercury, of Aquatic Plants, Seed Treatment, Thiodan, Wildlife, ...**4.0042**

Heptachlor

BIOTRANSFORMATION OF HEPTACHLOR BY BACTERIA - INTERACTION BETWEEN MICROORGANISMS AND PESTICIDES ...Bacterial Pollutant Sources, Biodegradation, Other, Soil Bacteria, Water Bacteria, ...**5.0645**

Herbicides

Acrolein

GROWTH SUPPRESSION AND REDUCTION IN REGROWTH POTENTIAL OF AQUATIC WEEDS ...Biological Pollutants - other, Maturity Or Growth Stage of , of Aquatic Plants, Plant Resistance, Submerged Plants, ...**2.0191**

Amiben

EVALUATION OF EARTHY MATERIALS FOR USE IN DECONTAMINATION OF WATER ...Clay, Removal of Residues, Waste Water Treatment-general, ...**5.0002**

INTERACTION OF INORGANIC AND ORGANIC FERTILIZER MATERIALS WITH PESTICIDES AS RELATED TO WATER QUALITY IN SOILS ...Fertilizers, ...**5.0051**

Atrazine

SOIL, PESTICIDES AND THE QUALITY OF WATER ...Aquatic Or Soil-aquatic Cycles, Monuron, Movement, Leaching, Pesticides, Soil Environment, ...**5.0196**

THE DISPOSITION OF PESTICIDES IN THE SOIL ...Aquatic Or Soil-aquatic Cycles, Groundwater Movement, Microbial Degradation, Movement, Leaching, Rhizosphere, Trifluralin, ...**5.0290**

Bensulide

SOILS, PESTICIDES, AND THE QUALITY OF WATER ...Groundwater Movement, Management, Movement, Leaching, Soil Environment, 2,4-d, ...**5.0752**

Diquat

EVALUATION OF EARTHY MATERIALS FOR USE IN DECONTAMINATION OF WATER ...Clay, Removal of Residues, Waste Water Treatment-general, ...**5.0002**

EFFECT OF EURASIAN WATERMILFOIL CONTROL PROCEDURES ON WILDLIFE AND OTHER ORGANISMS IN AQUATIC ENVIRONMENTS ...Aquatic Environments, Contamination - Water, Evaluation, Water Milfoil, Waterweed... , 2,4-d, ...**5.0505**

TOXIC AND OTHER CHEMICALS IN MARINE BIOTA ...Bioassay, Dibrom, Mollusks -non-specific & Other, Paraquat, ...**5.1074**

Diuron

RESULTS OF APPLICATIONS OF KARMEX FOR CONTROL OF PLANTS IN PONDS AND LAK ...Aquatic Plants (non-specific), Evaluation, Lakes, of Aquatic Plants, Water Quality-general, ...**6.0568**

Herbicides -non-specific

METHODS FOR CONTROLLING ALLIGATORWEED AND OTHER WEEDS IN CANALS, WATERWAYS, AND ADJACENT WATERS IN THE SOUTHEASTERN U. S. ...Canals, Evaluation, Integrated Biological Control, of Aquatic Plants, Southeast, ...**8.0210**

BUOYANCY AND SINKING CHARACTERISTICS OF FRESHWATER PHYTOPLANKTON ...Algal Pollutant Sources, Fresh Water, Phytoplankton, Primary Productivity, Vertical Distribution, ...**5.1064**

THE BIOASSAY OF WATER POLLUTANTS WITH CULTURED MAMMALIAN CELLS ...Bioassay, Bioassays, Toxicity Or Residues -other, ...**5.1055**

EFFECT OF HERBICIDES ON AN AQUATIC ENVIRONMENT ...Mode of Action -plant, Persistance of Residues, Pollution - Effects of , Wildlife, ...**5.0003**

CONTROL OF UNDESIRABLE AQUATIC VEGETATION IN LAKE TANEYCOMO, MISSOURI ...Lakes, Missouri, of Aquatic Plants, ...**5.0682**

CHEMICAL CONTROL OF WEEDS IN PONDS ...Algacides -non-specific, of Aquatic Plants, Plant Pollutants, Ponds, Wildlife, ...**5.0009**

INTERACTION OF TEMPERATURE WITH OTHER FACTORS ON THE RESPONSE OF CANADA THISTLE TO HERBICIDES ...Mineral Nutrition, Mode of Action -plant, Modified Water Use, Soil Moisture -non-specific, Temperature Levels Or Ranges, ...**2.0395**

THE MOVEMENT OF HERBICIDES OFF, INTO, AND THROUGH SOILS ...Agricultural Watersheds, Movement, Leaching, Persistance of Residues, Runoff, Soil Sampling, ...**5.0487**

ALTERATIONS OF THE PERSISTENCE AND MOVEMENT OF HERBICIDES IN SOIL, WATER, AND PLANTS ...Fungicides - non-specific, Movement, Leaching, Pollutants - Path of , Soil Degradation -other, ...**5.0486**

AN EVALUATION OF WIDELY USED HERBICIDES ON AQUATIC PLANTS, FISH AND FISH-FOOD ORGANISMS ...Environmental Effects, Food Supply, Wildlife, ...**5.0570**

CONSERVATION OF GROUNDWATER THROUGH REPLACEMENT OF PHREATOPHYTES WITH FORAGES ...Conservation-general, Groundwater, in Forages and Pasture, Soil Environment, Water Table - Depth of , ...**3.0318**

AQUATIC WEEDS ...Aquatic Plants (non-specific), of Aquatic Plants, Physical-general, Plant Pollutants, Range Or Territorial Distr. , ...**5.0735**

MOVEMENT AND PERSISTENCE OF HERBICIDES IN THE SOIL ...Mode of Action -plant, Movement, Leaching, Persistence in Soils, Soil Profile, ...**5.1125**

DEVELOPMENT OF A CHEMICAL FALLOW SYSTEM OF FARMING ...Great Plains Province, Moisture Retention, Rotations, Runoff, Tillage, Cropping Systems, ...**4.0236**

FATE OF HERBICIDES IN WATER AND CROPS IRRIGATED WITH WATER CONTAINING HERBICIDES ...Persistance of Residues, Pesticides, Plant -other, Residues in Foods, Sprinkler Irrigation, ...**5.1327**

INCREASING CHAPARRAL WATERSHED YIELD THROUGH IMPROVED USE OF PHENOXY-TYPE HERBICIDES ...Environmental Effects, Moisture Tension, Temperature, Translocation, Water Yield, Watersheds-other, ...**3.0089**

EVALUATION OF HERBICIDES FOR CONTROL OF AQUATIC WEEDS ...Application Rates, Evaluation, Floating Plants, of Aquatic Plants, Submerged Plants, ...**5.0247**

CHEMICAL BRUSH CONTROL - BIOCHEMISTRY AND TOXIC HAZARD ...Aquatic Or Soil-aquatic Cycles, Environmental Effects, Other, Pesticides, Range, ...**5.0944**

INVESTIGATION OF AQUATIC WEED PROBLEMS AND MEANS OF CONTROL WITH EMPHASIS ON BRAZILIAN WATERWEED ...Applied Ecology, of Aquatic Plants, Screening Potential Pesticides, Water Milfoil, Waterweed... , ...**5.0938**

EFFECTS OF VARIOUS PRE-HARVEST AND POST-HARVEST TREATMENTS ON SWEET POTATOES ...Irrigation, Root, Screening Potential Pesticides, Sweetpotatoes, ...**6.0560**

AQUATIC PLANT CONTROL - EQUIPMENT FOR MECHANICAL AND CHEMICAL DESTRUCTION ...Louisiana, of Aquatic Plants, Pest, Disease & Weed Control, ...**8.0208**

AQUATIC PLANT CONTROL ...Environmental Ecology, Fish - non-specific, of Aquatic Plants, Wildlife, ...**8.0168**

HERBICIDE EVALUATION FOR PHREATOPHYTE CONTROL ...Consumptive Use, Modified Water Use, Range, Saltcedar, Tamarisk, Water Loss Control, ...**3.0132**

FIELD EVALUATION OF SOIL-APPLIED HERBICIDE FOR TOTAL VEGETATION CONTROL ...Formulations -non-specific, Soil Treatments -non-specific, Weed Control -other, ...**3.0126**

AROMATIC SOLVENT AQUATIC HERBICIDES AND EMULSIFYING AGENT TESTING ...Aromatic Cpds, Chemical Analysis, Evaluation, of Aquatic Plants, Petroleum Cpds. -non-specific, Plant Pollutants, ...**3.0107**

LABORATORY STUDY OF AQUATIC ENVIRONMENTAL FACTORS AND PLANT GROWTH STAGES ON AQUATIC WEED GROWTH AND HERBICIDAL RESPONSE ...Environmental Effects, Light -other, Maturity & Growth Stages, of Aquatic Plants, Water Temperature -other, ...**3.0127**

CONTROL OF WOODY PLANTS ...Aerial - Airplane, New Mexico, Rio Grande River, Weed Control -other, ...**3.0121**

WEED CONTROL IN IRRIGATION AND DRAINAGE SYSTEMS ...Amphibious Plants, Aquatic Soils, of Aquatic Plants, Plant Pollutants, Submerged Plants, Timing -non-specific, ...**3.0094**

CONTINUOUS-FLOW INVERTEBRATE BIOASSAYS AND PESTICIDES AT COLUMBIA, MO. - ACUTE TOXICITY OF PESTICIDES TO FRESHWATER INVERTEBRATES ...Bioassay, Insecticides -non-specific, Invertebrates -non-specific, Laboratory Animals, ...**5.0665**

PRINCIPLES AND PRACTICES FOR THE CONTROL OF SUBMERSED, FLOATING, AND IMMERSED AQUATIC WEEDS ...Biocontrol, Canals, Environmental Effects, Evaluation, of Aquatic Plants, ...**5.1329**

PERSISTENCE AND FATE OF HERBICIDES IN WATER AND AQUATIC SOILS AND THE EFFECTS OF HERBICIDES IN IRRIGATION WATER ON CROP PLANTS ...Canals, Irrigation, Persistance of Residues, Persistence in Soils, Pollutants - Path of , ...**5.1330**

CONTROLLING UNDESIRABLE PHREATOPHYTES ...Environmental Effects, Evaluation, Integrated Physical Control, Phreatophytes, ...**3.0496**

Monuron

SOIL, PESTICIDES AND THE QUALITY OF WATER ...Aquatic Or Soil-aquatic Cycles, Atrazine, Movement, Leaching, Pesticides, Soil Environment, ...**5.0196**

Paraquat

TOXIC AND OTHER CHEMICALS IN MARINE BIOTA ...Bioassay, Dibrom, Diquat, Mollusks -non-specific & Other, ...**5.1074**

PMA

CONSERVING SOIL MOISTURE BENEATH RED PINE BY MEANS OF A FOLIAR SPRAY OF A STOMATA - CLOSING CHEMICAL ...Liquids Or Sprays, Moisture Content, Pines, Soil Environment, Soils and Fertilizer, Transpiration, ...**3.0151**

Prometryne

INTERACTION OF INORGANIC AND ORGANIC FERTILIZER MATERIALS WITH PESTICIDES AS RELATED TO WATER QUALITY IN SOILS ...Fertilizers, ...**5.0051**

Silvex

DEGRADATION KINETICS OF VARIOUS ESTER FORMULATIONS OF 2%2.4.5 TRICHLOROPHENOXYROPRIONIC ACID %SILVEX..Aquatic Or Soil-aquatic Cycles, Biodegradation, Chemical Degradation, Degradation, Physical Degradation, ...**5.0285**

Trifluralin

INTERACTION OF INORGANIC AND ORGANIC FERTILIZER MATERIALS WITH PESTICIDES AS RELATED TO WATER QUALITY IN SOILS ...Fertilizers, ...**5.0051**

THE DISPOSITION OF PESTICIDES IN THE SOIL ...Aquatic Or Soil-aquatic Cycles, Atrazine, Groundwater Movement, Microbial Degradation, Movement, Leaching, Rhizosphere, ...**5.0290**

LIMNOLOGY AND MANAGEMENT OF OREGON FARM PONDS AND SMALL IMPOUNDMENTS ...Aquaculture & Fish-farming, Farm Pond, Management, Productivity - Food Chain, Reservoirs and Impoundments, Wildlife, ...**6.0449**

Urea Cpds. -non-specific

SOILS, PESTICIDES, AND THE QUALITY OF WATER ...Aquatic Or Soil-aquatic Cycles, Hawaii, Movement, Leaching, Soil Environment, Triazines -non-specific, ...**5.0044**

2,4-d

EXPANDED AQUATIC PLANT CONTROL PROJECT ...Amaranthaceae -alligatorweed.., of Aquatic Plants, Submerged Plants, Translocation, ...**6.0248**

SOILS, PESTICIDES, AND THE QUALITY OF WATER ...Bensulide, Groundwater Movement, Management, Movement, Leaching, Soil Environment, ...**5.0752**

HERBICIDE RESIDUES ...Irrigation-general, Persistance of Residues, Soil Contamination -other, 2,4,5-t, ...**3.0109**

EFFECT OF EURASIAN WATERMILFOIL CONTROL PROCEDURES ON WILDLIFE AND OTHER ORGANISMS IN AQUATIC ENVIRONMENTS ...Aquatic Environments, Contamination - Water, Diquat, Evaluation, Water Milfoil, Waterweed... , ...**5.0505**

2,4-D UPTAKE AND METABOLISM - METABOLISM OF PESTICIDES IN FISH ...Channel Catfish, Goldfish, Laboratory Animals, Metabolism -animal, Rainbow Trout, Steelhead Trout, ...**5.0659**

FATE OF PESTICIDES ...Absorption, Fixation, Exchange, Aldrin, Biodegradation, DDT , Plant -other, ...**5.0741**

2,4,5-t

HERBICIDE RESIDUES ...Irrigation-general, Persistance of Residues, Soil Contamination -other, 2,4-d, ...**3.0109**

Insect Chemosterilants

Insect Chemosterilants, N.s.

DISTRIBUTION, ABUNDANCE, TAXONOMY, AND BIOLOGY OF MOSQUITOES AFFECTING AGRICULTURE ...Animal Taxonomy, Mosquitoes -non-specific, Number Or Density, Radiation, Range Or Territorial Distr. , ...**6.0148**

Insecticides

Parathion

LONG-TERM EFFECTS OF PESTICIDES ON AQUATIC INVERTEBRATES ...Endrin, Malathion, Pollution - Effects of , Pollution Effects, Sevin, ...**5.0548**

CHRONIC EFFECTS OF METYHL PARATHION AND ENDRIN ON CHANNEL CATFISH AND GOLDFISH IN PONDS. PESTICIDE-INDUCED CHANGES IN POND ECOLOGY ...Channel Catfish, Endrin, Goldfish, Ponds, ...**5.0648**

Insecticides -non-specific

ACUTE TOXICITY OF PESTICIDES TO FRESHWATER FISH AND OTHER VERTEBRATES ...Maturity & Growth Stages, Mode of Action -animal, Pollution - Effects of , Pollution Effects, Wildlife, ...**5.0649**

THE RELATIONSHIP OF SEWAGE HANDLING PRACTICE TO PESTICIDE RESIDUE LEVELS AND INVERTEBRATE ECOLOGY ...Aquatic Ecology, Aquatic Soils, Michigan, Pollutants - Path of , Pollution Effects, ...**5.0572**

ALTERNATE METHODS OF MOSQUITO CONTROL TO REDUCE CHEMICAL POLLUTION OF WATERS FOR RECHARGE OF THE OGALALLA FORMATION ...Alternative Planning, Aquifers-general, Chlorinated Hydrocarbons, Mosquitoes -non-specific, Playas, Pollution Abatement, ...**5.1180**

INSECTICIDE ADSORPTION BY LAKE SEDIMENTS AS A FACTOR CONTROLLING INSECTICIDE ACCUMULATION IN LAKES ...Adsorption Capacity, Degradation, Deposits-other, Lakes, Wisconsin, ...**5.1300**

REDUCTION OF HAZARDS ASSOCIATED WITH INSECTICIDAL CHEMICALS IN THE ENVIRONMENT ...Persistence in Soils, Pollution - Effects of , Pollution Effects, Removal of Residues, Residues in Foods, ...**5.0359**

REDUCTION OF INSECTICIDAL HAZARDS ...Atmospheric Contamination, Movement, Leaching, Persistence in Soils, Pest Control, Pollution - Effects of , ...**5.0393**

DISPERSAL OF CONCENTRATED OR UNDILUTED INSECTICIDES FOR IMPROVED MOSQUITO CONTROL ...Animal Appl. -other, California, Larvicides, Mosquitoes -non-specific, ...**5.0493**

ECOLOGY OF PESTICIDES IN AN AQUATIC ECOSYSTEM ...Food Chains, Animal And/or Man, Michigan, Pollutants - Path of , Pollution - Effects of , Pollution Effects, ...**5.0563**

INSECTICIDE RESIDUES ON ALFALFA ...Persistance of Residues, Persistence in Soils, Pest Control, Soil Chemical Properties, ...**5.1115**

PESTICIDES AND WILDLIFE ...Biodegradation, Food Chains, Animal And/or Man, Habitat Studies, Preventative Measures, Wildlife -non-specific, ...**5.0138**

INSECTICIDE LEACHING TESTS ...Bioassay, Granules, Capsules, Persistence in Soils, Soil and Rock Leaching, ...**2.0959**

ROLE OF ENTERIC MICROORGANISMS IN DETOXIFICATION - INTERACTION BETWEEN MICROORGANISMS AND PESTICIDES ...Bacterial Culture, Biodegradation, Fish -non-specific, Identification, Intestinal Bacteria, ...**5.0641**

CONTINUOUS-FLOW INVERTEBRATE BIOASSAYS AND PESTICIDES AT COLUMBIA, MO. - ACUTE TOXICITY OF PESTICIDES TO FRESHWATER INVERTEBRATES ...Bioassay, Herbicides -non-specific, Invertebrates -non-specific, Laboratory Animals, ...**5.0665**

MONITORING OF PESTICIDE LEVELS IN THE GREAT LAKES ...Great Lakes-general, Monitoring Systems, Pollutants-general, Water Sampling, ...**5.0544**

RATES OF PESTICIDE BUILDUP IN SALMONIDS RECENTLY INTRODUCED IN THE GREAT LAKES ...Pollution Effects, Wildlife, ...**5.0545**

MECHANISMS OF PESTICIDE ACCUMULATION IN AQUATIC ORGANISMS ...Chlorinated Hydrocarbons, Food Chains, Animal And/or Man, Pollution Effects, Productivity - Food Chain, ...**5.0546**

PESTICIDE KINETICS ...Aquatic Or Soil-aquatic Cycles, Degradation -non-specific, Estuaries, Marine Biology (non-specific), Pollutants - Path of , ...**5.0271**

DETERMINATION OF RESIDUES OF INSECT CONTROL CHEMICALS IN PLANT AND ANIMAL PRODUCTS AND IN SOILS ...Biodegradation, Persistance of Residues, Residues in Foods, ...**5.0482**

CONTROL OF INSECT VECTORS ON WATERFOWL MARSHES ...Cultural Control, Great Salt Lake, Land Use, Management, Swamps-marshes, ...**4.0263**

THE EFFECT OF SELECTED PESTICIDES ON INTERTIDAL BIOTA ...Intertidal Areas, Pesticides -non-specific, Pollutants-general, Pollution Effects, Productivity - Food Chain, Swamps-marshes, ...**5.0522**

Malathion

LONG-TERM EFFECTS OF PESTICIDES ON AQUATIC INVERTEBRATES ...Endrin, Parathion, Pollution - Effects of , Pollution Effects, Sevin, ...**5.0548**

CHRONIC EFFECTS OF MALATHION ON BLUEGILLS ...Bluegills, Bream, Channel Catfish, Mode of Action -animal, Pollution - Effects of , Wildlife, ...**[illegible]**

MINERAL IMBALANCE IN BLUEGILLS EXPOSED TO MALATHION PESTICIDE-INDUCED MINERAL IMBALANCE IN FISH ...Bluegills, Bream, Mineral, Wildlife, ...**[illegible]**

EFFECTS OF MALATHION ON LEARNING AND RETENTION IN THE GOLDFISH ...Escape and Avoidance, Goldfish, Mode of Action -animal, Pesticides, Pollution - Effects of , ...**5.0667**

THE CONSTITUENTS AND PHYSICO-CHEMICAL PROPERTIES OF SERUM FROM GOLD-FISH EXPOSED CHRONICALLY TO MALATHION AND ENDRIN ...Blood Plasma and Serum, Endocrine -other, Endrin, Goldfish, Mode of Action -animal, ...**5.0630**

THYROID FUNCTION OF GOLDFISH AND RAINBOW TROUT EXPOSED CHRONICALLY TO MALATHION AND ENDRIN - PESTICIDE EFFECTS ON FISH ENDOCRINE FUNCTIONS ...Endrin, Goldfish, Mode of Action -animal, Rainbow Trout, Steelhead Trout, Thyroid, ...**5.0631**

BLOOD OXYGEN AND CO2 CARRYING CAPACITY OF 4 FISH EXPOSED TO MALATHION AND ENDRIN - PESTICIDE EFFECTS ON FISH ENDOCRINE FUNCTIONS ...Blood Cells, Endrin, Laboratory Animals, Mode of Action -animal, Sevin, ...**5.0632**

EFFECTS OF MALATHION ON THE SEXUAL DEVELOPMENT OF MALE RAINBOW TROUT - PESTICIDE EFFECTS ON FISH ENDOCRINE FUNCTIONS ...Gonadotrophins, Gonadotropins, Mode of Action -animal, Pollution - Effects of , Rainbow Trout, Steelhead Trout, ...**5.0633**

EFFECTS OF ENDRIN & MALATHION ON GONADAL HYDRATION RESPONSE OF MALE GOLDFISH & RAINBOW TROUT PESTICIDE EFFECTS ON FISH ENDOCRINE FUNCTION ...Endrin, Goldfish, Male Gametes, Mode of Action -animal, Pesticides, Rainbow Trout, Steelhead Trout, ...**5.0634**

Metal Organics -non-specific

AGRICULTURAL SIGNIFICANCE OF CERTAIN TRANSITIONAL ELEMENTS FROM PESTICIDES AND OTHER AGRICULTURAL CHEMICALS ...Chelating, Extraction-other, Mineralogy, Movement, Availability, Soil Analysis, Soil Chemical Properties, ...**5.0483**

Methoxychlor

CHRONIC EFFECTS OF METHOXYCHLOR ON BLUEGILLS AT COLUMBIA, MISSOURI ...Bluegills, Bream, Missouri, Pollution - Effects of , ...**5.0647**

METHOXYCHLOR-CAUSED EFFECTS ON CUTTHROAT TROUT PHYSIOLOGY CHRONIC TOXICITY OF INSECTICIDES TO COLD-WATER FISH ...Cutthroat Trout, Mode of Action -animal, Wildlife, Wyoming, ...**5.0666**

EFFECTS OF CHRONIC EXPOSURE TO METHOXYCHLOR ON THE GROWTH AND REPRODUCTION OF GUPPIES - CHRONIC TOXIEITY OF PESTICIDES TO FISH ...Growth Rate, Killifishs - Cyprinodon, Maturity & Growth Stages, ...**5.0650**

SERUM ANALYSIS OF CUTTHROAT TROUT EXPOSED CHRONICALLY TO METHOXYCHLOR PESTICIDE EFFECTS ON FISH ENDOCRINE FUNCTIONS ...Blood Plasma and Serum, Cutthroat Trout, Endocrine -other, Mode of Action -animal, ...**5.0629**

Molluscicides

Molluscicides -non-specific

CORRELATION OF STRUCTURE VS. ACTIVITY OF POLLUTANTS OF FRESH WATER ...Bioindicators, Gastropods - slugs,conch,snails, Pesticide-other, Screening Potential Pesticides, Thiocarbamate, N.s. , ...**5.1050**

WATER QUALITY PROTECTION - SYNTHESIS OF POTENTIAL MOLLUSCICIDES ...Animal Pollutant Sources, Mode of Action -animal, Schistosoma, Screening Potential Pesticides, ...**5.1066**

Nematocides

Nematocides -non-specific

ROOT-KNOT NEMATODE CONTROL (MELOIDOGYNE NAASI-FRANKLIN) ...Animal Pollutant Sources, Formulation,rate,concentration, Nematodes, Population Dynamics, Rhabditoidea, ...**3.0042**

Organophosphorous Cpds.

SOILS, PESTICIDES AND THE QUALITY OF WATER ...Movement, Leaching, Organic Matter, Physical Property Effects, Soil and Rock Leaching, Soil Environment, ...**5.0325**

REDUCTION OF HAZARDS ASSOCIATED WITH THE PRESENCE OF RESIDUES OF INSECTICIDAL CHEMICALS IN THE ENVIRONMENT ...Chlorinated Hydrocarbons, Other, Persistence in Soils, Pesticides, Residues in Foods, ...**[illegible]**

FACTORS INFLUENCING INSECTICIDE RESIDUES ON OR IN FOOD AND FORAGE CROPS ...Environmental Effects, Kansas, Persistance of Residues, Persistence in Soils, Physical Degradation, Pollution Effects, ...**5.0429**

PESTICIDE CONTAMINATION OF THE ENVIRONMENT AND ITS SIGNIFICANCE ...Carbamates -non-specific, Louisiana, Monitoring Systems, Persistance of Residues, ...**5.0451**

THE PERSISTENCE, ACCUMULATION AND FATE OF PESTICIDES IN CRANBERRY SOILS AND RESERVOIRS ...Blueberries, Cranberries, Chlorinated Hydrocarbons, Persistence in Soils, Reservoirs and Impoundments, Swamps-marshes, ...**5.0533**

RELATIVE SUSCEPTIBILITIES OF FISH FAMILIES TO INSECTICIDES - ACUTE TOXICITY OF PESTICIDES TO FRESHWATER FISH AND OTHER VERTEBRATES ...Bioassay, Bioassays, Carbamates -non-specific, Chlorinated Hydrocarbons, Wildlife, ...**5.0653**

EFFECTS OF CHRONIC EXPOSURE TO SUBLETHAL LEVELS OF INSECTICIDES ON REPRODUCTION IN BROOK TROUT. CHRONIC TOXICITY OF PESTICIDES TO FISH ...Carbamates -non-specific, Chlorinated Hydrocarbons, Lake Trout, Brook Trout, Pollution - Effects of , Reproduction Studies (general), Wildlife, ...**5.0654**

MEASUREMENT OF THE EFFECTS OF PESTICIDES ON INVERTEBRATE RESPIRATION - ACUTE TOXICITY OF PESTICIDES TO FRESHWATER INVERTEBRATES ...Carbamates-non-specific, Chlorinated Hydrocarbons, Pollution - Effects of , Respiratory System, ...**5.0664**

HIGH RESOLUTION NUCLEAR MAGNETIC RESONANCE SPECTRA OF ORGANIC PESTICIDES ...Carbamates -non-specific, Chlorinated Hydrocarbons, Concentration, Decomposition-general, Isotopic, Nuclear Magnetic Resonance, Temperature-other, ...**5.0283**

FREQUENCY DISTRIBUTION OF CHEMICAL POLLUTANTS IN SHELLFISH AND THE MARINE ENVIRONMENT ...Food, Oysters, Pollution - Effects of , Southern, Toxicological and Allergy, ...**5.0021**

Pesticide-other

CORRELATION OF STRUCTURE VS. ACTIVITY OF POLLUTANTS OF FRESH WATER ...Bioindicators, Gastropods - slugs,conch,snails, Molluscicides -non-specific, Screening Potential Pesticides, Thiocarbamate, N.s. , ...**5.1050**

Pesticides -non-specific

RELATIONSHIPS BETWEEN SUB-LETHAL PESTICIDES AND REPRODUCTION AND BEHAVIOR OF FISHES ...Behavior - animal, DDT , Killifishs - Cyprinodon, Reproduction Studies (general), Wildlife, ...**5.0292**

PESTICIDE RESIDUE DATA PROCESSING ...Chemical Analysis, Data Analysis - General, Document & Literature Info, Information Retrieval Methods, Persistance of Residues, ...**5.0147**

PESTICIDE RESIDUE STUDY IN SPORT FISH WATERS ...Chemical Analysis (water), Filtration, Monitoring Systems, Pollution - Effects of , ...**5.1231**

THE ECOLOGY OF THE YOUNG FISHES OF THE WEWEANTIC RIVER ESTUARY ...Aquatic Ecology, Estuaries, Massachusetts, Pollution - Effects of , Population Dynamics, ...**2.0607**

RELATIONSHIPS BETWEEN PESTICIDAL APPLICATION AND WATER CONTAMINATION UNDER IRRIGATION IN THE GREAT PLAINS ...Great Plains Province, Irrigation-general, Kansas, Pollutants - Path of , Water Application, ...**5.0430**

ELECTROPHORETIC CLARIFICATION OF WATER ...Bacterial Pollutant Sources, Colloidal Phenomena, Desalination, Other, Tertiary Treatment, Waste Water Treatment-general, ...**5.1157**

MOVEMENT AND ADSORPTION OF PESTICIDES IN STERILIZED SOIL COLUMNS ...Absorption Rates, Absorption, Fixation, Exchange, Column Leaching & Diffusing, Internal Water Movement, Movement, Leaching, Soil Tests, ...**5.0256**

DETECTION AND IDENTIFICATION OF MOLECULAR WATER POLLUTANTS BY LASER RAMAN SPECTROSCOPY ...Chemical Analysis, Detectors and Sensors, Industrial Wastes, Lasers and Masers, Physical Parameters, Raman, Surfactants, ...**5.0441**

MASSACHUSETTS PESTICIDE MONITORING STUDY ...Massachusetts, Monitoring Systems, Sampling, Watershed-general, ...**5.0539**

SOILS, PESTICIDES AND THE QUALITY OF WATER ...Absorption, Fixation, Exchange, Aquatic Or Soil-aquatic Cycles, Boundary Process (moisture), Groundwater Movement, Movement, Leaching, ...**5.0079**

SORPTION AND DESORPTION FACTORS INFLUENCING TRANSPORT, PERSISTENCE, & ALTERATION OF PESTICIDES IN VARIOUS AGRICULTURAL SOILS ...Boundary Process (moisture), Movement, Leaching, Physical Properties-general, Radioisotopes, Soil Chemical Properties, ...**5.0140**

THE DISPOSITION OF PESTICIDES IN THE SOIL ...Georgia, Groundwater Movement, Movement, Leaching, Persistence in Soils, Soil Environment, ...**5.0287**

IDENTIFICATION AND REMOVAL OF PESTICIDES FROM RURAL WATER SUPPLIES ...Removal of Residues, Residues in Potable Water, Rural Areas, Waste Water Treatment-general, Water Utilization -domestic, ...**5.0448**

BIOCHEMICAL AND ECOLOGICAL RELATIONSHIPS OF PESTICIDES AND THE BIOLOGICAL CONSTITUENTS OF AQUATIC COMMUNITIES ...Applied Ecology, Bioenergetics, Cell Injury and Autolysis, Mortality Rates, Sterility, ...**5.0566**

PESTICIDAL RESIDUES OF AGRICULTURAL CHEMICALS ...Nevada, Persistence in Soils, Pollutants-general, Residue Analysis -other, Soil Degradation -other, ...**5.0707**

DEVELOPMENT OF ANALYTICAL METHODS FOR PESTICIDE CONTAMINANTS IN DOMESTIC, IRRIGATION, LAKE, AND POND WATERS ...Chemical Analysis, Chemical Analysis (water), Chemical Treatment-general, Irrigation-general, Lakes, Ponds, ...**5.0139**

EFFECT OF PESTICIDE RESIDUES AND OTHER ORGANOTOXICANTS ON THE QUALITY OF SURFACE AND GROUND WATER RESOURCES ...Groundwater, Persistence in Soils, Pollution - Effects of , Surface Water, Water Quality Control-general, ...**5.0392**

TOXICOLOGY OF PESTICIDES IN THE ENVIRONMENT ...Animal Tox. or Resid. -other, Food Chains, Animal And/or Man, Mode of Action -animal, Persistence in Soils, ...**5.0943**

CHEMICAL BIOCIDES IN LAKES ...Lakes, Pollution - Effects of , Pollution Effects, Productivity - Food Chain, South Dakota, ...**5.1111**

THE EFFECT OF PESTICIDES ON AN ECOSYSTEM ...Environments-general, Food Chains, Animal And/or Man, Persistance of Residues, Physical Properties-general, Pollution - Effects of , Soil Chemical Properties, ...**5.1154**

BEHAVIOR OF POLLUTANTS IN WATER ...Aquatic Or Soil-aquatic Cycles, Decomposition-general, Infiltration, Movement, Leaching, Persistence in Soils, Pollutants - Path of , ...**5.0190**

EFFECTS OF PESTICIDES ON AQUATIC ANIMALS IN THE ESTUARINE AND MARINE ENVIRONMENT (ABBREV) ...Bioindicators, Estuaries, Laboratory Animals, Pollution - Effects of , ...**5.0062**

COMPARISON OF METHODS USED TO MEASURE ESTERASE ACTIVITY. INTERACTIONS BETWEEN PESTICIDE ON FISH ENZYME SYSTEMS ...Bluegills, Bream, Channel Catfish, Cholinesterase, Cutthroat Trout, Manometers, Visible, ...**5.0637**

SEASONAL CHANGES IN ESTERASE ACTIVITY IN FISH AND INVERTEBRATES. INTERACTIONS BETWEEN PESTICIDES ON FISH ENZYME SYSTEMS ...Biochemical Analysis, Bluegills, Bream, Cholinesterase, Invertebrates -non-specific, Mode of Action -animal, ...**5.0638**

EFFECTS OF PESTICIDES ON PROTEIN, CARBOHYDRATE, AND NUCLEIC ACID METABOLISM. INTERACTION BETWEEN MICROORGANISMS AND PESTICIDES ...Biosynthesis, Cell Injury and Autolysis, Microorganisms (non-specific), Mode of Action -animal, Mode of Action -plant, Respiration, ...**5.0643**

LITERATURE SURVEY OF PESTICIDE METABOLISM IN FISH - METABOLISM OF PESTICIDES IN FISH ...Metabolism - animal, Mode of Action -animal, Survey Studies, Wildlife, ...**5.0661**

ACUTE TOXICITY OF PESTICIDES TO FRESHWATER INVERTEBRATES - DEVELOPMENT OF A LABORATORY STREAM FOR REARING AND TESTING AQUATIC INVERTEBRATES ...Captive Rearing, Invertebrate Cultures, Invertebrates -non-specific, Laboratory, Laboratory Animals, ...**6.0319**

ACUTE TOXICITY OF PESTICIDES TO FRESHWATER FISH AND OTHER VERTEBRATES ...Pollution - Effects of , Stamina, Wildlife, ...**5.0651**

ACUTE TOXICITY OF PESTICIDES TO FRESHWATER FISH AND OTHER VERTEBRATES ...Fish -non-specific, Screening Potential Pesticides, Temperature, Water Quality-general, Wildlife, ...**5.0652**

BEHAVIOR OF ESTUARINE ANIMALS ...Behavior -animal, Estuaries, Pollution - Effects of , Pollution Effects, ...**2.0833**

ESTUARINE ECOSYSTEMS ...Aquatic Or Soil-aquatic Cycles, Estuaries, Pollution - Effects of , Pollution Effects, Water Properties-general, ...**2.0834**

REMOVAL OF PESTICIDES FROM FRESHWATER FISH ...Bioassay, Fish -non-specific, Fish Meals, Mode of Action -animal, Removal of Residues, ...**5.0543**

RURAL RUNOFF CONTROL ...Adsorption-desorption, Nutrients, Runoff, Rural Areas, Thermal Properties-other, ...**5.0282**

THE DISPOSITION OF PESTICIDES IN SOIL AND CLOSELY RELATED WATER ...Farm Pond, Louisiana, Management, Pollutants - Path of , Soil and Rock Leaching, ...**5.0276**

CHEMICAL, PHYSICAL AND BIOLOGICAL REACTIONS OF PESTICIDES WITH SOILS AFFECTING SOIL PRODUCTIVITY AND PESTICIDE STABILITY ...Microbiology -soil, Movement, Leaching, Pollutants - Path of , Residue Analysis -other, Soil Conditions, Soil Temp. -non-specific, ...**5.0202**

THE ECONOMIC ANALYSIS OF WATER POLLUTION BY PESTICIDES AND OTHER AGRICULTURAL WASTES ...Agricultural Watersheds, Benefit-cost Analysis, Economic Impact, Model Studies, Pollution, Pollution Abatement, ...**5.0238**

TOXICOLOGY OF PESTICIDES IN THE ENVIRONMENT ...Air Pollution -other, Contamination - Water, Food Chains, Animal And/or Man, Pollution Effects, Soil Contamination -other, ...**5.0945**

INFORMATION PROCEDURES IN ENVIRONMENTAL CONTAMINATION ...Atmospheric Contamination, Atmospheric Pollution-general, General Information Services, ...**[illegible]**

THE EFFECT OF SELECTED PESTICIDES ON INTERTIDAL BIOTA ...Insecticides -non-specific, Intertidal Areas, Pollutants-general, Pollution Effects, Productivity - Food Chain, Swamps-marshes, ...**5.0522**

DEPURATION OF CHEMICAL POLLUTANTS IN SHELLFISH ...Chromium, Contamination - Water, Metabolism, Oysters, Shellfish Depuration, ...**5.0020**

Petroleum Cpds. -non-specific

AROMATIC SOLVENT AQUATIC HERBICIDES AND EMULSIFYING AGENT TESTING ...Aromatic Cpds, Chemical Analysis, Evaluation, Herbicides -non-specific, of Aquatic Plants, Plant Pollutants, ...**3.0107**

INFLUENCE OF PROTOZOAN ACTIVITY ON HALOGENATED HYDROCARBON RESIDUES - INTERACTION BETWEEN MICROORGANISMS AND PESTICIDES ...Axenic Culture, Metabolism, Mode of Action -animal, Protozoa -other, ...**5.0642**

Piscicides

Piscicides -non-specific

FISH TOXICANT STUDIES ...Ammonium, Control of Nuisance Species, Evaluation, Fish -non-specific, Screening Potential Pesticides, ...**5.1147**

BIOLOGICAL FACTORS IN THE MANAGEMENT OF LAKE FLIES ...Lakes, Midges, Pollution - Effects of , Predation, Predators and Parasite, Wisconsin, ...**6.0644**

BIOASSAY ...Animal Pollutant Sources, Evaluation, Lampreys, Streams, Water Properties-general, ...**5.0580**

Rotenone

STATEWIDE FISHERIES RESEARCH ...Bioindicators, Bluegills, Bream, Environmental Effects, Pollution - Effects of , Temperature, ...**5.0817**

Sevin

LONG-TERM EFFECTS OF PESTICIDES ON AQUATIC INVERTEBRATES ...Endrin, Malathion, Parathion, Pollution - Effects of , Pollution Effects, ...**5.0548**

AN EVALUATION OF THE INSECTICIDE SEVIN AS A WATERSHED POLLUTANT ...Forest Watersheds, Persistance of Residues, Pollution - Effects of , ...**5.1206**

EFFECTS OF PESTICIDES ON ESTUARINE ORGANISMS ...Bioassay, Estuaries, Persistance of Residues, Pollution - Effects of , Swamps-marshes, ...**5.0950**

BLOOD OXYGEN AND CO2 CARRYING CAPACITY OF 4 FISH EXPOSED TO MALATHION AND ENDRIN - PESTICIDE EFFECTS ON FISH ENDOCRINE FUNCTIONS ...Blood Cells, Endrin, Laboratory Animals, Malathion, Mode of Action -animal, ...**5.0632**

Thiocarbamate, Na.

CORRELATION OF STRUCTURE VS. ACTIVITY OF POLLUTANTS OF FRESH WATER ...[illegible], [illegible] - [illegible], Molluscicides -non-specific, Pesticide-other, Screening Potential Pesticides, ...**[illegible]**

Thiodan

CURRENT FISH AND WILDLIFE PESTICIDE PROBLEMS ...Azodrin, Endrin, Guthion, Mercury, of Aquatic Plants, Seed Treatment, Wildlife, ...**4.0042**

THIODAN AS A TOXICANT FOR ERADICATION OF FISHES IN LAKE MANAGEMENT ...Control of Nuisance Species, Evaluation, Lakes, Management, ...**6.0567**

Toxaphene

TOXAPHENE FILTRATION PUBLICATION ...Carbon, Filtration, Publications -other, Removal of Residues, ...**5.1146**

Triazines -non-specific

SOILS, PESTICIDES, AND THE QUALITY OF WATER ...Aquatic Or Soil-aquatic Cycles, Hawaii, Movement, Leaching, Soil Environment, Urea Cpds. -non-specific, ...**5.0844**

Zectran

THE BEHAVIOR AND FATE OF DDT AND ZECTRAN IN A FOREST SOIL ...DDT , Persistence in Soils, Soils and Fertilizer, ...**[illegible]**

Petrography

PERMEABILITY DISTRIBUTION AND SEDIMENTATIONAL FEATURES ...Big Horn, Clastic Aquifers, Permeability, Sedimentary Structures-other, Water Yield, ...**2.0271**

EVALUATION OF ROCK RIPRAP AND DEVELOPMENT OF SUBSTITUTES ...Aggregrates - Crushed Rock, Engineering Structures-general, Erosion Control, Slopes, Soil Cement, Wave Action, ...**8.0081**

PETROGRAPHIC INVESTIGATIONS ...Aggregates, Extenders, Fillers, Cement, Concrete, Construction Materials-other, Structure-materials-general, ...**8.0119**

DEVELOPMENT OF SOIL TESTING PROCEDURES AND ANALYSIS OF RESULTS ...Compaction, Direct Shear and Plane Shear, Soil Sampling, Triaxial, Vane, ...**8.0084**

Petroleum

EFFECTS OF PETROLEUM AND PETROLEUM WASTES UPON IMPORTANT SPECIES OF ESTUARINE PHYTOPLANKTON AND ZOOPLANKTON ...Contamination - Water, Contamination, Pollution-water, Estuaries, Oil, Phytoplankton, Zooplankton, ...**5.1086**

Petroleum Chemistry

MARINE OIL-WATER SEPARATION SYSTEM SUBGROUP V ...Filtration, Removal--organics, Ship Wastes, ...**5.0209**

DEMONSTRATION OF INDUSTRIAL WATER RENOVATION PLANT AT ODESSA, TEXAS ...Chemical Manufacturing Wastes, Process Design, Recycle, Waste Treatment-economics, Water Reuse, ...**5.1181**

SOLUBILITIES OF SILICATES IN SALINE WATERS ...Silicate, Solubility, ...**1.0096**

EFFECTS OF CRUDE OILS AND THEIR EMULSIONS TO MARINE ORGANISMS ...Chelating Agents, Emulsion, Oil, Poisons-other, Removal--organics, ...**5.1082**

THE CHARACTERISTICS AND POLLUTIONAL PROBLEMS OF PETROCHEMICAL WASTES ...Groundwater, Mining Activities, Other, Petroleum Industry, Pollution - Effects of , ...**5.0908**

RESEARCH NEEDS PERTAINING TO PETROLEUM WASTE WATERS ...Industrial Processes-other, Mining Activities, Petroleum Industry, Water Quality Control-general, ...**5.0914**

Petrology

General Petrology

BASIC ROCK PHYSICS ...Engineering Structures-general, Foundations-general, Geology - Engineering, Joints-fractures, Weathering, ...**8.0118**

Igneous Rocks

Crystalline

HYDROLOGY OF THE CRYSTALLINE ROCK SYSTEM IN SOUTHEASTERN STATES ...Groundwater, Groundwater Movement, Hydrology-general, Water Quality-general, Water Wells, Water Yield, ...**2.0825**

Intrusives

FACTORS RESTRICTING INFILTRATION RATES ON DECOMPOSED GRANITIC SOILS ...Floods, Infiltration, Organic-general, Sand, Sierra Nevada, ...**2.0732**

Metamorphic Rocks

Non-foliated Rocks

CONCRETE AGGREGATE RESEARCH ...Aggregates, Extenders, Fillers, Cement, Concrete, Chert, Sandstones, Standards, Specifications, Test Methods, ...**8.0237**

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Igneous Rocks

HYDROLOGY OF THE COLUMBIA RIVER BASALT ...Columbia Plateau, Hydrology-general, Infiltration, Runoff, Specific Rock Unit, Tectonics-general, ...**[illegible]**

Pharmacology

Side Effects

EFFECTIVENESS OF IODINE FOR DISINFECTION OF PUBLIC WATER SUPPLIES & TO DETERMINE PHYSIOLOGICAL EFFECTS ON A HUMAN POPULATION (ABBREV) ...Chemical Treatment-other, Iodine, Pollution-water, ...**5.0249**

Toxicology

LITERATURE SEARCH FOR POSSIBLE PESTICIDE DETOXIFYING AGENTS - CHEMICAL AND PHYSICAL STUDIES ON REDUCTION OF PESTICIDE HAZARDS ...Removal of Residues, Survey Studies, ...**5.0635**

DEVELOPMENT OF A METHOD FOR CHRONIC TOXICITY BIOASSAY USING MARINE PLANKTONIC ALGAE ...Algal Culture, Bioassays, Marine Plants, Microbiological Analysis, Monitoring (long Term Studies), Phytoplankton, Technique Development, ...**5.1088**

MARINE TOXINS OF THE TROPICAL PACIFIC ...Algal Metab.(non-specific &ot), Animal Origin, Fish -non-specific, Other, Polynesia, ...**5.0315**

COMPARATIVE STUDIES OF DINOFLAGELLATE TOXINS ...Action- & Bioelectrical Pot. , Algal Culture, Algal Toxins, Dinophyceae (non-specific &ot), ...**5.0716**

Phosphate, Phosphite

PHOSPHATE TRANSFORMATION IN WATERLOGGED SOILS ...Rice, Soil-water-plant Relationships, ...**4.0124**

AN ANALYSIS OF PHOSPHORUS AND NITROGEN COMPOUNDS IN TIDAL MARSHLAND DRAINAGE - LABORATORY PROCEDURES ...Colorimetric, Computers-general, Conductrometry, Management, Nitrogen, Swamps-marshes, ...**1.0024**

AN INVESTIGATION OF THE EFFECT OF CONTROLLED RELEASES ON THE PHYSICAL, CHEMICAL AND BACTERIOLOGICAL CHARACTERISTICS OF FORT LOUDOUN RESERVOIR ...Nitrogen, Stratified Flow, Suspension, Temperature-other, Tennessee, ...**5.1128**

FLUIDIZED EXCHANGE SYSTEMS FOR REMOVAL OF NITROGEN AND PHOSPHOROUS FROM WASTEWATER ...Fluidized Bed, Ion Exchange-other, Nitrate, Nitrite, Nutrients, Waste Water Treatment-general, ...**5.0556**

DETERMINATION OF THE FEASIBILITY OF REMOVAL OF ALGAL NUTRIENTS IN LAKE WATERS BY ION-EXCHANGE ...Algae- General, Eutrophication, Ion Exchange-other, Lakes, Nutrients, ...**2.0610**

PHOSPHATE UPTAKE, STORAGE, AND RELEASE BY MICROORGANISMS IN WASTEWATER TREATMENT ...Chemostat, Microorganisms (non-specific), Nutrition, Storage, Waste Water Treatment-general, ...**5.1282**

RELATIONSHIPS BETWEEN PHOSPHATE AND OTHER CHEMICALS AT THE WATERSUBSTRATE INTERFACE IN WESTERN LAKE ERIE ...Aquatic Soils, Chemical, Chemical-general, Sediments, ...**5.0874**

PRECIPITATION OF PHOSPHATES FROM WATER WITH FERROUS SALTS ...Biochemical Oxygen Demand, Chemical Treatment, Iron, Precipitation, Waste Water Treatment-general, ...**5.0882**

MICROBIAL RELEASE OF SOLUBLE PHOSPHATE IN AN ACTIVATED SLUDGE ENVIRONMENT ...Cell. env.(non-specific & Ot.), Microorganisms (non-specific), Oxygen, ...**5.1213**

REMOVAL OF PHOSPHATE FROM WATER BY ALUMINUM AND IRON ...Aluminum, Complexes, Iron, Mechanisms, Waste Water Treatment-general, ...**5.0732**

SPECTROPHOTOMETRIC AND FLUOROMETRIC DETERMINATION OF SELECTED ANION WATER CONTAMINANTS ...Carbonate, Bicarbonate, Chemical Identification, Fluorometry, Iodide, Spectroscopy-general, Thiocyanate, ...**5.0672**

A FIELD AND LABORATORY STUDY OF FLUORIDE UPTAKE BY OYSTERS ...Estuaries, Fluoride, Laboratory, Metabolism, Mining Activities, Oysters, ...**6.0407**

BOD, SOLIDS AND NUTRIENT REMOVAL FROM SECONDARY EFFLUENT BY FOAM FRACTIONATION ...Denitrification, Foam, Nitrate, Nitrite, Pilot Plant, ...**5.0155**

PHOSPHATE REMOVAL BY BIOLOGICAL PROCESS ...Activated, Drying-dewatering, Process Design, ...**5.0582**

PHOSPHATE EXCHANGE WITH SEDIMENTS ...Chemical-general, Eutrophication, Pollution - Effects of , Pollution Abatement, Water Quality Control-general, ...**5.0525**

PHOSPHATE MINING EFFLUENT IN ESTUARINE ECOLOGY ...Applied Ecology, Estuaries, Mining Activities, Mountmorillanite, Pollution - Effects of , ...**5.0821**

UPTAKE AND RELEASE OF SOLUBLE ORTHOPHOSPHATE BY ACTIVATED SLUDGE ...Activated, Aeration, Concentration, Effluents-waste Water, ...**5.0365**

PHOSPHORUS REMOVAL BY ADDITION OF ALUMINUM TO THE ACTIVATED SLUDGE PROCESS ...Activated, Aluminum, Waste Treatment-economics, ...**5.0109**

PHOSPHORUS REMOVAL AND DISPOSAL FROM MUNICIPAL WASTEWATER ...Biological Treatment-other, Chemical Treatment, Domestic Wastes-general, Waste Disposal-general, Waste Treatment-economics, ...**5.1172**

PHOSPHORUS REMOVAL IN THE ACTIVATED SLUDGE PLANT ...Activated, Aeration, Aluminum, Precipitation, Sewage - Domestic, ...**5.0788**

PROCESS TO REMOVE CARBONACEOUS, AND PHOSPHORUS-MATERIALS FROM ANAEROBIC DIGESTER SUPERNATANT AND RELATED PROCESS STREAMS ...Anaerobic, Coagulation, Denitrification, Lime Treatment, Organics, ...**5.0156**

AN ELECTROCHEMICAL METHOD FOR REMOVAL OF PHOSPHATES FROM WASTEWATERS ...Electrochemistry-other, Electrode, Waste Treatment-economics, ...**5.0523**

A STUDY OF A PROCESS FOR PHOSPHATE REMOVAL FROM WATER SUPPLIES USING LANTHANUM PRECIPITATION ...Lanthanum, Material Recovery Wastes, Process Design, Waste Treatment-economics, Waste Water Treatment-other, ...**5.0074**

PARAMETRIC STUDY OF THE KINETICS OF PRECIPITATION AND NATURE OF THE PRECIPITATE OBTAINED IN PHOSPHATE REMOVAL USING IRON AND ALUMINUM SALT ...Aluminum, Iron, Precipitation, Solubility, Tertiary Treatment, ...**5.0075**

ULTIMATE DISPOSAL OF PHOSPHATE FROM WASTEWATER BY RECOVERY AS FERTILIZER ...Activated, Ammonia, Disposal, Fertilizers, Material Recovery Wastes, Nutrients, ...**5.0342**

SELECTIVE NITRATE AND PHOSPHATE REMOVAL ...Denitrification, Ion Exchange-other, Ion Selective, Nitrate, Nitrite, Selective-removal, Waste Treatment-economics, ...**5.0532**

STUDY OF UTILIZATION AND DISPOSAL OF LIME SLUDGES CONTAINING PHOSPHATES ...Disposal, Lime Treatment, Material Recovery Wastes, Waste Treatment-economics, Waste Water Treatment-general, ...**5.0892**

EXPERIMENTS TO DETERMINE THE EFFECTIVENESS OF PHOSPHATE REMOVAL BY MEANS OF THE MOVING BED FILTER ...Filtration, Flocculation, Process Design, Solid Waste, Waste Treatment-economics, ...**5.0723**

ALUMINA COLUMNS FOR THE SELECTIVE REMOVAL OF PHOSPHORUS FROM WASTEWATERS AND THE ULTIMATE DISPOSAL OF PHOSPHORUS AS CALCIUM PHOSPHATE ...Aluminum, Material Recovery Wastes, Process Design, Regeneration-other, Selective-removal, ...**5.1243**

STORM WATER TREATMENT FACILITIES ...Chemical Treatment-general, Lime Treatment, Overflow, Sewage Treatment Plant, Storm Water, ...**5.1164**

INTERRELATIONSHIPS OF SOIL PHYSICAL PROPERTIES AND SOIL WATER MOVEMENTS ...Adsorption Capacity, Drawdown, Internal Water Movement, Moisture Tension, Permeability, ...**2.0829**

FIXATION AND AVAILABILITY OF ADDED PHOSPHORUS IN SOILS ...Absorption, Fixation, Exchange, Fertilizer Technology - other, Phosphorus, Soil Environment, ...**1.0053**

SOLUBLE PHOSPHORUS REMOVAL IN THE ACTIVATED SLUDGE PROCESS ...Activated, Aeration, Aluminum, Chemical Treatment, Digestion, Filter-other, ...**5.1037**

DETERMINATION OF THE PHOSPHATE CONTENT OF NATURAL WATERS, AT THE NUTRIENT LEVEL, BY SOLVENT EXTRACTION ...Automatic Systems, Extraction-other, Fresh Water, Nutrients, Trace Analyses-other, ...**1.0015**

INVESTIGATION AND CONTROL OF ALGAE BLOOMS AND NUISANCE GROWTHS OF WATER WEEDS ...Eutrophication, of Aquatic Plants, ...**6.0110**

PEACE RIVER POLLUTION INVESTIGATIONS ...Fish -non-specific, Florida, Industrial Wastes, Pollution - Effects of , Pollution Effects, Streams, ...**5.0273**

REMOVAL OF PHOSPHATE FROM WATER BY ALUMINUM AND IRON ...Aluminum, Chemical Treatment, Chemical Treatment-general, Iron, Reaction-general, ...**5.0738**

LIME SLUDGE RECOVERY AND REUSE ...Demineralization, Lime Treatment, Material Recovery Wastes, Silicate-general, Treatment-other, ...**5.0858**

PHOSPHATE REMOVAL BY ACTIVATED SLUDGE PROCESS SPECIFICATION - PLANT SCALE RESEARCH ...Pilot Plant, ...**5.0915**

PHOSPHATE REMOVAL BY ACTIVATED SLUDGE PROCESS APPLICATION - PLANT SCALE DEMONSTRATION ...Activated, Location, Mechanisms, Pollutant-other, Sewage Treatment Plant, ...**5.0912**

STUDY OF MICROBIOLOGICAL-BIOCHEMICAL PHOSPHATE SORPTION MECHANISM BY ACTIVATED SLUDGE ...Absorption-other, Activated, Mechanisms, Other, Sewage Bacteria, ...**5.0907**

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IN SITU STUDY OF FACTORS CONTROLLING NUTRIENT REGENERATIONS IN THE BOTTOM SEDIMENTS ...Adirondack Province, Aquatic Soils, Exchange Capacity, Mineral Content -water, Nutrients, Ponds, ...**2.0806**

SEASONAL VARIATIONS IN THE PHYTOPLANKTON - BACTERIA POPULATIONS AND THE NUTRIENT CONCENTRATION IN BEAVER RESERVOIR ...Nitrogen, Phytoplankton, Reservoirs and Impoundments, Temporal Distribution, Water Bacteria, ...**6.0027**

PHOSPHORUS BUDGETS OF LAKES SIDNEY, LANIER AND HARTWELL ...Chemical-general, Georgia, Nutrients, Pollutants - Path of , Reservoirs and Impoundments, ...**5.0293**

APPLICATION OF RADIOISOTOPO TECHNIQUES TO A CRITICAL WATER RESOURCES PROBLEM AREA (NUTRITIONAL POLLUTION) ...Algae, Nutrients, Radioisotopes, ...**5.0919**

RELATION OF PHOSPHORUS IN LAKE BOTTOM DEPOSITS AND POLLUTIONAL HISTORY OF MINNESOTA LAKES ...Chemical, Core Analysis, Lakes, Minnesota, ...**5.0602**

BIOLOGICAL AND CHEMICAL STUDY OF VIRGINIAS ESTUARIES ...Estuaries, Nitrogen, Phytoplankton, Population Dynamics, Primary Productivity, Virginia, ...**2.1112**

STUDIES ON PHOSPHORUS TRANSFORMATIONS IN EUTROPHIC LAKES ...Bacterial Culture, Bacterial Pollutant Sources, Budgets -other, Connecticut, Eutrophication, Nutrition, ...**5.0216**

INVESTIGATION OF PHOSPHORUS AVAILABILITY IN OLIGOTROPHIC LAKES ...Adsorption Capacity, Aquatic Ecology, Chemical, Exchange Capacity, Lakes, ...**2.0807**

EUTROPHIC EVALUATION OF A SMALL MULTI-LAND USE WATERSHED ...Eutrophication, Nitrogen, Small Watersheds, Urban Environments, Wisconsin, ...**5.1319**

LUXURY METABOLIC STORAGE OF PHOSPHORUS IN THE ACTIVATED SLUDGE FLOC ...Activated, Adsorption-absorption-other, Flocculation, Nutrients, Waste Water Treatment-general, ...**5.1318**

WATER QUALITY DEGRADATION BY SEPTIK TANK DRAINAGE ...Degradation, Drainage, Lakes, Nitrogen, Septic Tanks, ...**5.0468**

MICROBIOLOGICAL CHARACTERIZATION OF ACTIVATED SLUDGE IN A WASTEWATER TREATMENT PLANT CHEMICALLY MODIFIED FOR PHOSPHORUS REMOVAL ...Activated, Aerobic, Cell. env.(non-specific & Ot.), Chemical Treatment, Sewage Bacteria, ...**5.1046**

NUTRIENT ASSIMILATION RATES - FIELD STUDIES ...Estuaries, Fertilizers -aquatic, Nutrients, Ponds, ...**5.0620**

SEWAGE PHOSPHORUS REMOVAL BY AN ACTIVATED SLUDGE PLANT ...Activated, Aerobic, Digestive Tanks, Sewage Testing, ...**5.1321**

ENZYMATIC TECHNIQUE FOR DETECTION OF SURPLUS PHOSPHORUS UPTAKE BY ACTIVATED SLUDGE ...Activated, Biological Techniques, Nutrients, ...**5.1149**

A STUDY OF THE REMOVAL OF CARBONACEOUS, NITROGENOUS AND PHOSPHORUS MATERIALS FROM CONCENTRATED PROCESS WASTE STREAMS ...Carbon, Digestion, Nitrogen, Process Design, Streams, ...**5.0060**

PHOSPHORUS IN LAKE SEDIMENTS ...Aquatic Soils, Lakes, Mineral Equilibria, Soil Environment, Temperature, ...**5.0210**

STUDY OF ROOT DISTRIBUTION AND DENSITY OF VEGETABLE CROPS ...Absorption, Fixation, Exchange, Root Absorption, Soil Morphology, Profiles, Soil Types, Water Loss-other, ...**2.0583**

FIXATION AND AVAILABILITY OF ADDED PHOSPHORUS IN SOILS ...Absorption, Fixation, Exchange, Fertilizer Technology - other, Soil Environment, ...**1.0053**

STUDIES ON INORGANIC NUTRIENT ASSIMILATION RATES IN ESTUARINE PONDS ...Estuaries, Mineral Content -water, Nitrogen, Nutrients, Self-purification, ...**5.0621**

DETERMINATION OF CRITICAL PHOSPHATE AND NITRATE CONCENTRATIONS FOR ALGAL BLOOM CONDITIONS IN LAKE ERIE ...Algal Pollutant Sources, Eutrophication, Growth and Differentiation, Nitrogen, ...**6.0086**

WATER QUALITY ASPECTS OF RECREATIONAL LAKES ...Lakes, Nitrogen, Recreation Sites, Septic Tanks, Waste Water Treatment-general, ...**5.0469**

TURFGRASS MANAGEMENT ...in Turf, Management, New Mexico, Nitrogen, Potassium, Species and Variety Evaluation, ...**6.0367**

DISSOLVED INORGANIC REMOVAL BIOASSAY OF ALGAL GROWTH POTENTIAL ...Bioindicators, Denitrification, Nitrogen, Waste Water Treatment-general, ...**5.0852**

Photogrammetry

STUDIES ON THE GEOSCIENCE VALUE OF RADAR IMAGERY ...Bibliography, Mapping, Mountains-alpine, Radar, River Basins, ...**8.0199**

SNOW ACCUMULATION AND MELT ON STUDY AREAS ...Energy-general, Idaho, Mountains-alpine, Patterns, Snowmelt, ...**2.0388**

Photography

THREE BASIC PROBLEMS IN FLUID MECHANICS EVAPORATIVE CONVECTION, ELECTRO-OSMOSIS, INTERNAL WAVES ...Electrochemistry-other, Flow Characteristics -water, Fluid Dynamics, Internal Waves, Reverse Osmosis, Wave Motion in Fluids-other, ...**3.0074**

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HYDROLOGY PROGRAM ADMINISTRATION AND SUPPORT ...Aircraft, E M Radiation-general, Hydrology-general, Satellites, Water Resources - General, ...**6.0141**

URBAN AND METROPOLITAN STUDIES ...Geography-physical, Planning, Remote Sensing-general, Urban, Urban Environments, ...**6.0139**

CARTOGRAPHIC MAPPING ...Aerospatial, Compilation, Resource Inventories, Satellites, Topographic, ...**6.0140**

HYDROLOGICAL DATA ACQUISITION THROUGH REMOTE RECONNAISSANCE SYSTEMS ...Data Acquisition-other, Hydrology-general, Infrared Radiation, Mapping, Moisture Content, Reflectance, ...**7.0075**

APPLICATION OF AERIAL PHOTOGRAPHS FOR THE INVESTIGATION OF THE DISCHARGE PROPERTIES OF DRAINAGE BASINS ...Data Acquisition-general, Discharge-general, Photogrammetry, River Basins, Water Yield, ...**2.0792**

HYDROLOGIC CHARACTERIZATION OF SMALL WATERSHEDS ...Area, Illinois, Mathematical Analysis, Slopes, Small Watersheds, ...**6.0206**

GROUND-WATER GEOLOGY OF DEKALB AND BOONE COUNTIES, ILLINOIS ...Clastic Aquifers, Deposits, Geophysical Analysis, Groundwater, Local Stratigraphy, Mapping, ...**4.0096**

GROUND-WATER GEOLOGY OF OGLE COUNTY, ILLINOIS ...Available Water, Groundwater, Joints-fractures, Observation Wells, Unconsolidated Aquifers, ...**7.0034**

INVESTIGATIONS OF SHORE EROSION ALONG THE OHIO SHORELINE OF LAKE ERIE ...Engineering Structures-general, Erosion-general, Gaging, Lake Erie, Shoreline - Coastline, ...**8.0275**

GREAT LAKES RESEARCH - ICE CHARACTERISTICS ...Lake Superior, Micrometeorology, Origin, Petrofabrics, Radiation-terrestrial, Sea Ice, ...**2.0644**

GREAT LAKES RESEARCH - ICE COVER DISTRIBUTION ...Aerospatial, Alteration, Great Lakes-general, Petrofabrics, Sea Ice, ...**2.0645**

AERIAL MEASUREMENT OF HYDROLOGIC PHENOMENA ...Data Acquisition-general, Geophysical Analysis, Humidity Instruments, Hydrology-general, Infrared Radiation, ...**7.0003**

REMOTE SENSING OF ESTUARINE WATER AND VEGETATION, MARYLAND ...Bioindicators, Chemical-general, Estuaries, Physical-general, Remote Sensing -other, ...**2.0268**

COORDINATION OF ESTUARINE REMOTE SENSING IN ATLANTIC COAST REGION ...Atlantic Ocean-general, Estuaries, Satellites, ...**2.0910**

ENGINEERING GEOLOGIC PROPERTIES OF ROCK ...Borehole Geophysics, Foundations-general, Geology - Engineering, Microstructure, Technique Development, ...**8.0098**

Laboratory

SUSPENDED SEDIMENTS IN THE UPPER CHESEPECKE BAY - EVALUATION OF METHODS FOR SIZE ANALYSIS OF SUSPENDED MATERIALS ...Chesapeake Bay, Sampling, Size, Size Frequency Distribution, Turbidity, ...**2.0557**

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COOPERATIVE GULF OF MEXICO INVENTORY AND STUDY (AUDIO-VISUAL FILM) ...Estuaries, Gulf of Mexico, Survey Studies, ...**7.0060**

Photography-general

ASYMMETRIC BUBBLE COLLAPSE STUDIES 6310 ...Bubbles, Cavity Flow, Coaxial, Pressure Gradient, ...**1.0067**

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USE OF INFRARED AND OTHER RADIATION TECHNIQUES TO EVALUATE DROUGHT IN IOWA AND ADJACENT AREAS ...Drought, Infrared Radiation, Iowa, Spectral Reflectance, ...**2.0483**

DISTRIBUTION OF LIFE WITH DEPTH ...Continental Shelf, Marine Photography-television, North Carolina, Vertical Distribution, ...**5.0272**

DEVELOPMENT OF IDENTIFICATION KEYS TO LARVAL, AND JUVENILE RESERVIOR FISHES ...Animal Taxonomy, Captive Rearing, Fish -non-specific, Maturity & Growth Stages, Reservoirs and Impoundments, ...**6.0018**

Photometric Techniques

ANALYTICAL METHODS - WATER CHEMISTRY ...Analysis and Detection, Chemical Analysis (water), Chromatography-general, Emission, Other, ...**2.0196**

Phycobilins

THE INCORPORATION OF C14 BICARBONATE INTO PIGMENTS OF A NATURALLY OCCURRING BLUE-GREEN ALGAE COMMUNITY WITH RESPONSE TO WAVELENGTH ...Chlorophyll, Oscillatoria, Physiological Ecology, Pigments, Vitamins, ...**6.0432**

THE INCORPORATION OF C14-BICARBONATE INTO THE PIGMENTS OF BLUE-GREEN ALGAE POPULATION ...Carotenoid Pigments, Chlorophyll, Nutrients, Oscillatoria, Pigments, ...**6.0433**

Physical Forces

Pressure & Mech Stress

HYDROSTATIC PRESSURE-TEMPERATURE, AS ENVIRONMENTAL PARAMETERS, ON GROWTH, BIOCHEMISTRY AND PHYSIOLOGY OF MICROORGANISMS ...Growth (non-specific & Ot.), Marine Biology (non-specific), Microorganisms (non-specific), Temperature, ...**6.0459**

THEORETICAL AND EXPERIMENTAL INVESTIGATIONS OF THE MECHANISM OF FLOW OF WATER AND SOLUTES IN PLANT ROOTS ...Ionic Effect, Osmotic and Turgor Pressure, Thermodynamics, Ultrafiltration, Water Movement, ...**2.0497**

Physics - Theoretical

Quantum Mechanics

Approximations

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Perturbation Methods

THEORY OF LIQUIDS ...Approximations, Interparticle Forces, Potential Functions, Solution-other, Statistical, ...**1.0016**

Self Consistent Fields

THE BASIC NATURE OF LIQUIDS ...Absorption Spectra, Infrared, Interparticle Forces, Spin-orbit Interaction, ...**1.0117**

Physiography

Erosion

SOURCES, MOVEMENT, AND DISTRIBUTION OF SEDIMENT IN A SMALL WATERSHED ...Energy-dynamics, Sediment Transport-general, Slopes, Small Watersheds, ...**2.0567**

PHYSIOGRAPHIC STUDY OF PART OF THE HENRY MOUTAINS REGION, UTAH ...Henry Mountains, Physical Features-general, Physiography-general, Processes, Utah, ...**2.0563**

INVESTIGATIONS OF EROSION CONTROL AND WATER CONSERVATION ...Amount, Conservation-general, Gullys - Arroyos, Land Use, Runoff, Sediment Yield, Stabilization-general, ...**3.0226**

MATHEMATICAL GEOMORPHOLOGY ...Features, Geomorphology-quantitative, Model Studies, Processes, Terrain Analysis, ...**2.0425**

SEDIMENT YIELD FROM RANGELAND WATERSHEDS IN THE SOUTHWEST ...Agricultural Watersheds, Land Use, Sediment Transport-other, Sediment Yield, Supply Rate, ...**2.0041**

Physical Features

Physical Features-general

PHYSIOGRAPHIC STUDY OF PART OF THE HENRY MOUTAINS REGION, UTAH ...Erosion, Henry Mountains, Physiography-general, Processes, Utah, ...**2.0563**

MISSOURI SPRINGFLOW CHARACTERISTICS ...Aquifers-general, Chemical-general, Discharge-general, Springs, Water Supply-general, ...**2.0701**

Physiography-general

PHYSIOGRAPHIC STUDY OF PART OF THE HENRY MOUTAINS REGION, UTAH ...Erosion, Henry Mountains, Physical Features-general, Processes, Utah, ...**2.0563**

INFLUENCE OF GEOHYDROLOGY ON LANDSCAPE AND SOIL FORMATION ...Hydrology-general, Morphology-general, Soil Genesis, Weathering-general, ...**5.0409**

HYDRAULIC GEOMETRY OF STREAMS ...Flow Characteristics - water, Hydraulics-general, Ions and Gases, Low Flow, River Basins, ...**2.0444**

DEVELOPING COMPUTER PROGRAMS FOR SOLUTION OF HYDROLOGIC PROBLEMS RELATED TO SMALL WATERSHEDS ...Climate-general, Forecasting-prediction, Hydrographs, Small Watersheds, Water Yield, ...**7.0102**

MATHEMATICAL METHODS OF EVALUATION OF RESULTS OF ATMOSPHERIC WATER RESOURCES PROGRAMS ...Error Analysis, Intermontane Plateaus-other, Mountains-alpine, Reliability Theory, Weather Modification-general, ...**2.0189**

ESTUARINE INVENTORY (FORMERLY CHEMICAL ENVIRONMENT) ...Estuaries, Florida, Gulf of Mexico, Marine Biology, Sedimentology-general, ...**2.0325**

RELATION OF CLIMATIC AND WATERSHED PHYSIOGRAPHIC AND CULTURAL FACTORS TO WATER YIELD ...Agricultural Watersheds, Conservation-general, Flow Characteristics -water, Land Use, Water Yield, ...**3.0462**

RUNOFF AND SEDIMENT MOVEMENT ON UNIT SOURCE WATERSHEDS OF THE PACIFIC INFLUENCED BY CLIMATE, SOILS, VEGETATION AND TOPOGRAPHY ...Idaho, Runoff, Sediment Yield, Water Yield, Watersheds-general, ...**2.0387**

Terrain Analysis

GEOTHERMAL INVESTIGATIONS - YELLOWSTONE PARK ...Gravity Surveys, Hot Springs, Magnetic Surveys, Satellites, Seismic Surveys, Yellowstone Plateau, ...**6.0147**

DEVELOPMENT OF DRAINAGE ASSESSMENT PROCEDURES BASED ON PHYSICAL FEATURES IN ILLINOIS ...Benefit-cost Analysis, Drainage, Drainage Engineering, Illinois, Mathematical Analysis, ...**6.0207**

SHALLOW WELLS AND IRRIGATION PITS FOR IRRIGATION AND OTHER FARM WATER SUPPLY IN THE COASTAL PLAINS ...Aquifers-general, Coastal Plain, Irrigation-general, Pumping, Water Wells, ...**3.0194**

ENVIRONMENTAL GEOLOGY OF MCHENRY COUNTY, ILLINOIS ...Aquifers-general, Illinois, Land Use, Potential of Deposit, Subsurface, ...**6.0192**

MATHEMATICAL GEOMORPHOLOGY ...Erosion, Features, Geomorphology-quantitative, Model Studies, Processes, ...**2.0425**

Phytoplankton

BIOLOGY AND CHEMISTRY OF MARINE PLANKTON POPULATIONS ...Buoys, Chlorophyll, Food Chains, Nutrients, Vertical Distribution, Zooplankton, ...**6.0289**

THE BIOLOGY AND CHEMISTRY OF TRACE ELEMENTS IN MARINE AND ESTUARINE WATERS ...Chesapeake Bay, Estuaries, Productivity - Food Chain, Trace Element Analysis, Zooplankton, ...**2.0556**

ENERGY SOURCES OF HETEROTROPHIC MICROORGANISMS IN AN AQUATIC ENVIRONMENT ...Bioenergetics, Glycolic Acid Cpds, Heterotrophic Bacteria, Photosynthesis, ...**2.0622**

AMERICAN RIVER HYDROBIOLOGIC POTENTIAL STUDY ...Bioindicators, California, Lower Plants, Primary Productivity, Water Quality-general, ...**5.0143**

SEASONAL VARIATIONS IN THE PHYTOPLANKTON - BACTERIA POPULATIONS AND THE NUTRIENT CONCENTRATION IN BEAVER RESERVOIR ...Nitrogen, Phosphorus, Reservoirs and Impoundments, Temporal Distribution, Water Bacteria, ...**6.0027**

BIOPOTENTIAL OF NATURAL WATERS ...Acidity, Atomic Absorption, Lakes, Primary Productivity, Visible, Wisconsin, ...**7.0114**

DETERMINATION OF THE STAGES OF EUTROPHICATION OF SOME OF NEW HAMPSHIRES LARGE LAKES PHASE II ...Eutrophication, Lakes, New Hampshire, Primary Productivity, Water Properties-general, Zooplankton, ...**2.0746**

LIMNOLOGY OF LAKE CHAMPLAIN ...Biological-general, Chemical-general, Physical-general, Pollution - Effects of , Sediments, Zooplankton, ...**2.1088**

NATURAL WATER SYSTEMS IN WESTERN MONTANA ...Freshwater Ecology, Lakes, Montana, Streams, Zooplankton, ...**2.0719**

LIMNOLOGICAL STUDIES OF LENTIC WATERS IN IDAHO ...Alpine, Idaho, Lakes, Primary Productivity, Productivity - Food Chain, Reservoirs and Impoundments, ...**2.0398**

DETERMINING CHANGES IN PHYTOPLANKTON POPULATIONS IN CLOUDS OF FLUORESCENT DYE MOVING IN THE MISSISSIPPI RIVER ...Dyes, Fluorometry, Minnesota, Mississippi River, Standing Crops, ...**5.0617**

MICROBIAL INTERVENTION IN THE EUTROPHICATION PROCESS ...Eutrophication, Food Chains, Nutrients, Organic, Water Bacteria, ...**5.0515**

BASIC RESEARCH IN THE AQUATIC ENVIRONMENT EFFECTS OF EUTROPHICATION ON PLANKTON ALGAE AND *BENTHIC PLANTS* COMMUNITIES ...Eutrophication, Nutrients, ...**2.0803**

BIOLOGICAL AND CHEMICAL STUDY OF VIRGINIAS ESTUARIES ...Estuaries, Nitrogen, Phosphorus, Population Dynamics, Primary Productivity, Virginia, ...**2.1112**

PRIMARY PRODUCTIVITY, AND STANDING CROPS IN RELATION TO WATER QUALITY IN LAKE ASHTABULA RESERVOIR, NORTH DAKOTA ...North Dakota, Productivity - Food Chain, Reservoirs and Impoundments, Water Quality-general, Zooplankton, ...**6.0414**

BUOYANCY AND SINKING CHARACTERISTICS OF FRESHWATER PHYTOPLANKTON ...Algal Pollutant Sources, Fresh Water, Herbicides -non-specific, Primary Productivity, Vertical Distribution, ...**5.1064**

COMPARATIVE PRODUCTIVITIES OF SMALL BODIES OF WATER IN DESERT AND MONTANE AREAS OF SOUTHERN NEW MEXICO ...New Mexico, Plant Prod. (non-specific), Ponds, Productivity - Food Chain, Zooplankton, ...**3.0336**

NUTRITIONAL ECOLOGY AND COMMUNITY STRUCTURE OF THE PHYTOPLANKTON OF GREEN BAY ...Bays, Mineral Composition, Nutrition Studies, Physiological Ecology, Wisconsin, ...**5.1290**

LIMNOLOGICAL FACTORS AFFECTING PESTICIDE RESIDUES IN SURFACE WATERS ...Chlorinated Hydrocarbons, Iowa, Persistance of Residues, Reservoirs and Impoundments, Runoff, Surface Water, ...**5.0416**

A STUDY OF PHYTOPLANKTON DYNAMICS IN LAKE FAYETTEVILLE AS A MEANS OF ASSESSING WATER QUALITY ...Algal Culture, Bioindicators, Eutrophication, Growth Rate, Primary Productivity, ...**6.0031**

ANNUAL PHYTOPLANKTON PRODUCTION IN PUGET SOUND WATERS ...Copepods, Invertebrate Cultures, Puget Sound, Standing Crops, Tides, ...**5.1256**

THE AUTECOLOGY OF SOME BLUE-GREEN PLANKTON ALGAE ...Algal Culture, Cyanophyta (non-specific & Ot), Eutrophication, Mixed Culture, Nutrition Studies, ...**5.0955**

A DETAILED STUDY OF LAKE MICHIGAN PLANKTON DIATOMS ...Lake Michigan, Planktonic - Floating, Plant Taxonomy, Range Or Territorial Distr. , ...**5.0554**

COLLECTION AND ESTABLISHMENT IN CULTURE OF SPECIES AND STRAINS OF MARINE PHYTOPLANKTON ORGANISMS ...Algal Culture, Culture Collections, Marine Plants, Pollution-general, ...**5.1063**

LIMNOLOGICAL INVESTIGATION OF ONEIDA LAKE ...Food Chains, Lakes, New York, Primary Productivity, Zooplankton, ...**5.0773**

MAJOR FACTORS INFLUENCING PRODUCTION OF PHYTOPLANKTON IN NEW YORK LAKES ...Energy, Lakes, New York, Nutrients, ...**2.0796**

A SURVEY OF PHYTOPLANKTON IN AND OLD AND A NEW RESERVOIR ...Algal Pollutant Sources, Ohio, Reservoirs and Impoundments, ...**6.0434**

COMPARATIVE STUDY OF PHYTOPLANKTON IN NEW AND RECLAIMED ACID MINE DRAINAGE PONDS ...Acidity, Mining Activities, Nutrition Studies, Ponds, Waste Water Treatment-general, ...**6.0437**

BIOLOGICAL ASPECTS OF TERTIARY PONDS ...Effluents-waste Water, Pond, Protozoa -other, Sewage, Tertiary Treatment, ...**5.0352**

PLANKTON-PERIPHYTON STUDIES IN THE COLUMBIA RIVER ...Columbia River, Food Webs, Periphyton, Radioactivity-general, Radioecology, ...**2.1127**

FACTORS INFLUENCING THE PRODUCTION OF PLANKTONIC AND BENTHIC PLANTS ...Benthic Flora, Growth Rate, Nutrition, Secretions and Products, Standing Crops, ...**5.1119**

HYDROLOGY OF CACHUMA RESERVOIR ...Aeration, Destratification, Reservoirs and Impoundments, Stratification, ...**5.0118**

GENERAL HYDROGRAPHIC FEATURES OF OAHE RESERVOIR AND LAKE SHARPE ...Chemical Analysis (water), South Dakota, Temperature, Turbidity, Zooplankton, ...**6.0516**

PRIMARY PRODUCTIVITY IN LAKE FRANCIS CASE ...Bays, Benthic Fauna, Primary Productivity, Reservoirs and Impoundments, Standing Crops, ...**6.0524**

PRIMARY PRODUCTION IN LEWIS AND CLARK LAKE ...Photosynthesis, Primary Productivity, Reservoirs and Impoundments, South Dakota, ...**6.0525**

PLANKTON POPULATIONS IN LEWIS AND CLARK LAKE AND LAKE FRANCIS CASE ...Plankton Sampling, Reservoirs and Impoundments, Zooplankton, ...**6.0526**

PLANKTON ECOLOGY ...Estuaries, Eutrophication, Gulf of Mexico, Gymnodinium, Range Or Territorial Distr. , ...**6.0155**

USE OF MARINE PLANKTONIC ORGANISMS FOR EVALUATING THE QUALITY OF MARINE AND ESTUARINE WATERS ...Bioassays, Estuaries, Pollution - Effects of , Pollution Effects, Zooplankton, ...**5.1093**

DETERMINATION OF SELECTED ENVIRONMENTAL REQUIREMENTS OF IMPORTANT MARINE PHYTOPLANKTON SPECIES ...Axenic Culture, Environment, Growth and Differentiation, Marine Biology, Marine Plants, ...**5.1094**

EFFECTS OF PETROLEUM AND PETROLEUM WASTES UPON IMPORTANT SPECIES OF ESTUARINE PHYTOPLANKTON AND ZOOPLANKTON ...Contamination - Water, Contamination, Pollution-water, Estuaries, Oil, Petroleum, Zooplankton, ...**5.1086**

INTEGRATED FIELD AND LABORATORY SYSTEM FOR ASSAYING THE EFFECTS OF POLLUTANTS AND TOXICANTS UPON WATER QUALITY ...Algal Culture, Axenic Culture, Environment, Pollution - Effects of , ...**5.1087**

EFFECT OF NITRILOTRIACETIC ACID (NTA) UPON THE TOXICITY OF METALS TO SELECTED SPECIES OF ESTUARINE PHYTOPLANKTON ...Acids, Carbon, Chemicals (incl. algacides), Estuaries, Radioisotopes, ...**5.1085**

DEVELOPMENT OF A METHOD FOR CHRONIC TOXICITY BIOASSAY USING MARINE PLANKTONIC ALGAE ...Algal Culture, Bioassays, Marine Plants, Microbiological Analysis, Monitoring (long Term Studies), Technique Development, Toxicology, ...**5.1088**

Piezometers

DESIGN OF OPEN CHANNELS TO PREVENT BANK FAILURE ...Seepage, Subsurface Flow, ...**4.0253**

OBSERVATION AND EVALUATION OF INSTRUMENTATION IN THE FOUNDATION AND EMBANKMENT OF MORAINE STATE PARK DAM ...Embankments, Foundations-general, Soil Settlements, Soil Stability Analysis, Uplift, ...**8.0170**

PROTOTYPE ANALYSIS-STRUCTURAL BEHAVIOR ...Gravity Dams, Mass, Ohio River, Seepage, Uplift, ...**8.0149**

DEVELOPMENT AND EVALUATION OF SURFACE AND SUBSURFACE DRAINAGE PRACTICES ...Drainage, Interception, Seepage, Subsurface Flow, Surface Flow, ...**4.0132**

Piezometry

THE ARTESIAN SYSTEM IN GEORGIA STRATIGRAPHY AND HYDROLOGY OF THE OCALA ...Artesian Flow, Carbonate Aquifers, Georgia, Groundwater Movement, Natural Recharge, ...**4.0082**

DEVELOPMENT OF GROUND WATER CONTROL METHODS FOR THE HEAVY SOILS OF THE LAJAS VALLEY ...Aquifers-general, Groundwater, Hydrology-general, Puerto Rico, Soil Environment, ...**4.0209**

RELATIONSHIP BETWEEN EXCESSIVE SOIL MOISTURE AND CITRUS ROOT DAMAGE ...Citrus, Drainage, Drainage Engineering, Excessive Moisture, Other Enviromental Conditions, ...**2.0316**

SALT-WATER ENCROACHMENT IN THE BRUNSWICK AREA, GEORGIA ...Aquifers-general, Georgia, Observation Wells, Pumping, Saline Water Intrusion, ...**5.0306**

Pigments -animal

Respiratory Or Blood

PIGMENT INDICES OF ENVIRONMENTAL OXYGEN STRESS ...Environmental Physiology, Hemoglobin, Oxygen, ...**5.0810**

Pilot Plant

DEVELOPMENT OF PERMANENT SYSTEMS FOR DROPWISE CONDENSATION ...Condensation, Distillation-other, Films, Heat Transfer, Vapor, ...**3.0411**

DEVELOPMENT OF ADVANCED TRANSPORT DEPLETION PROCESSES ...Brackish Water, Desalination, Electrodialysis, Ion Selective, ...**3.0002**

REVERSE OSMOSIS TUBULAR MODULE OPTIMIZATION ...Desalination, Digital Computers, Membranes-other, Reverse Osmosis, ...**3.0070**

DESIGN AND CONSTRUCTION OF A REVERSE OSMOSIS PILOT PLANT FOR THE DESALINATION OF SEA WATER ...Desalination, Membranes-other, Nitrogen, Reverse Osmosis, Sea Water-general, ...**3.0051**

THE DESIGN, CONSTRUCTION AND TESTING OF A 10,000 GPD TRANSPORT DEPLETION DESALINATION PILOT PLANT ...Cost Analysis, Desalination, Ion Selective, Other, ...**3.0148**

HYDRODYNAMIC STUDIES FOR ELECTRODIALYSIS ...Electrodialysis, Membranes-other, ...**5.0121**

TRAINING, TECHNICAL SUPERVISION, AND ASSISTANCE REGARDING THE OPERATION OF A SKID-MOUNTED MSF UNIT ...Aeration, Distillation-other, Foam, Mobile, Other, ...**3.0491**

AN EVAPORATIVE FREEZING PROCESS FOR DESALTING WATER ...Batch, Desalination, Evaporation, Freezing, ...**3.0163**

REVERSE OSMOSIS MEMBRANES CONTAINING GRAPHITIC OXIDE ...Desalination, Graphite, Membranes-other, Reverse Osmosis, ...**3.0416**

REVERSE OSMOSIS PERMEATORS - DESIGN STUDY ...Cost Analysis, Membranes-other, Other, Reverse Osmosis, ...**3.0367**

ELECTROLYTIC REGENERATION OF ION EXCHANGE RESINS ...Brackish Water, Desalination, Ion Exchange-other, Regeneration-other, ...**3.0327**

CONTROLLED FLASH EVAPORATOR, ECONOMIC ANALYSIS AND THE DESIGN OF A DEMONSTRATION PLANT ...Cost Analysis, Desalination, Evaporation, ...**3.0326**

CONSTRUCTION AND OPERATION OF 7-GPM PILOT PLANT FOR SILICA REMOVAL ...Adsorption-other, Evaporation, Hardness, Pollutant-other, Silicon, ...**3.0323**

REVERSE OSMOSIS PILTO PLANT INVESTIGATIONS ...Cost Analysis, Desalination, Membranes-other, Other, Reverse Osmosis, ...**3.0056**

PROCESS AND CONFIGURATION DEVELOPMENT FOR TUBULAR REVERSE OSMOSIS UNITS ...Brackish .Water, Desalination, Other, Reverse Osmosis, ...**3.0057**

CONCEPTUAL DESIGN STUDY ON REVERSE OSMOSIS MEMBRANE ASSEMBLY MODULAR UNIT ...Desalination, Membranes-other, Process Development-other, Reverse Osmosis, ...**3.0215**

BRACKISH WATER FIELD TEST EVALUATION OF MEMBRANE PROCESSES ...Brackish Water, Desalination, Economic Efficiency, Membranes-other, ...**3.0072**

PARAMETRIC ECONOMIC AND ENGINEERING EVALUATION STUDY OF THE REVERSE OSMOSIS PROCESS ...Cost Analysis, Marketing, Membranes-other, Reverse Osmosis, ...**3.0164**

TEST OPERATION OF A 2,500 GPD TWO-STAGE SEA WATER REVERSE OSMOSIS PILOT PLANT ...Brines, Cost Analysis, Desalination, Membranes-other, Optimization, Reverse Osmosis, ...**3.0079**

DEVELOPMENT OF A WATER DESALINATION SYSTEM BASED ON HOLLOW FINE FIBER MEMBRANES ...Cellulosics, Desalination, Fiber, Filament, Whisker, Membranes-other, Reverse Osmosis, ...**3.0274**

OPERATION OF A 50,000 GPD PORTABLE PILOT PLANT ...Membranes-other, Mobile, Reverse Osmosis, Scale Formation, Zeolite, ...**3.0029**

PARAMETRIC ECONOMIC AND ENGINEERING EVALUATION STUDY OF THE ELECTRODIALYSIS PROCESS ...Brackish Water, Cost Analysis, Desalination, Electrodialysis, Other, ...**3.0270**

CONCEPTUAL DESIGN STUDY ON ELECTRODIALYSIS MEMBRANE ASSEMBLY MODULAR UNIT DESIGN ...Cost Analysis, Desalination, Electrodialysis, Membranes-other, Potable, ...**3.0228**

DEVELOPMENT OF THE VACUUM FREEZING VAPOR COMPRESSION PROCESS ...Desalination, Evaporation, Freezing, High, Potable Water, ...**1.0128**

SEWAGE TREATMENT, PILOT PLANT EVALUATION ...Ash-coal, Coal, Coal-general, Industrial Wastes, Waste Treatment-economics, ...**5.0870**

AN EVALUATION OF RECENT APPROACHES FOR THE DESIGN OF BIOLOGICAL WASTES TREATMENT ...Biological Treatment-general, Data Analysis - General, Process Design, Waste Water Treatment-general, ...**5.0928**

PRACTICAL APPLICATION OF FOAM FRACTIONATION TREATMENT OF LOW QUAITY WATER ...Color, Cost Analysis, Foam, Groundwater, Iron, ...**5.0037**

DEVELOPMENT OF PULSATING ADSORPTION FILTER FOR TERTIARY TREATMENT OF WASTE WATERS ...Adsorption-other, Ash-coal, Biological, Sand, Tertiary Treatment, ...**5.0408**

FLOC STRENGTH AND FILTERABILITY OF PRE-TREATED WATER ...Coagulation, Filtration, Flocculation, Sand, Waste Water Pre-treatment, ...**5.0061**

BOD, SOLIDS AND NUTRIENT REMOVAL FROM SECONDARY EFFLUENT BY FOAM FRACTIONATION ...Denitrification, Foam, Nitrate, Nitrite, Phosphate, Phosphite, ...**5.0155**

TREATMENT OF SELECTED INTERNAL KRAFT MILL WASTES IN COOLING TOWERS ...Economic Efficiency, Pulp and Paper Wastes, Recycle, Thermal Pollution, Waste Treatment-economics, ...**5.0308**

AEROBIC TREATMENT OF PACKINGHOUSE WASTES ...Aerobic, Food Processing Industry, Industrial Processes-other, Pilot Plants, Waste Water Treatment-general, ...**5.0418**

USE OF MODIFIED ACTIVATED SLUDGE TREAT TO ACHIEVE NUTRIENT REMOVAL & TO PROVIDE CONSISTENT FEED TO TERTIARY TREATMENT SYSTEM ...Activated, Aeration, Pollutant-other, Tertiary Treatment, Waste Treatment-economics, ...**5.0245**

IMPROVEMENTS TO THE BOROUGH OF NEW PROVIDENCE SEWAGE PUMPING STATION AND TREATMENT FACILITIES ...Chlorination, Plastics - General, Polyelectrolytes, Pumping Stations, Sedimentation, Trickling, ...**6.0353**

SPREADING TREATED SEWAGE FOR GROUNDWATER RECHARGE ...Artificial Recharge, Groundwater, Loading, Percolation, Sewage, ...**3.0005**

TERTIARY TREATMENT OF COMBINED STORM WATER, SANITARY RELIEF DISCHARGE AND SEWAGE TREATMENT PLANT EFFLUENT ...Activated Carbon, Combined Sewer, Filtration, Process Design, Sedimentation, Storm Water, ...**5.0387**

MODEL ADVANCED WASTE-TREATMENT PLANT ...Activated Carbon, Lime Treatment, Material Recovery Wastes, Process Design, Solid Waste, ...**5.0504**

PILOT-SCALE STUDY OF IMPROVED PHOSPHATE REMOVAL BY MODIFIED ACTIVATED SLUDGE PROCESS ...Activated, Algal Pollutant Sources, Bacteria, Disposal, Waste Treatment-economics, ...**5.0560**

DEMONSTRATION AND EVALUATION OF POLYMERIC ADDITIVES IN THE TREATMENT OF STORM SEWER OVERFLOW ...Combined Sewer, Polymer Type-other, ...**5.0579**

COMBINED INDUSTRIAL AND MUNICIPAL WASTE TREATMENT ...Biological Treatment-other, Combined Sewer, Process Design, Pulp and Paper Wastes, Waste Water Treatment-general, ...**5.1289**

KINETICS OF ALGAL SYSTEMS IN WASTE TREATMENT ...Algae, Biological, Model Studies, Nutrients, Process Design, ...**5.0069**

IDENTIFICATION OF LIMITING FACTORS IN THE BIOLOGICAL TREATMENT OF SEWAGE ...Activated, Biological Treatment-other, Other, Sewage Bacteria, ...**5.0230**

OPTIMIZATION AND DEVELOPMENT OF IMPROVED CHEMICAL TECHNIQUES FOR THE TREATMENT OF COAL MINE DRAINAGE ...Acid Mine Wastes, Chemical Treatment, Drainage, Mining Activities, Optimization, Process Design, ...**5.0999**

ALGAL BIOASSAY TO DETERMINE THE EXTENT OF NUTRIENT REMOVAL BY AWT AT THE WASTE TREATMENT PLANT AT ELY, MINNESOTA ...Algae, Bioassays, Denitrification, Nutrients, Waste Water Treatment-general, ...**5.1304**

USE OF PURE STRAINS OF ALGAE AND MIXED ALGAE-PROTOZOA, AND ALGAE-BACTERIA CULTURES IN SEWAGE TREATMENT ...Algae, Algal Culture, Microbial-bacterial, Waste Water Treatment-general, ...**5.0382**

SECONDARY EFFLUENT POLLSHING BY RAPID SEND FILTRATION ...Activated, Biochemical Oxygen Demand, Chemical Oxygen Demand, Sand, Solid Waste, ...**5.0362**

PROGRAM FOR FIELD EVALUATION OF REVERSE OSMOSIS PILOT PLANTS ON BRACKISH WATERS ...Brackish Water, Cost Analysis, Membranes-other, Other, Reverse Osmosis, ...**3.0115**

DEVELOPMENT OF WASTE STABILIZATION LAGOONS FOR APPLICATION IN ALASKA ...Alaska, Lagoon, Process Design, Sewage Lagoons, Storage-retention-facilities, ...**5.0026**

COMPLETE MIX ACTIVATED SLUDGE UNIT PROCESS ADAPTION TO LOW TEMP ...Activated, Loading, Low, Separation-other, Solid Waste, ...**5.0028**

PHOSPHATE REMOVAL BY ACTIVATED SLUDGE PROCESS SPECIFICATION - PLANT SCALE RESEARCH ...Phosphate, Phosphite, ...**5.0915**

Pilot Plants

DEVELOPMENT OF THE VACUUM FREEZING VAPOR COMPRESSION PROCESS FOR USE WITH BRACKISH WATERS ...Brackish Water, Desalination, Freezing, Mobile, North Carolina, ...**3.0487**

EVALUATION OF BRINE DESULFATING PROCESS AS APPLIED TO FEEDWATER FOR DESALINATION PLANTS ...Cost Analysis, Desalination, Economics-general, Sulfate, Sulfite, ...**3.0409**

LIFE TEST OF NOVEL EVAPORATOR ...Desalination, Distilling Units, Heat Trans Coefficient, Sea Water-general, ...**3.0368**

DESALINATION BY THE INVERSION ON THE ORDER OF MELTING BY APPLIED PRESSURE ...Crystallization, Desalination, Freezing, Heat Transfer, ...**3.0240**

JET-PUMP TOPPING-UNIT PILOT PLANT ...Desalination, ...**3.0276**

DESIGN, CONSTRUCTION AND OPERATION OF A SKID-MOUNTED ION EXCHANGE PILOT PLANT ...Cost Analysis, Desalination, Economics-general, Ion Exchange-other, Mobile, ...**3.0329**

OPERATION AND EVALUATION OF A 50,000 GALLONS PER DAY REVERSE OSMOSIS PILOT PLANT ...Cost Analysis, Desalination, Economic Efficiency, Reverse Osmosis, ...**3.0061**

CONSTRUCTION AND DEVELOPMENT OF SPIRAL DESIGN ELECTRODIALYSIS MODULE ...Desalination, Electrodialysis, Membranes-other, ...**3.0154**

NITRATE REMOVAL FROM ACTIVATED SLUDGE SYSTEMS ...Activated, Denitrification, Process Design, Washington, Waste Water Treatment-general, ...**5.1257**

AEROBIC TREATMENT OF PACKINGHOUSE WASTES ...Aerobic, Food Processing Industry, Industrial Processes-other, Pilot Plant, Waste Water Treatment-general, ...**5.0418**

MICROSTRAINING PILOT TESTS OF STORM WATER OVERFLOWS FROM COMBINED STORM AND SANITARY SEWER SYSTEMS ...Chlorination, Combined Sewer, Ozonization, Screening, ...**5.1003**

WATER TREATMENT BY REVERSE OSMOSIS METHOD ...Fresh Water, Membranes-other, Reverse Osmosis, Waste Water Treatment-general, ...**5.0164**

NUTRIENT REMOVAL FROM AGRICULTURAL WASTE WATERS ...California, Denitrification, Eutrophication, Nutrients, San Francisco Bay, Waste Water Treatment-general, ...**4.0032**

EUTROPHICATION - PILOT OPERATIONS ...Economics-general, Eutrophication, Systems Analysis, Water Quality Control-general, ...**5.0981**

BACTERIAL DEPURATION OF WEST COAST SHELLFISH ...Clams, Oysters, Salinity, Shellfish Depuration, Turbidity, ...**5.1229**

Pipe, Tube

PREPARATION OF SMALL TUBES AND THE DETERMINATION OF THEIR PROPERTIES FOR REVERSE OSMOSIS ...Dimensions, Expansion, Mechanical Properties-general, Permeability, Reverse Osmosis, Stretch Forming, Cryoform, ...**3.0387**

PRODUCTION OF 90-10 COPPER NICKEL TUBING FOR DESALTING ...Copper, Desalination, Equipment Purchase Operation, ...**3.0158**

APPLICATION OF IRON-ALUMINUM BASE ALLOYS TO SALINE WATER CONVERSION ...Alloy & Systems, Cost Analysis, Desalination, Stainless Steels-other, Water, ...**3.0099**

EVALUATION OF POLYVINYL CHLORIDE (PVC) AND VINYL CLAD ALUMINUM PIPE USED FOR CARRYING IRRIGATION WATER WHEN BURIED WITHIN THE FROST ZONE ...Aluminum, Cladding, Irrigation-general, Joining, Bonding-general, Polyvinyls-other, Soils, ...**8.0271**

DRAINAGE DESIGNS AS INFLUENCED BY CONDITIONS IN THE VICINITY OF THE DRAIN LINE ...Drainage Systems, Erosion Control, Pipes, Plastics - General, Seepage, ...**8.0010**

STUDIES OF CORROSION SPECIMENS ...Galvanized, Test Methods, Water, Water Quality-general, ...**8.0177**

FREE DROP WATER CONTAINER ...Airborne-operation, Equipment, Laminates, Logistics, Urethanes, ...**8.0209**

FACTORS INFLUENCING THE DURABILITY OF CONCRETE ...Cement, Concrete, Chemicals, Durability, Deterioration, Organic-general, Sulfate, Sulfite, ...**8.0043**

PROTECTIVE LININGS FOR WATER PASSAGE SURFACES OF FERROUS METALWORK ...Erosion, Linings-pavings, Organic-general, Water, ...**8.0087**

PLASTIC PIPE AND TUBING ...Ceramic Matrix, Corrosion General, Engineering Structures-general, Plastic Matrix, Plastics - General, ...**8.0132**

GLASS FIBER REINFORCED PLASTIC MORTAR PIPE FOR PRESSURE IRRIGATION DISTRIBUTION SYSTEM ...Fiber, Filament, Whisker, Glass, Irrigation Engineering, Pipelines, Plastic Matrix, ...**8.0027**

IMPROVEMENT AND MODERNIZATION OF SURFACE AND SUBSURFACE DRAINAGE PRACTICES AND FACILITIES IN THE CORN BELT ...Corn Belt, Drainage, Drainage Systems, Plastics - General, ...**4.0191**

Pipelines

DEVELOPMENT OF AUTOMATED SUBIRRIGATION SYSTEM ...Arkansas, Automated Equipment, Design Criteria, Irrigation Engineering, Spray Devices, Subsurface Irrigation, ...**3.0025**

PHYSICAL, CHEMICAL AND MICROBIOLOGICAL FACTORS AFFECTING THE DISCHARGE OF WATER INTO DRAIN TILE ...Drainage, Drainage Engineering, Water Properties-general, ...**2.0145**

PIPELINE AND TUNNEL HYDRAULICS ...Conduit, Friction, Hydraulics-general, Pipes, Texas, ...**8.0042**

GLASS FIBER REINFORCED PLASTIC MORTAR PIPE FOR PRESSURE IRRIGATION DISTRIBUTION SYSTEM ...Fiber, Filament, Whisker, Glass, Irrigation Engineering, Pipe, Tube, Plastic Matrix, ...**8.0027**

DRAINAGE SYSTEMS - PIPE AND FILTERS ...Drainage Engineering, Drainage Systems, Filters, Hydraulic Gradient, Pipes, ...**8.0018**

Plankton (non-specific)

LIMNOLOGY OF ROSS ISLAND, ANTARCTICA ...Antarctica, Benthic Organisms (non-specif), Chemical-general, Lakes, Pubilications -other, ...**2.0087**

LIMNOLOGY OF DESOTO BEND LAKE, IOWA AND NEBRASKA ...Benthic Organisms (non-specif), Iowa, Lakes, Nebraska, Stratification, ...**7.0040**

PLANKTON STUDIES ...Chemical-general, Lakes, Number, Water Level Fluctuation, ...**4.0125**

FOOD HABITS STUDY ...Aquatic Ecology, Benthic Organisms (non-specif), Food Supply, Lakes, Mississippi, ...**6.0314**

ATCHAFALAYA RIVER - CALLIOU LAKE SYSTEM ...Lakes, Louisiana, Number Or Density, Physical-general, Vertical Distribution, ...**2.0545**

CHANGES DURING EUTROPHICATION OF AN ESTUARY ...Estuaries, Eutrophication, North Carolina, Pollution - Effects of , ...**5.0820**

PRIMARY PRODUCTIVITY OF MINNESOTA LAKES ...Chemical-general, Lakes, Primary Productivity, Trace Element Analysis, Water Sampling, ...**5.0607**

EFFECT OF INDUST WASTES OF MEMPHIS & SHELBY COUNTY ON PRIMARY PLANKTONIC PRODUCERS ...Cell Cloning, Drainage, Industrial Wastes, Primary Productivity, Tennessee, ...**5.1134**

ECOLOGICAL SUCCESSION IN A NORTHEASTERN OHIO RESERVOIR ...Eutrophication, Nutrients, Ohio, Plant Succession, Reservoirs and Impoundments, ...**5.0894**

DIATOM REMOVAL BY FLOCCULATION ...Algae- Diatoms, Algal Pollutant Sources, Flocculation, Sand, ...**5.0353**

PRIMARY PRODUCTION ...Primary Productivity, Strontium, ...**2.1001**

A COMPARATIVE STUDY OF TRACE ELEMENT CYCLES IN SIX LAKES IN SOUTH CAROLI ...Chemical-general, Lakes, South Carolina, Trace Element Analysis, Water Cycle, ...**2.0944**

WATER QUALITY AND NUTRIENTS, SACRAMENTO-SAN JOAQUIN RIVER SYSTEM ...Environmental Ecology, Eutrophication, Fish -non-specific, Nutrients, Water Quality-general, ...**2.0127**

EVAPORATION REDUCTION INVESTIGATIONS STUDY OF THE EFFECTS OF FATTY ALCOHOLS ON THE ECOLOGY OF LAKE HEFNER ...Alcohols, Antitranspirants, Lakes, Physiological Ecology, Texas, ...**3.0130**

Plankton Sampling

WALLEYE FRY - ZOOPLANKTON RELATIONSHIPS IN SOUTHEASTERN WISCONSIN LAKES ...Aquatic Ecology, Food Supply, Lakes, Walleyes, Zooplankton, ...**6.0640**

DEVELOPMENT AND IMPROVEMENT OF INSTRUMENTATION AND SAMPLING GEAR FOR USE IN LIMNOLOGY AND FISHERY BIOLOGY ...Basses -sea,white, White Perch, Nets, Salmon & Trout - Non-specific, Tags, Telemetry, ...**7.0115**

LAKEBORGNE-CHANDELEUR SOUND SYSTEM ...Aquatic Ecology, Louisiana, Nets, Number Or Density, Tides, ...**2.0543**

BRETON SOUND - MOUTH OF MISSISSIPPI RIVER SYSTEM ...Aquatic Ecology, Mississippi River, Nets, Number Or Density, ...**2.0544**

VERMILION - CALCASIEU - SABINE SYSTEM ...Aquatic Ecology, Data Acquisition-general, Louisiana, Nets, Number Or Density, ...**2.0546**

TIMBALIER - TERREBONNE BAYS SYSTEM ...Aquatic Ecology, Data Acquisition-general, Louisiana, Nets, Number Or Density, ...**2.0547**

A STUDY OF THE OPEN WATER DISTRIBUTION AND ABUNDANCE OF NET-PLANKTON AS AN INDEX OF EUTROPHICATION IN LAKE SUPERIOR ...Automatic Data Aquisition, Bioindicators, Lake Superior, Water Quality-general, Zooplankton, ...**5.0600**

DIATOM POPULATIONS CHANGES IN LAKE GEORGE ...Algae- Diatoms, Eutrophication, New York, Plant Succession, Recreation Sites, ...**2.0816**

FARMINGTON RIVER SHAD STUDIES ...Alewife,menhaden,shad,herring, Bottom Sampling, Migration, Water Properties-general, Water Sampling, ...**6.0117**

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PLASTICS TECHNOLOGY AND ENGINEERING APPLICATIONS ...Impact, Polyamides, Tensile, ...**8.0133**

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EFFECTS OF ORGANIC POLLUTION ON HATCHABILITY AND SURVIVAL OF BROOK TROUT, SALVELINUS FONTINALIS, AND GROWTH OF BROWN TROUT, SALMO TRUTTA ...Brown Trout, Lake Trout, Brook Trout, Nutrients, Population Dynamics, Streams, ...**5.1027**

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THE EFFECTS OF PESTICIDE RESIDUES ON LARVAL AND JUVENILE WINTER FLOUNDER IN THE WEWEANTIC RIVER ESTUARY, MASSACHUSETTS ...Estuaries, Massachusetts, Righteye Flounders, Wildlife, ...**5.0509**

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EFFECTS OF INCREASE IN SALTON SEA SALINITY ON THE SURVIVAL OF ORANGEMOUTH CORVINA, SARGO, BAIR-

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A PROGRAM FOR DEMONSTRATING COMBINED SEWER OVERFLOW CONTROL TECHNIQUE FOR WATER QUALITY IMPROVEMENTS AND BEACH PROTECTION ...Chlorination, Combined Sewer, Disinfection, Lake Erie, Polyelectrolytes, Shoreline - Coastline, ...**5.0867**

BASIC SALINOGEN ION EXCHANGE RESINS FOR SELECTIVE NITRATE REMOVAL FROM POTABLE AND EFFLUENT WATER ...Effluents-waste Water, Ion Exchange-other, Nitrate, Nitrite, Organic, Selective-removal, ...**5.0537**

A STUDY OF A WATER TOXICITY PROBLEM ...Bioassays, Bioindicators, Growth Rate, Management, Toxins and Poisons - other, ...**5.0197**

NUTRIENT REMOVAL IN A WATER TREATMENT PLANT ...Biological Treatment-other, Coagulation, Denitrification, Flocculation, Nutrients, Sand, ...**5.0355**

PRODUCTION OF HIGHLY PALATABLE WATER FROM AIR FOR HOUSEHOLD, LIVESTOCK, AND INDUSTRIAL USE ...Absorption-other, Cost Analysis, Process Development-other, Solar Still, Water Development, ...**3.0242**

CW-BW WATER DECONTAMINATION SET ...Chlorination, Coagulation, Filtration, ...**5.1214**

DEVELOP DESIGN DATA FOR LIGHT WEIGHT WATER PURIFICATION UNIT ...Filtration, Mobile, Potable, Technique Development, Waste Water Treatment-other, ...**8.0297**

COAGULANT DOSAGE TEST KIT ...Coagulation, Potable, ...**5.1218**

REVERSE OSMOSIS WATER PURIFICATION ...Cellulose Acetate, Military Aspects, Mobile, Other, Reverse Osmosis, ...3.0251

ION EXCHANGE UNIT, 3000 GPH ...Demineralization, Ion Exchange-other, Mobile, Other, Radioactivity-general, ...5.1215

ARTIFICIAL RECHARGE OF TREATED SEWAGE WATER AT BAY PARK, N.Y. ...Artificial Recharge, ...4.0183

BIBLIOGRAPHY ON FLUORIDATION OF PUBLIC WATER SUPPLIES ...Abstracts, Bibliography, Fluoridation, ...7.0088

SELECTED FACTORS INFLUENCING TASTE OF DRINKING WATER ...Hardness-minerals, Mineralization, Saliva, Studies, Organoleptic, Temperature Control, Water for Cooking Or Drinking, ...5.0085

CONSUMER ATTITUDES TOWARD MINERAL TASTE IN DOMESTIC WATER ...Attitudes & Attitude Change, California, Hardness-minerals, Taste and Odor, Water Standards, ...6.0039

PARTICULATE-ORGANIC EFFECT - SENSORY QUALITY OF WATER ...Adsorption-other, Coagulation, Colloidal Phenomena, Organic Matter, Taste and Odor, Waste Water Treatment-other, ...5.1013

INVESTIGATION OF WATER SUPPLY PROBLEMS IN ARCTIC AND SUB-ARCTIC AREAS ...Arctic, Groundwater, Storage of Water, Surface Water, Water Supply-general, ...3.0004

Potassium

MINERAL RECOVERY FROM CONCENTRATED BRINES ...Brines, Chloride, Desalination, Great Salt Lake, Magnesium, Regeneration-other, ...5.1198

THE EXTRACTION OF POTASSIUM FROM FRESH AND SALINE WATERS BY CLAY MINERALS ...Adsorption Capacity, Analysis and Detection, Clay Minerals-general, Extraction, ...2.0359

TURFGRASS MANAGEMENT ...in Turf, Management, New Mexico, Nitrogen, Phosphorus, Species and Variety Evaluation, ...6.0367

Potholes

THE EFFECT OF THE NATURAL SEALING OF POTHOLES UPON WATER MOVEMENT AND GROUNDWATER RESOURCES ...Groundwater, Internal Water Movement, Linings-pavings, Permeability, Subsurface Flow, ...2.0667

THE EFFECT OF POTHOLE DRAINAGE UPON GROUNDWATER RESOURCES ...Drainage, Groundwater, Radioisotopes, Unsaturated Flow, ...4.0144

AN EVALUATION OF SOME MARSH MANAGEMENT TECHNIQUES ...Management, Spawn Or Nesting Sites, Swamps-marshes, Water Fowl, N.s. , Water Utilization -animal, ...4.0107

HYDROLOGY OF PRAIRIE POTHOLES ...Management -other, North Dakota, Seepage, Water Balance-budget, Water Fowl, N.s. , Water Utilization -animal, ...2.0170

INTENSIVE COOPERATIVE INVESTIGATIONS OF SELECTED POTHOLES ON MISSOURI COTEAU IN DICKEY, WARD AND STUTSMAN COUNTIES, NORTH DAKOTA ...Hydrology-general, Natural Recharge, Water Fowl, N.s. , Water Level Fluctuation, Water Loss-general, ...6.0419

LIMNOLOGICAL INVESTIGATIONS OF PRAIRIE POTHOLES ...Chemical-general, Habitat Studies, North Dakota, Water Fowl, N.s. , ...2.0850

CHEMICAL CHARACTERIZATION OF WATERS OF PRAIRIE AND FOREST WETLANDS ...Chemical-general, Habitat Studies, Wetlands, ...1.0092

Potomac River

THE POTOMAC RIVER BASIN DEMONSTRATION PROJECT IN GEORGES CREEK ...Alternative Planning, Multiple-purpose Projects, River Basins, State-local Government, ...6.0261

Poultry Husbandry

Management

A STUDY OF A WATER TOXICITY PROBLEM ...Bioassays, Bioindicators, Growth Rate, Potable Water, Toxins and Poisons - other, ...5.0197

Poultry- Other

POULTRY MANURE PROPERTIES, HANDLING AND DISPOSAL ...Animal Waste Removal-treatment, Solid Waste, Waste Disposal-general, Waste Water Treatment-general, ...5.0775

Power Conditioner

COORDINATION OF PLANT FREQUENCY, D-C-TRANSMISSION AND SYSTEM CONTROL ...Ac-dc, Electric Power Plants, Evaluation Other, Other Generators, Power Transmission, ...8.0126

Power Conversion Systems

Ac-dc

HIGH-VOLTAGE D-C TRANSMISSION INVESTIGATIONS ...Dc-ac, Digital Computers, Electrical Engineering-general, Power Regulator, Power Transmission, Silicon-controlled-rectifiers, ...8.0054

COORDINATION OF PLANT FREQUENCY, D-C-TRANSMISSION AND SYSTEM CONTROL ...Electric Power Plants, Evaluation Other, Other Generators, Power Conditioner, Power Transmission, ...8.0126

Dc-ac

HIGH-VOLTAGE D-C TRANSMISSION INVESTIGATIONS ...Ac-dc, Digital Computers, Electrical Engineering-general, Power Regulator, Power Transmission, Silicon-controlled-rectifiers, ...8.0054

Power Generation

WATER DISPATCHING OPERATIONS BY ELECTRONIC COMPUTER ...Daily, Design Flow-flood, Dynamic Control System, Electric Power Plants, Inflow, Reservoirs and Impoundments, ...2.0984

Power Regulator

HIGH-VOLTAGE D-C TRANSMISSION INVESTIGATIONS ...Ac-dc, Dc-ac, Digital Computers, Electrical Engineering-general, Power Transmission, Silicon-controlled-rectifiers, ...8.0054

ELECTRICAL MACHINERY TEMPERATURE CONTROL ...Electric Power Plants, Motors and Appliances, Other Control Systems, Temperature, ...8.0125

Power Sources

Radioactive Isotope

DESALINIZATION AND INTERREGIONAL STUDIES ...Atomic Plants, Benefit-cost Analysis, Desalination, Marketing, Water Costs, ...6.0099

Power Transmission

REACTOR SWITCHING DUTY EVALUATION ...Electrical Engineering-general, Evaluation Other, Relay Circuits, Switching, ...8.0121

FIELD TESTS OF POWER TRANSMISSION EQUIPMENT ...Colorado River, Field Testing, Relay Circuits, Switching, Transmission Lines, ...8.0036

RELAY, CONTROL, AND METERING CIRCUIT INVESTIGATIONS ...Control, Evaluation Other, Relay Circuits, ...8.0122

UNDERGROUND TRANSMISSION AND EQUIPMENT DIELECTRICS--SOLID, LIQUID, AND INERT GAS ...Cables and Transmission Lines, Electric Power Plants, Evaluation Other, Field Testing, Insulators, ...8.0123

HIGH-VOLTAGE D-C TRANSMISSION INVESTIGATIONS ...Ac-dc, Dc-ac, Digital Computers, Electrical Engineering-general, Power Regulator, Silicon-controlled-rectifiers, ...8.0054

POWER TRANSMISSION STRUCTURES, NEW TYPES ...Electric Power Plants, Electrical Engineering-general, Public Utilities, Structural, Transmission Lines, ...8.0120

HIGH-VOLTAGE A-C TRANSMISSION ...Analog Computers, Development of Models, Digital Computers, Electrical Engineering-general, Switching, ...8.0056

CIRCUIT BREAKER RESEARCH ...Circuit Breaker, Electric Power Plants, Electrical Engineering-general, Evaluation Other, Switching, ...8.0052

COORDINATION OF PLANT FREQUENCY, D-C-TRANSMISSION AND SYSTEM CONTROL ...Ac-dc, Electric Power Plants, Evaluation Other, Other Generators, Power Conditioner, ...8.0126

Pre-impoundment Sites

EVALUATION OF CLEARED SEINING AREAS ...Land Use, Nets, Reservoirs and Impoundments, Texas, ...6.0540

SOME EFFECTS OF WATER IMPOUNDMENTS ON WATERFOWL POPULATIONS AND REPRODUCTION ON THE SNAKE RIVER, WASHINGTON ...Other, Reservoirs and Impoundments, Snake River, Washington, Water Utilization -animal, ...6.0609

IMPOUNDMENT EFFECTS ON WATER QUALITY AS REFLECTED IN PARASITISM OF RESERVOIR BASSES ...Copepods, Pathology, Reservoirs and Impoundments, Water Level Fluctuation, Water Quality-general, ...6.0024

A STUDY OF THE ECOLOGY OF THE NAVASOTA RIVER, TEXAS ...Aquatic Ecology, Fish -non-specific, Texas, Water Properties-general, Zooplankton, ...6.0547

A PRELIMINARY RECONNAISSANCE OF AREAS TO BE IMPOUNDED IN THE SALT RIVER BASIN OF KENTUCKY ...Kentucky, Reconnaissance, River Basins, Survey Studies, ...6.0242

A PRELIMINARY RECONNAISSANCE OF AREAS TO BE IMPOUNDED IN THE SALT RIVER BASIN OF KENTUCKY ...Environmental Effects-geologic, Kentucky, Morphology-general, Water Quality-general, ...6.0243

WATERFOWL POPULATIONS AND RECREATIONAL USE PATTERNS IN THE PROPOSED SAYLORVILLE RESERVOIR AREA AS RELATED TO PRE-IMPOUNDMENT CONDITIONS ...Access, Frequency of Use, Iowa, Population Dynamics, User Patterns, Water Fowl, N.s. , ...6.0227

A SYSTEMATIC STUDY OF RESPONSES TO IMPENDING INUNDATIONS AND THE DIRECTIONS OF IMPELLED POPULATION MOVEMENT ...Attitudes & Attitude Change, Mobility, Social Aspects, ...6.0238

MINERAL RESOURCE STUDY--RESERVOIR SITES ...Appraisals-general, Metallic Deposits-other, Reservoirs and Impoundments, Resource Inventories, Texas, ...2.1008

EFFECT OF IMPOUNDMENTS ON WATER QUALITY ...Oklahoma, Optimization, Reservoirs and Impoundments, Water Quality Control-general, Water Sampling, ...5.0904

Precipitation

Hail and Sleet

Formation

PRODUCTION AND DETECTION OF ARTIFICIAL ICE NUCLEI ...Cloud Physics, Model Studies, Modification, Nucleation Physics, Precipitation Instruments, ...2.0173

Modification

METEOROLOGICAL ANALYSIS OF PRECIPITATION EFFECTS OF SWISS HAIL SUPPRESSION EXPERIMENTS ...Clouds-precipitation, Patterns, Pressure-density, Weather Charts-maps, ...2.0108

WEATHER MODIFICATION IN NORTH DAKOTA ...Amount, Clouds-precipitation, Hail, North Dakota, Weather, ...2.0831

CLIMATOLOGY OF HAIL ...Applied Climatology, Patterns, Radar, Storms-general, ...4.0097

PRODUCTION AND DETECTION OF ARTIFICIAL ICE NUCLEI ...Cloud Physics, Formation, Model Studies, Nucleation Physics, Precipitation Instruments, ...2.0173

Patterns

CLIMATOLOGY OF HAIL ...Applied Climatology, Modification, Radar, Storms-general, ...4.0097

Topographic Influences

TOPOGRAPHIC INFLUENCES ON PRECIPITATION ...Alaska, Orographic Effects, Patterns, Runoff, ...2.0028

SKYWATER--PARK RANGE FOREST HYDROLOGY ...Colorado, Forest Watersheds, Model Studies, Mountains-alpine, Weather Modification-general, ...2.0172

Precipitation-general

Amount

(U) RADAR MEAS REMENT OF RAINFALL ...Radar, ...2.0423

PROBABLE MAXIMUM PRECIPITATION FOR SOUTHWEST STATES ...Design Flow-flood, Floods, Patterns, Snowmelt, Southwest, Weather Forecasting, ...2.0597

HYDROLOGIC RELATIONSHIPS IN A CONIFEROUS FOREST ...Evapotranspiration, Forest Watersheds, Groundwater, Storage of Water, Water Balance-budget, ...2.0552

SEASONAL SHALLOW STORAGE AND DEEP SEEPAGE COMPONENTS FOR THE HYDROLOGIC BUDGET OF A SMALL FORESTED OZARK WATERSHED ...Forest Watersheds, Groundwater Movement, Missouri, Seismic Surveys, Storage of Water, ...2.0700

WATER UTILIZATION ASPECTS OF WEATHER MODIFICATION AS APPLIED TO KANSAS ...Clouds-precipitation, Development of Models, Kansas, Model Studies, Water Harvesting, ...2.0505

WEATHER MODIFICATION IN NORTH DAKOTA ...Clouds-precipitation, Hail, Modification, North Dakota, Weather, ...2.0831

INVESTIGATIONS OF EROSION CONTROL AND WATER CONSERVATION ...Conservation-general, Erosion, Gullys - Arroyos, Land Use, Runoff, Sediment Yield, Stabilization-general, ...3.0226

CLIMATOLOGICAL MEASUREMENTS RELATED TO AGRICULTURE ...Fog-haze-mist, Land Use, Physical Climatology, Sunshine, Temperature, Water Utilization -general, ...2.0741

RAINFALL FREQUENCY RELATIONS FOR PENNSYLVANIA ...Design Flow-flood, Gages, Hydrographic, Pennsylvania, Weather Charts-maps, ...2.0926

RELATION OF CLIMATIC AND WATERSHED CHARACTERISTICS TO STORM RUNOFF IN THE EDWARDS PLATEAU ...Runoff, Small Watersheds, Storm Water, Storms-general, Texas, ...2.1030

SCALE OF PRECIPITATION ...Clouds-precipitation, Modification, Precipitation Instruments, ...2.0605

PRECIPITATION ...Forecasting-prediction, Gages, Runoff, Snowpack, Water Yield, ...2.0601

IMPROVE PRECIPITATION MEASURING EQUIPMENT - D-III PRECIPITATION EQUIPMENT ...Automatic Data Aquisition, Automatic Stations, Gages, Technique Development, ...2.0591

PROBABLE MAXIMUM PRECIPITATION FOR THE LOWER RIO GRANDE ...Mexico, River Basins, ...2.0598

GREAT LAKES RESEARCH - LAKE PRECIPITATION ...Forecasting, Great Lakes-general, Lake Erie, Lake Michigan, Ocean Meteorological Studies, ...2.0638

FLOODING OF SMALL STREAMS IN NASHVILLE-DAVIDSON CO. AREA, TENN. ...Discharge-general, Floods, Gaging, Tennessee, Urban Environments, ...2.0994

Forecasting

EVALUATION OF CLIMATIC PATTERNS AFFECTING IDAHO AGRICULTURE ...Agricultural Watersheds, Applied Climatology, Data Analysis - General, Evaporation, Idaho, Meteorological Averages, Patterns, ...2.0396

CALCULATION OF TEMPERATURE AND PRECIPITATION VALUES ...Air Temperature -non-specific, Distributions, Patterns, Temperature, Utah, ...2.1058

PROBABILITIES OF SEQUENCES OF DRY DAYS IN TEXAS ...Computers-general, Irrigation-general, Planning, Tables, Compilations, Catalogs, Water Supply-general, ...3.0442

GENERAL CIRCULATION - NUMERICAL MODELING OF PRECIPITATION ...Air Motion-general, Heat Exchange, Humidity, Model Studies, Weather Modification-general, ...2.0265

NUMERICAL PREDICTION OF CLOUDINESS AND PRECIPITATION ...Applications, Prediction Models, ...2.0266

WEATHER RADAR - PRECIPITATION RELATIONSHIP ...Automatic Stations, Computers-general, Patterns, Radar, ...2.0876

CLOUD AND PRECIPITATION FORECAST MODEL ...Cloud Cover, Condensation-general, Latent Heats, Model Studies, Weather Forecasting, ...2.0267

NATIONWIDE PRECIPITATION - NMC FORECAST TECHNIQUES ...Clouds-general, Computers-general, Forecasting-prediction, General Synoptic Observations, Regression Analysis, ...2.0589

NUMERICAL PRECIPITATION MODEL ...Computers-general, Model Studies, Simulation Theory, Western, ...2.0588

GREAT LAKES RESEARCH - LAKE PRECIPITATION ...Amount, Great Lakes-general, Lake Erie, Lake Michigan, Ocean Meteorological Studies, ...2.0638

A TEST OF CERTAIN EVALUATION DESIGNS FOR CLOUD-SEEDING EXPERIMENTS ...Clouds-precipitation, Mathematical Analysis, Model Studies, Oklahoma, Weather Charts-maps, ...2.0180

THE DEVELOPMENT OF SNYOPTIC CLIMATOLOGY AND STATISTICAL FORECASTING METHODS AND OROGRAPHIC PRECIPITATION ...Patterns, ...2.0205

PRECIPITATION PATTERNS ON RANGELAND WATERSHEDS IN THE SOUTHWEST ...Climatography, Patterns, Runoff, Sediment Yield, Southwest, ...2.0040

Formation

ICE FORMATION BY CONTACT NUCLEATION ...Growth and Preparation, Model Studies, Nucleation, Nucleation Physics, Temperature, ...3.0339

ROCKY MOUNTAIN OROGRAPHIC CLOUD PRECIPITATION AND MODIFICATION ...Cloud Structure, Clouds-precipitation, Colorado, Patterns, Topographic Influences, ...3.0140

ELECTRIC FIELDS IN THE CONDENSATION AND COALESCENCE OF WATER ...Field Properties, Ionization, Laboratory Analysis, Nucleation Physics, ...3.0299

NUMERICAL SIMULATION OF THE MACROPHYSICAL AND MICROPHYSICAL PROCESSES OF MOIST CONVECTION ...Cloud Formation and Evolution, Clouds-precipitation, Convection, Model Studies, Thermodynamics, ...2.0239

CASCADES ATMOSPHERIC WATER RESOURCES PROGRAM ...Augmentation-general, Cascade Mountains, Clouds-precipitation, Data Analysis - General, Washington, ...2.1128

Modification

NORTH SIERRA OROGRAPHIC, CONVECTIVE CLOUD STUDY - ATMOSPHERIC WATER RESOURCES PROGRAM ...Cloud Physics, Data Display Systems, Hydrology-general, Orographic Effects, Precipitation Instruments, ...2.0731

METEOROLOGICAL ANALYSIS OF PRECIPITATION EFFECTS OF SWISS HAIL SUPPRESSION EXPERIMENTS ...Clouds-precipitation, Patterns, Pressure-density, Weather Charts-maps, ...2.0108

DENSE RAINGAGE NETWORK PROJECTS ...Climatography, Data Networks, Gages, Storms-general, Weather Modification-general, ...2.0424

RAINFALL EVALUATION STUDIES ...Data Analysis Applications, Gages, General Synoptic Observations, Patterns, Storms-general, ...2.0416

SCALE OF PRECIPITATION ...Amount, Clouds-precipitation, Precipitation Instruments, ...2.0605

ATMOSPHERIC WATER RESOURCES PROGRAM ...Augmentation-general, Clouds-precipitation, Reservoirs and Impoundments, Technique Development, Water Quantity-general, ...2.0163

ATMOSPHERIC WATER RESOURCES RESEARCH ...Augmentation-general, California, Clouds-precipitation, Technique Development, ...2.0206

ECOLOGICAL EFFECTS OF WEATHER MODIFICATION ...Climate-general, Management, Water Properties-general, Weather Modification-general, ...2.0168

EVALUATION OF PRECIPITATION MANAGEMENT PROGRAMS BY PRECIPITATION RATE MEASUREMENTS ...Clouds-precipitation, Planning-support, ...2.0199

INVESTIGATION OF THE FEASIBILITY OF WARM-CLOUD MANAGEMENT ...Cloud Temperature, Clouds-precipitation, Model Studies, Other, ...2.0165

HYDROLOGIC BEHAVIOR OF SELECTED WATERSHEDS IN THE NORTHERN APPALACHIAN REGION ...Appalachian Highlands-other, Clouds-precipitation, Flow Characteristics -water, Model Studies, Watersheds-general, ...2.0184

Patterns

PRECIPITATION, STREAMFLOW AND SEDIMENT CONVEYANCE IN A SMALL ARID WATERSHED ...Climate, Deserts, Flash Floods, Flow Characteristics -water, Sediment Transport-other, ...2.0496

ROCKY MOUNTAIN OROGRAPHIC CLOUD PRECIPITATION AND MODIFICATION ...Cloud Structure, Clouds-precipitation, Colorado, Formation, Topographic Influences, ...3.0140

PROBABLE MAXIMUM PRECIPITATION FOR SOUTHWEST STATES ...Amount, Design Flow-flood, Floods, Snowmelt, Southwest, Weather Forecasting, ...2.0597

UTAH ATMOSPHERIC WATER RESOURCES (THE WASATCH WEATHER MODIFICATION PROJECT) ...Automatic Stations, Clouds-precipitation, Data Networks, Gages, Utah, ...2.1074

A GEOGRAPHIC ANALYSIS OF THE HYDROLOGIC RESPONSE IN THE SOUTHEASTERN UNITED STATES ...Atlases-maps, Drainage, Land Use, Southeast, ...2.0346

A HYDROMETEOROLOGICAL STUDY RELATED TO THE DISTRIBUTION OF PRECIPITATION AND RUNOFF OVER SMALL DRAINAGE BASINS - URBAN VERSUS RURAL AREAS ...Amount, Runoff, Small Watersheds, Texas, Urban Environments, ...2.1024

A GENERALIZED, PROBABILISTIC APPROACH TO REGIONAL WATER SUPPLY ASSESSMENT ...Available Water, Confidence Intervals, Model Studies, Regional Areas, Runoff, ...6.0059

PRECIPITATION AND RUNOFF DISTRIBUTIONS - ANALYSIS AND COMPARISONS ...Data Analysis - General, Discharge-general, Forecasting-prediction, Other Probability, Runoff, ...2.0739

SOIL-WATER-VEGETATION RELATIONS IN THE DOUGLAS FIR ZONE ...Flow Characteristics -water, Forest Watersheds, Moisture Content, Runoff, Water Balance-budget, Water Cycle, ...3.0027

EVALUATION OF CLIMATIC PATTERNS AFFECTING IDAHO AGRICULTURE ...Agricultural Watersheds, Applied Climatology, Data Analysis - General, Evaporation, Forecasting, Idaho, Meteorological Averages, ...2.0396

CLIMATE AND PHENOLOGICAL PATTERNS FOR AGRICULTURE IN THE WESTERN REGION ...Nevada, ...2.0730

CLIMATE AND PHENOLOGICAL PATTERNS FOR AGRICULTURE IN THE WESTERN REGION ...Applied Climatology, Meteorological Averages, Other Water Conditions, Phenology, Tables, Compilations, Catalogs, ...3.0332

PREPARATION AND ANALYSIS OF CLIMATOLOGICAL DATA IMPORTANT TO AGRICULTURE AND FORESTRY ...Applied Climatology, Atmpopheric Pollution-general, Precipitation -non-specific, Stochastic Processes, Western, ...4.0199

STATISTICAL ANALYSES OF THE VARIATIONS OF PRECIPITATION-TEMPERATURE AND EVAPORATION IN TEXAS ...Data Analysis Applications, Evaporation, Temperature, Texas, ...2.1027

CALCULATION OF TEMPERATURE AND PRECIPITATION VALUES ...Air Temperature -non-specific, Distributions, Forecasting, Temperature, Utah, ...2.1058

THEORY FOR THE DESIGN OF PRECIPITATION NETWORKS FOR HYDROLOGIC ANALYSIS ...Gages, Storms-general, ...7.0009

COMPUTER SIMULATION AND EVALUATION OF CLIMATOLOGICAL MODELS ...Computers-general, Model Studies, Statistics-general, ...7.0044

ANALYSIS AND SYNTHESIS OF HYDROLOGIC SYSTEMS ...Computers-general, Flow Characteristics -water, Hydrology-general, Open Channel Flow, Technique Development, ...2.0615

CHAMPLAIN VALLEY PRECIPITATION STUDY ...Gages, Pulp and Paper, Sulfur, Valleys and Canyons, ...2.0812

RAINFALL EVALUATION STUDIES ...Data Analysis Applications, Gages, General Synoptic Observations, Modification, Storms-general, ...2.0416

DROUGHT FREQUENCY, INTENSITY & DURATION - ITS CORRELATION TO STREAMFLOW AND ITS IMPACT UPON SYNTHETIC HYDROLOGY ...Climatography, Flow Characteristics -water, Meteorological Extremes, Synthetic Hydrology-general, Water Loss-general, ...2.0763

USE OF RADAR FOR HYDROLOGICAL STUDIES ...Cloud Physics, Evaporation, Groundwater Movement, Radar, Structure-size, ...2.0776

WEATHER RADAR - PRECIPITATION RELATIONSHIP ...Automatic Stations, Computers-general, Forecasting, Radar, ...2.0876

PRECIPITATION-FREQUENCY MAPS FOR WESTERN UNITED STATES ...Climate, Geomorphology, Weather Charts-maps, Western, ...7.0052

TOPOGRAPHIC INFLUENCES ON PRECIPITATION ...Alaska, Orographic Effects, Runoff, Topographic Influences, ...2.0028

PARK RANGE ATMOSPHERIC WATER RESOURCES PROGRAM ...Clouds-precipitation, Colorado, Nucleation Physics, Orographic Effects, Technique Development, ...2.0164

LARGE SCALE DYNAMIC EFFECTS OF CLOUD SEEDING ...Clouds-precipitation, Statistics-general, ...2.0171

STATE OF WASHINGTON DEPARTMENT OF WATER RESOURCES CASCADE ATMOSPHERIC WATER RESOURCES PROGRAM ...Augmentation-general, Cascade - Sierra Mountains, Clouds-precipitation, Nucleation Physics, Washington, ...2.0195

WATER YIELD IN RELATION TO CLIMATIC & WATERSHED CHARACTERISTICS OF LAND ...Agricultural Watersheds, Climate, Morphology-general, Subsurface Flow, Water Yield, ...3.0419

PRECIPITATION CHARACTERISTICS INFLUENCING RUNOFF FROM AGRICULTURAL WATERSHEDS ...Agricultural Watersheds, Amount, Gages, Runoff, Topographic Influences, ...2.0334

RELATION OF CLIMATIC AND WATERSHED FACTORS TO STORM RUNOFF IN CORN BELT STATES ...Agricultural Watersheds, Corn Belt, Physical Climatology, Runoff, Storms-general, ...2.0867

WATER YIELD AS RELATED TO CLIMATIC WATERSHED CHARACTERISTICS IN THE NORTHERN PLAINS ...Agricultural Watersheds, Climate, Groundwater Movement, Morphology-general, Water Yield, ...**3.0145**

PRECIPITATION CHARACTERISTICS INFLUENCING HYDROLOGIC PERFORMANCE OF AGRICULTURAL WATERSHEDS IN THE PACIFIC NORTHWEST ...Agricultural Watersheds, Hydrology-general, Runoff, Sediment Yield, Snow-other, ...**2.0386**

PRECIPITATION PATTERNS ON RANGELAND WATERSHEDS IN THE SOUTHWEST ...Climatography, Forecasting, Runoff, Sediment Yield, Southwest, ...**2.0040**

PRECIPITATION PATTERNS ON UPSTREAM WATERSHEDS IN CENTRAL AND SOUTHERN CALIFORNIA ...California, Climatography, Runoff, Sediment Yield, Watersheds-general, ...**2.0103**

Precipitation-general

RATE OF EVAPOTRANSPIRATION ...Drought, Energy Budgets, Evapotranspiration, Missouri, Yield, ...**2.0692**

RAIN SCAVENGING STUDIES - DATA ANALYSIS, SYNTHESIS AND INTERPRETATION ...Clouds-precipitation, Dust - Particulate Matter, Storms-general, Tracers, Washout, ...**7.0057**

REVIEW AND ANALYSIS OF PRECIPITATION AND RUNOFF DATA FOR SELECTED WATERSHEDS IN MINNESOTA ...Floods, Hydrographs, Infiltration, Runoff, Watersheds-general, ...**4.0140**

STUDY OF THE HYDROLOGY FOR MODELS OF THE GREAT LAKES ...Evaporation, Great Lakes-general, Management, Runoff, Systems Analysis, ...**2.0435**

DRAINAGE CORRELATION RESEARCH PROJECT ...Climatography, Drainage, Floods, Peak Flow, Small Watersheds, ...**2.0710**

ELECTRONIC ANALOG MODEL STUDIES OF RIVER BASINS ...Analog Computers, Groundwater, Management, Model Studies, River Basins, Runoff, Water Cycle, Water Resources Development, ...**2.1059**

HYDROLOGIC MODEL FOR STREAMFLOW FORECASTING ...Flow Characteristics -water, Forecasting-prediction, Hydrographs, Model Studies, Peak Flow, Runoff, ...**2.0600**

MISCELLANEOUS FIELD RESEARCH IN CLIMATOLOGY ...Amount, Physical Climatology, Water Resources Development, Water Yield, Weather Modification-general, ...**2.0606**

GREAT LAKES RESEARCH - LAKE EVAPORATION ...Evaporation, Great Lakes-general, Heat Budget, Humidity, Velocity, ...**2.0637**

CHEMISTRY OF ATMOSPHERIC PRECIPITATION ...Chemical Composition, Environmental Effects-geologic, Groundwater, Streams, Water Quality-general, ...**2.0279**

MANAGEMENT FOR IMPROVEMENT OF WATER YIELD IN THE CONIFER ZONE OF CALIFORNIA ...Evapotranspiration, Forest Watersheds, Land Use, Radioisotopes, Snowmelt, Water Yield, ...**3.0032**

PRECIPITATION AND SNOW MELT CHARACTERISTICS INFLUENCING RUNOFF FROM WATERSHEDS IN CORN BELT ...Agricultural Watersheds, Corn Belt, Permafrost-frozen, Runoff, Snowmelt, ...**2.0865**

WATER USE UNDER DRYLAND CONDITIONS IN COASTAL VALLEYS OF CALIFORNIA ...Applied Climatology, California, Modified Water Use, Moisture Content, Soil Environment, ...**3.0092**

Precipitation-other

PROBABILITY TABLES FOR PRECIPITATION ...Moisture-other, Other Probability, Requirements for Water, Tables, Compilations, Catalogs, Weather Forecasting, ...**2.0604**

DEVELOP PROTOTYPE PRECIPITATION OCCURRENCE SENSOR - DEVELOP AMOS III-70 (AUTOMATIC WEATHER STATION) ...Automatic Data Aquisition, Automatic Stations, Precipitation Instruments, Technique Development, ...**7.0053**

Topographic Influences

ROCKY MOUNTAIN OROGRAPHIC CLOUD PRECIPITATION AND MODIFICATION ...Cloud Structure, Clouds-precipitation, Colorado, Formation, Patterns, ...**3.0140**

HYDROMETEOROLOGY ...Mountains-alpine, Orographic Effects, Snowpack, Turbulence-other, Velocity, ...**2.0218**

TOPOGRAPHIC EFFECTS ON PRECIPITATION ...Applied Climatology, Illinois, Precipitation Instruments, ...**2.0412**

AIRFLOW AND DIFFUSION PARAMETERS IN CONNECTION WITH ATMOSPHERIC WATER RESOURCES PROGRAM ...Diffusion, Model Studies, Orographic Effects, Weather Modification-other, Wind Tunnels, ...**2.0167**

THE RELATION OF RAIN, SNOW, AND FROZEN SOILS TO THE HYDROLOGY OF AGRICULTURAL WATERSHEDS ...Agricultural Watersheds, Northeast, Patterns, Permafrost-frozen, ...**2.0919**

Rain

Amount

A STUDY OF THE HYDROLOGIC EFFECTS OF RAINFALL AUGMENTATION ...Augmentation-general, Clouds-precipitation, Digital Computers, Model Studies, Watersheds-general, ...**3.0076**

PROBABLE MAXIMUM PRECIPITATION FOR SMALL BASIN IN THE TENNESSEE RIVER DRAINAGE SYSTEM ...Drainage, Storms-general, Tennessee River, Topographic Influences, Weather Forecasting, ...**2.0594**

WATER LOSS ...Depth, Meteorological Studies-general, Requirements for Water, Water Level Fluctuation, Water Loss-general, ...**4.0228**

HYDROLOGY OF SUBURAN AREAS ...Conservation-general, Land, New Jersey, Runoff, Surburban Areas, ...**4.0173**

HYDROLOGY OF WATER YIELD PREDICTION ...Forecasting-prediction, Forest Watersheds, Moisture Retention, Water Balance-budget, Water Yield, ...**2.0892**

FLOODS FROM SMALL WATERSHEDS ...Floods, Rural Areas, Small Watersheds, Synthetic Hydrology-general, Systems Analysis, ...**2.0231**

HYDROLOGY OF SMALL DRAINAGE BASINS FOR DEVELOPING HYDRAULIC DESIGN ...Flow Characteristics -water, Hydrographs, Runoff, Small Watersheds, South Dakota, ...**2.0972**

PRECIPITATION INTENSITY-FREQUENCY RELATIONSHIPS FOR WEST VIRGINIA ...Digital Computers, Patterns, West Virginia, ...**2.1141**

INVESTIGATION OF A LINEAR MODEL TO DESCRIBE THE HYDROLOGIC PHENOMENON OF DRAINAGE BASINS ...Hydrographs, Model Studies, Runoff, Small Watersheds, Testing of Models, ...**2.1041**

RUNOFF GENERATION AS A FUNCTION OF PRECIPITATION AND WATERSHED CHARACTERISTICS ...Hydrographs, Runoff, Washington, Watersheds-general, ...**2.1120**

A HYDROMETEOROLOGICAL STUDY RELATED TO THE DISTRIBUTION OF PRECIPITATION AND RUNOFF OVER SMALL DRAINAGE BASINS - URBAN VERSUS RURAL AREAS ...Patterns, Runoff, Small Watersheds, Texas, Urban Environments, ...**2.1024**

HYDROLOGIC AND PHOTOGEOLOGIC DETERMINATION OF RAINFALL, RUNOFF, AND GROUNDWATER RELATIONSHIPS IN A DOLOMITE AREA ...Dolomite, Groundwater, Hydrology-general, Photogrammetry, Runoff, ...**2.0702**

SMALL WATERSHED YIELDS ...Aquifers-general, Land Use, Runoff, Small Watersheds, Water Yield, ...**4.0149**

SOIL DRAINAGE ...Drainage, New Jersey, Soil Morphology, Profiles, Water Table Fluctuation, ...**4.0171**

DEVELOPMENT OF IMPROVED SNOW SURVEYING AND STREAM-FLOW FORECASTING TECHNIQUES ...Antecedent Moisture, Flow Characteristics -water, Forecasting-prediction, Moisture Content, Temperature, ...**2.1072**

FACTORS AFFECTING WATER YIELDS FROM SMALL WATERSHEDS AND SHALLOW GROUND AQUIFERS ...Applied Climatology, Aquifers-general, Runoff, Small Watersheds, Soil Types-general, Water Yield, ...**4.0207**

TREATING AN INADEQUACY OF THE UNIT HYDROGRAPH HYPOTHESIS BY STORAGE ROUTING WITH VARIABLE EMPIRICAL VALUES OF LAG AND STORAGE ...Arizona, Hydrographs, Model Studies, Runoff, Storage of Water, ...**2.0063**

SYSTEM ANALYSIS OF RAINFALL-RUNOFF RELATIONSHIP ...Digital Computers, Digital Computers, Ordinary, Runoff, Systems Analysis, ...**2.0427**

STOCHASTIC ANALYSIS OF RAINFALL-RUNOFF RELATIONSHIP ...Mathematical Analysis, North Carolina, Runoff, Stochastic Processes, ...**2.0428**

HYDROLOGIC MEASUREMENT SYSTEMS ...Data Networks, Error Analysis, Gages, Hydrology-general, Instrumentation-general, Rain-general, Technique Development, Urban Environments, ...**7.0056**

COOPERATIVE WATERSHED MANAGEMENT ON BRUSHLANDS OF CALIFORNIA ...California, Management, Management and Fertility, Runoff, Sediment Yield, ...**4.0036**

EXPERIMENTAL INVESTIGATION OF SMALL WATERSHED FLOODS ...Floods, Runoff, Small Watersheds, Synthetic Hydrology-general, ...**2.0232**

SHORT-DURATION CONVECTIVE RAINFALL - DEPTH-DURATION AND INTENSITY-DURATION RELATIONSHIPS AND VARIATIONS ...Convection, Gages, Patterns, Thunderstorms, ...**2.0921**

RUNOFF PRODUCTION FROM UNIT SOURCE WATERSHEDS IN THE EDWARDS PLATEAU ...Forecasting-prediction, Rocks - Bedrock, Runoff, Small Watersheds, Texas, ...**2.1028**

PRECIPITATION CHARACTERISTICS INFLUENCING RUNOFF FROM AGRICULTURAL WATERSHEDS IN THE BLACKLANDS AND EDWARDS PLATEAU OF TEXAS ...Agricultural Watersheds, Drought, Gages, Runoff, Texas, ...**2.1032**

RUNOFF AND WATER YIELD AS AFFECTED BY CLIMATIC AND WATERSHED CONDITIONS IN THE BLACKLANDS OF TEXAS ...Agricultural Watersheds, Floods, Runoff, Texas, Water Yield, ...**2.1021**

COMPUTER-ORIENTED MATHEMATICAL MODEL FOR CONTINUOUS STREAMFLOW PREDICTION ...Computers-general, Development of Models, Discharge-general, Prediction Models, ...**2.0985**

GENERALIZED HYDROLOGIC DESIGN CRITERIA ...Hydrology-general, Reservoirs and Impoundments, Technique Development, Water Resources Development, ...**6.0079**

HYDROLOGIC RELATIONS IN HAWAII ...Data Networks, Floodproofing, Hawaii, Hydrology-general, Runoff, ...**2.0365**

GENERALIZED SOIL - MOISTURE RUNOFF-RELATIONS ...Forecasting-prediction, Moisture Content, River Basins, Runoff, ...**2.0900**

FLOOD-FREQUENCY AND BASIN PARAMETER RELATIONSHIPS IN SMALL DRAINAGE AREAS ...Discharge-general, Floods, Morphology-general, Peak Flow, Small Watersheds, ...**2.0280**

FLOODS IN NORTH LOUISIANA - RAINFALL-RUNOFF RELATIONSHIPS ...Floods, Gaging, Louisiana, Runoff, Storms-general, ...**2.0537**

WRAGG SWAMP CANAL INVESTIGATION, ALABAMA ...Alabama, Canals, Control Factors-general, Runoff, Urban Environments, ...**4.0001**

HYDROLOGIC INVESTIGATIONS OF URBAN AREAS - HOUSTON, TEXAS ...Discharge-general, Floods, Gaging, Texas, Urban Environments, ...**4.0233**

EVALUATION OF PRECIPITATION MANAGEMENT PROGRAMS BY PRECIPITATION RATE MEASUREMENTS ...Clouds-precipitation, Modification, Planning-support, ...**2.0199**

A THEORETICAL STUDY OF INFILTRATION INTO RANGE AND FOREST SOILS ...Infiltration, Runoff, ...**2.1066**

PRECIPITATION CHARACTERISTICS INFLUENCING RUNOFF FROM AGRICULTURAL WATERSHEDS ...Agricultural Watersheds, Gages, Patterns, Runoff, Topographic Influences, ...**2.0334**

PRECIPITATION CHARACTERISTICS INFLUENCING RUNOFF FROM WATERSHEDS IN THE SOUTHERN PLAINS ...Agricultural Watersheds, Great Plains Province, Patterns, Runoff, Topographic Influences, ...**2.1054**

Forecasting

STATISTICAL, METEOROLOGICAL AND DEPTH-AREA ANALYSIS OF RAINFALL ...Data Analysis Applications, Hydrology-general, Middle-east-general, Patterns, ...**2.0492**

TROPICAL STORM RAINFALL AND HURRICANE WIND FIELDS ...Gulf of Mexico, Pressure-density, Tropical Cyclones, Velocity, ...**2.0595**

INFLUENCE OF TOPOGRAPHIC FEATURES ON RAINFALL IN WEST VIRGINIA ...Mathematical Analysis, Patterns, Topographic Influences, Weather Charts-maps, West Virginia, ...**2.1140**

PACIFIC OCEAN INFLUENCE UPON CALIFORNIA RAINFALL ...California, Pacific Ocean-general, Patterns, Rain-other, Temperature, ...**2.0104**

CLIMATIC PATTERNS IN WASHINGTON STATE ...Climate, Data Analysis Applications, Data Networks, Evaporation, Patterns, ...**2.1122**

Modification

RAINFALL EVALUATION STUDIES ...Data Analysis - General, Gages, Patterns, Sampling-general, Weather Modification-general, ...**3.0219**

RAINFALL OVER MISSOURI ...Data Analysis - General, Gages, Geography-physical, Patterns, Topographic Influences, ...**2.0694**

EVALUATION OF PRECIPITATION MANAGEMENT PROGRAMS BY PRECIPITATION RATE MEASUREMENTS ...Clouds-precipitation, Planning-support, ...**2.0199**

Patterns

STATISTICAL, METEOROLOGICAL AND DEPTH-AREA ANALYSIS OF RAINFALL ...Data Analysis Applications, Forecasting, Hydrology-general, Middle-east-general, ...**2.0492**

(U) RADAR MEAS REMENT OF RAINFALL ...Radar, ...**2.0423**

STOCHASTIC STRUCTURE OF HYDROLOGIC SERIES ...Hydrology-general, Runoff, Stochastic Processes, ...**6.0109**

RAINFALL EVALUATION STUDIES ...Data Analysis - General, Gages, Modification, Sampling-general, Weather Modification-general, ...**3.0219**

INFLUENCE OF TOPOGRAPHIC FEATURES ON RAINFALL IN WEST VIRGINIA ...Forecasting, Mathematical Analysis, Topographic Influences, Weather Charts-maps, West Virginia, ...**2.1140**

PRECIPITATION INTENSITY-FREQUENCY RELATIONSHIPS FOR WEST VIRGINIA ...Amount, Digital Computers, West Virginia, ...**2.1141**

A SYSTEMATIC TREATMENT OF THE PROBLEM OF INFILTRATION ...Hysteresis, Infiltration, Model Studies, Moisture Content, Soil Profile, ...**2.0219**

TIME DISTRIBUTION OF RAINFALL INTENSITIES ...Atmosphere Disturbance, Mathematical Analysis, ...**2.0920**

SMALL AGRICULTURAL WATERSHED HYDROLOGY ...Agricultural Watersheds, Floods, Gages, Runoff, Sediment Yield, ...**4.0138**

RAINFALL OVER MISSOURI ...Data Analysis - General, Gages, Geography-physical, Modification, Topographic Influences, ...**2.0694**

STATISTICAL ANALYSES OF THE VARIATIONS OF PRECIPITATION-TEMPERATURE AND EVAPORATION IN TEXAS ...Data Analysis Applications, Evaporation, Temperature, Texas, ...**2.1027**

CLIMATIC PATTERNS IN WASHINGTON STATE ...Climate, Data Analysis Applications, Data Networks, Evaporation, Forecasting, ...**2.1122**

RAINFALL CHARACTERISTICS, DROUGHT INCIDENCE AND THE DEVELOPMENT OF A RAINFALL DEFICIENCY INDEX FOR THE AGRICULTURAL REGIONS OF PUERTO RICO ...Drought, Irrigation-general, Meteorological Extremes, Puerto Rico, Rain, ...**2.0932**

RESEARCH ON GEOHYDROLOGY OF THE EASTERN SLOPE OF WEST MAUI ...Aquifers-general, Hawaii, Mountains-alpine, Projections and Estimations, Slopes, Water Yield, ...**6.0170**

CHAMPLAIN VALLEY PRECIPITATION STUDY ...Gages, Pulp and Paper, Sulfur, Valleys and Canyons, ...**2.0812**

FACTORS AFFECTING WATER YIELDS FROM SMALL WATERSHEDS AND SHALLOW GROUND AQUIFERS ...Atlases-maps, Moisture Content, Puerto Rico, Runoff, Water Yield, ...**4.0208**

REGIONAL CORRELATIONS IN HYDROLOGIC VARIABLES ...Annual, Correlation, Data Analysis - General, Evaporation, Runoff, ...**7.0097**

HYDROMETEOROLOGICAL ANALYSIS OF SEVERE RAINSTORMS ...Illinois, Meteorological Extremes, Radar, Storms-general, Weather Charts-maps, ...**2.0414**

WATER SUPPLY FROM AGRICULTURAL WATERSHEDS AND UTILIZATION IN IRRIGATION ...Agricultural Watersheds, Forecasting-prediction, Irrigation-general, Moisture Content, Runoff, Water Yield, ...**4.0187**

SHORT-DURATION CONVECTIVE RAINFALL - DEPTH-DURATION AND INTENSITY-DURATION RELATIONSHIPS AND VARIATIONS ...Amount, Convection, Gages, Thunderstorms, ...**2.0921**

INVESTIGATION OF RAINFALL DISTRIBUTION ON URBAN RUNOFF FOR IMPERVIOUS AREAS ...Drainage, Hydrographs, Model Studies, Runoff, Urban Environments, ...**2.0306**

HYDROLOGIC STUDIES (STORM STUDIES) ...Flood Control, Floodproofing, Hydrology-general, Storms-general, Tables, Compilations, Catalogs, ...**2.0549**

GEOMORPHIC ASPECTS (SISTERS AND WATTS BRANCHES, MARYLAND) ...Energy-dynamics, Ephemeral, Groundwater Movement, Runoff, Sediment Transport-general, Water Cycle, ...**2.0283**

THE RELATION OF RAIN, SNOW, AND FROZEN SOILS TO THE HYDROLOGY OF AGRICULTURAL WATERSHEDS ...Agricultural Watersheds, Northeast, Permafrost-frozen, Topographic Influences, ...**2.0919**

PRECIPITATION CHARACTERISTICS INFLUENCING RUNOFF FROM WATERSHEDS IN THE SOUTHERN PLAINS ...Agricultural Watersheds, Amount, Great Plains Province, Runoff, Topographic Influences, ...**2.1054**

Rain-general

INVESTIGATION AND ANALYSIS OF FLOOD HYDROGRAPHS FROM SMALL DRAINAGE BASINS IN SOUTH DAKOTA ...Bridges & Culverts, Culvert, Drainage, Floods, Hydrographs, Small Watersheds, ...**2.0294**

PREDICTION OF THE MAGNITUDES AND FREQUENCIES OF FLOODS IN MICHIGAN ...Drainage, Floods, Forecasting-prediction, Michigan, Morphology-general, ...**2.0635**

CHEMICAL CHARACTERISTICS OF PRECIPITATION FALLING IN CHAMPLAIN VALLEY ...Chemical Analysis, Snow-general, Storms-general, Vermont, Water Quality-general, ...**2.1086**

PHASE TWO - EXPERIMENTAL INVESTIGATION OF SMALL WATERSHED FLOODS ...Floods, Mathematical Analysis, Model Studies, Runoff, Small Watersheds, ...**2.0233**

THE INTERFLOW PROCESS ON SLOPING WATERSHED AREAS ...Forecasting-prediction, Groundwater Movement, Mathematical Analysis, Physical Properties-general, Tracers-general, ...**2.0961**

MECHANICS OF SOIL EROSION BY WATER ...Erosion Control, Erosion-general, Particle Surface, Stability, Thermal Properties-general, ...**2.0457**

HYDROLOGIC MEASUREMENT SYSTEMS ...Amount, Data Networks, Error Analysis, Gages, Hydrology-general, Instrumentation-general, Technique Development, Urban Environments, ...**7.0056**

NEUTRON ACTIVATION ANALYSIS OF IMPURITIES IN RAIN AND SNOW ...Activation Analysis, Calcium, Lake Erie, Snowmelt, Storms-general, Sulfur, ...**5.0767**

GENERALIZED ANALYSIS OF SMALL WATERSHED RESPONSES ...Mathematical Analysis, Sequences - Series, Small Watersheds, Water Yield, ...**2.0085**

MATHEMATICAL MODELING OF SMALL WATERSHED FLOODS ...Floods, Mathematical Analysis, Model Studies, Runoff, Small Watersheds, ...**4.0073**

PILOT-STUDY OF SMALL WATERSHED HYDROLOGY ...Data Analysis - General, Floods, Instrumentation-general, Mathematical Analysis, Runoff, Small Watersheds, ...**2.0379**

RADIOACTIVITY IN RAINFALL ...General Synoptic Observations, Illinois, Radioactivity, ...**2.0415**

CHARACTERIZATION OF WATER TABLES IN OREGON SOILS WITH REFERENCE TO TRAFFICABILITY ...Dynamic, Moisture Content, Static Load-general, Trafficability, Water Table Fluctuation, ...**2.0887**

WATER POLLUTION FROM ERODED SEDIMENTS ...Flow Characteristics -water, Other Transport Effects, Sediments, Suspension, Velocity -water, ...**2.1042**

RUNOFF PRODUCTION BY UNIT SOURCE AREA ...Evaporation, Forecasting-prediction, Land Use, Moisture Content, Runoff, ...**2.1029**

NUTRIENT INPUT TO WASHINGTON SOILS FROM ATMOSPHERIC SOURCES. ...Air - Water - Plant Relations, Irrigation, Irrigation-general, Nutrients, Soil and Rock Leaching, ...**2.1124**

IMPROVE COMPONENTS OF THE DATA ACQUISITION SYSTEM - SATELLITE COMMUNICATIONS EQUIPMENT ...Automatic Data Aquisition, Data Acquisition Systems, Instrumental Services, Satellites & Deep Space Probes, Streams, ...**7.0050**

NATURAL RECHARGE OF GROUND WATER IN CENTRAL AND SOUTHERN CALIFORNIA ...Infiltration, Natural Recharge, Runoff, ...**3.0063**

Rain-other

EFFECT OF RAINDROP IMPACT AND SURFACE ROUGHNESS ON SHEET FLOW ...Flow Characteristics -water, Model Studies, Rainfall Simulators, Roughness, Sheetflow, ...**2.0447**

PACIFIC OCEAN INFLUENCE UPON CALIFORNIA RAINFALL ...California, Forecasting, Pacific Ocean-general, Patterns, Temperature, ...**2.0104**

EVALUATION OF THE SULFUR SUPPLYING CAPACITY OF HAWAIIAN SOILS ...Hawaii, Irrigation-general, Movement, Availability, Soil Chemical Properties, Sulfur, ...**2.0373**

PRECIPITATION SCAVENGING ...Dispersion - Transporation, Nuclear Explosions - Fallout, Nucleation Physics, Snow-other, Washout, ...**5.1252**

Structure-size

SCAVENGING STUDY OF SNOW AND ICE CRYSTALS ...Charge on Droplets, Nucleation Physics, Structure, Washout, ...**2.0406**

(U) RADAR MEASUREMENT OF RAINFALL ...Radar, ...**2.0423**

SPATIAL BEHAVIOR OF ROUGHNESS IN LABORATORY WATERSHED, PHASE II ...Energy Loss -water, Model Studies, Roughness, Runoff, Surface Flow, Synthetic Hydrology-general, ...**2.0703**

USE OF RADAR FOR HYDROLOGICAL STUDIES ...Cloud Physics, Evaporation, Groundwater Movement, Patterns, Radar, ...**2.0776**

BASIC PRINCIPLES AND MECHANICS OF RAINFALL, RUNOFF, SOIL MOVEMENT AND LOSS IN THE CORN BELT ...Engineering Properties-general, Erosion-general, Runoff, Sediment Transport-general, Slopes, Surface Flow, ...**2.0475**

Topographic Influences

PROBABLE MAXIMUM PRECIPITATION FOR SMALL BASIN IN THE TENNESSEE RIVER DRAINAGE SYSTEM ...Amount, Drainage, Storms-general, Tennessee River, Weather Forecasting, ...**2.0594**

INFLUENCE OF TOPOGRAPHIC FEATURES ON RAINFALL IN WEST VIRGINIA ...Forecasting, Mathematical Analysis, Patterns, Weather Charts-maps, West Virginia, ...**2.1140**

RAINFALL OVER MISSOURI ...Data Analysis - General, Gages, Geography-physical, Modification, Patterns, ...**2.0694**

PRECIPITATION CHARACTERISTICS INFLUENCING RUNOFF FROM AGRICULTURAL WATERSHEDS ...Agricultural Watersheds, Amount, Gages, Patterns, Runoff, ...**2.0334**

PRECIPITATION CHARACTERISTICS INFLUENCING RUNOFF FROM WATERSHEDS IN THE SOUTHERN PLAINS ...Agricultural Watersheds, Amount, Great Plains Province, Patterns, Runoff, ...**2.1054**

Snow

Amount

DEVELOPMENT OF IMPROVED SNOW SURVEYING AND STREAM-FLOW FORECASTING TECHNIQUES ...Antecedent Moisture, Flow Characteristics -water, Forecasting-prediction, Moisture Content, Temperature, ...**2.1072**

MISCELLANEOUS FIELD RESEARCH IN CLIMATOLOGY ...Physical Climatology, Precipitation-general, Water Resources Development, Water Yield, Weather Modification-general, ...**2.0606**

TEST AND EVALUATION OF TELEMETERING STORAGE PRECIPITATION GAGE ...Automatic Data Aquisition, Automatic Stations, Gages, Technique Development, ...**7.0048**

SKYWATER ...Clouds-precipitation, Fronts, Montana, Storms-general, Topographic Influences, ...**2.0200**

Formation

LAKE EFFECT STORM STUDY ...Lake Erie, Lake Ontario, Model Studies, Sea of Japan, Weather Forecasting, ...**2.0778**

Modification

RESEARCH IN ATMOSPHERIC SCIENCES AS RELATED TO INCREASING WATER SUPPLY ...Montana, Nucleation Physics, Snowmelt, Topographic Influences, ...**2.0904**

Patterns

SNOW DISTRIBUTION MAPPING FROM SATELLITE PHOTOGRAPHY ...Aerospatial, Mapping, Maps-general, Mountains-alpine, ...**8.0214**

THE RELATION OF RAIN, SNOW, AND FROZEN SOILS TO THE HYDROLOGY OF AGRICULTURAL WATERSHEDS ...Agricultural Watersheds, Northeast, Permafrost-frozen, Topographic Influences, ...**2.0919**

SNOW ACCUMULATION AND MELT ON STUDY AREAS ...Energy-general, Idaho, Mountains-alpine, Photogrammetry, Snowmelt, ...**2.0388**

Snow-general

CHEMICAL CHARACTERISTICS OF PRECIPITATION FALLING IN CHAMPLAIN VALLEY ...Chemical Analysis, Rain-general, Storms-general, Vermont, Water Quality-general, ...**2.1086**

THE URBAN SNOW HAZARD ...Economic Impact, Social Aspects, Urban Environments, Weather, Welfare Economics, ...**6.0186**

Snow-other

A STUDY OF SNOW INTERCEPTED BY CONIFEROUS TREE CROWNS AND ITS DISPOSITION UNDER THE CLIMATIC CONDITIONS OF CENTRAL NEW YORK ...Coniferous Forests, Conifers -non-specific, Interception, New York, Snow, ...**2.0787**

PRECIPITATION SCAVENGING ...Dispersion - Transporation, Nuclear Explosions - Fallout, Nucleation Physics, Rain-other, Washout, ...**5.1252**

PRECIPITATION CHARACTERISTICS INFLUENCING HYDROLOGIC PERFORMANCE OF AGRICULTURAL WATERSHEDS IN THE PACIFIC NORTHWEST ...Agricultural Watersheds, Hydrology-general, Patterns, Runoff, Sediment Yield, ...**2.0386**

Structure

SCAVENGING STUDY OF SNOW AND ICE CRYSTALS ...Charge on Droplets, Nucleation Physics, Structure-size, Washout, ...**2.0406**

STUDY OF SNOW CRYSTAL TYPES IN GREAT LAKES SNOWSTORMS ...Activation Analysis, Great Lakes-general, Inorganic, Iodine, Storm Water, ...**2.0784**

Topographic Influences

LAKE EFFECT SNOW SITUATIONS, EASTERN LAKE ONTARIO AREA ...Atmospheric Pressure, Data Acquisition, General Synoptic Observations, Lake Ontario, ...**7.0084**

SKYWATER ...Amount, Clouds-precipitation, Fronts, Montana, Storms-general, ...**2.0200**

RESEARCH IN ATMOSPHERIC SCIENCES AS RELATED TO INCREASING WATER SUPPLY ...Modification, Montana, Nucleation Physics, Snowmelt, ...**2.0904**

Precipitation Instruments

NORTH SIERRA OROGRAPHIC, CONVECTIVE CLOUD STUDY - ATMOSPHERIC WATER RESOURCES PROGRAM ...Cloud Physics, Data Display Systems, Hydrology-general, Modification, Orographic Effects, ...**2.0731**

TOPOGRAPHIC EFFECTS ON PRECIPITATION ...Applied Climatology, Illinois, Topographic Influences, ...**2.0412**

SCALE OF PRECIPITATION ...Amount, Clouds-precipitation, Modification, ...**2.0605**

DEVELOP PROTOTYPE PRECIPITATION OCCURRENCE SENSOR - DEVELOP AMOS III-70 (AUTOMATIC WEATHER STATION) ...Automatic Data Aquisition, Automatic Stations, Precipitation-other, Technique Development, ...**7.0053**

ATMOSPHERIC WATER RESOURCES RESEARCH IN THE STATE OF NEW MEXICO ...Clouds-general, Clouds-precipitation, New Mexico, Rio Grande, Storms-general, ...**2.0175**

PRODUCTION AND DETECTION OF ARTIFICIAL ICE NUCLEI ...Cloud Physics, Formation, Model Studies, Modification, Nucleation Physics, ...**2.0173**

Gages

RAINFALL EVALUATION STUDIES ...Data Analysis - General, Modification, Patterns, Sampling-general, Weather Modification-general, ...**3.0219**

UTAH ATMOSPHERIC WATER RESOURCES (THE WASATCH WEATHER MODIFICATION PROJECT) ...Automatic Stations, Clouds-precipitation, Data Networks, Patterns, Utah, ...**2.1074**

SYSTEM MONITORING AND REMOTE CONTROL ...Automatic Data Aquisition, Effluents-waste Water, Instrumental Services, Other Telemetry, Physical Parameters, ...**5.0559**

SMALL AGRICULTURAL WATERSHED HYDROLOGY ...Agricultural Watersheds, Floods, Patterns, Runoff, Sediment Yield, ...**4.0138**

RAINFALL OVER MISSOURI ...Data Analysis - General, Geography-physical, Modification, Patterns, Topographic Influences, ...**2.0694**

THEORY FOR THE DESIGN OF PRECIPITATION NETWORKS FOR HYDROLOGIC ANALYSIS ...Patterns, Storms-general, ...**7.0009**

HYDROLOGIC MEASUREMENT SYSTEMS ...Amount, Data Networks, Error Analysis, Hydrology-general, Instrumentation-general, Rain-general, Technique Development, Urban Environments, ...**7.0056**

CHAMPLAIN VALLEY PRECIPITATION STUDY ...Patterns, Pulp and Paper, Sulfur, Valleys and Canyons, ...**2.0812**

DENSE RAINGAGE NETWORK PROJECTS ...Climatography, Data Networks, Modification, Storms-general, Weather Modification-general, ...**2.0424**

RAINFALL EVALUATION STUDIES ...Data Analysis Applications, General Synoptic Observations, Modification, Patterns, Storms-general, ...**2.0416**

SHORT-DURATION CONVECTIVE RAINFALL - DEPTH-DURATION AND INTENSITY-DURATION RELATIONSHIPS AND VARIATIONS ...Amount, Convection, Patterns, Thunderstorms, ...**2.0921**

RAINFALL FREQUENCY RELATIONS FOR PENNSYLVANIA ...Amount, Design Flow-flood, Hydrographic, Pennsylvania, Weather Charts-maps, ...**2.0926**

PRECIPITATION CHARACTERISTICS INFLUENCING RUNOFF FROM AGRICULTURAL WATERSHEDS IN THE BLACKLANDS AND EDWARDS PLATEAU OF TEXAS ...Agricultural Watersheds, Amount, Drought, Runoff, Texas, ...**2.1032**

PRECIPITATION ...Amount, Forecasting-prediction, Runoff, Snowpack, Water Yield, ...**2.0601**

TEST AND EVALUATION OF TELEMETERING STORAGE PRECIPITATION GAGE ...Amount, Automatic Data Aquisition, Automatic Stations, Technique Development, ...**7.0048**

IMPROVE PRECIPITATION MEASURING EQUIPMENT - PRESSURE TRANSDUCER ANALYSIS ...Automatic Stations, Instrumental Services, Transducers, ...**2.0590**

IMPROVE PRECIPITATION MEASURING EQUIPMENT - HYDROLOGIC EQUIPMENT IMPROVEMENT ...Atmospheric Pressure, Data Acquisition Systems, Instrumental Services, Technique Development, Transducers, ...**7.0051**

IMPROVE PRECIPITATION MEASURING EQUIPMENT - D-III PRECIPITATION EQUIPMENT ...Amount, Automatic Data Aquisition, Automatic Stations, Technique Development, ...**2.0591**

FISHER AND PORTER INSTALLATION METHODS ...Evaporation, Technique Development, Testing Devices, ...**7.0049**

PROJECT SKYWATER - NEW MEXICO ...Automatic Stations, Instrumental Services, New Mexico, Other Telemetry, Snow-general, Technique Development, ...**2.0203**

PROJECT SKYWATER - COLORADO - STEAMBOAT SPRINGS ...Automatic Stations, Colorado, Instrumental Services, Other Telemetry, Snow-general, ...**2.0204**

PRECIPITATION CHARACTERISTICS INFLUENCING RUNOFF FROM AGRICULTURAL WATERSHEDS ...Agricultural Watersheds, Amount, Patterns, Runoff, Topographic Influences, ...**2.0334**

Pressure Studies

Density

LIGHTWEIGHT WATER PURIFICATION UNIT ...Brackish Water, Desalination, Distillation-other, Distilling Units, Mobile, Plastic Matrix, Technique Development, Waste Water Treatment-general, ...**3.0250**

Extreme High Pressure - K Bar

TRANSPORT AND DIELECTRIC PROPERTIES OF SALINE SOLUTIONS ...Analysis and Detection, Compressibility--gas-liq, Dielectric Properties, Transference, Water, ...**1.0103**

High Pressure - 1-1000 Atm

SOLUBILITY OF NATURAL GASES IN CONNATE WATER AND OF WATER IN NATURAL GASES ...Brines, Interstitial - Connate Water, Ions and Gases, Natural Gas, Solubility, Solution Chemistry, ...**1.0080**

DESALINATION BY HIGH PRESSURE SOLIDIFICATION OF WATER TO ICE ...Crystallization-other, Desalination, Other, ...**3.0360**

MODIFIED ION-EXCHANGE MEMBRANES FOR WATER PURIFICATION BY REVERSE OSMOSIS ...Cellulose Acetate, Desalination, Ion Exchange-other, Reverse Osmosis, ...**3.0289**

HIGH-PRESSURE VAPOR EXTRACTION OF SOLUBLE ORGANIC SOLUTES FROM AQUEOUS INDUSTRIAL WASTE STREAMS ...Extraction, Flow of Gas in Liquid, Gaseous, Industrial Processes-other, Two-phase-other, ...**5.0070**

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SURFACE TEMPERATURE STUDIES USING RADIOMETRY TECHNIQUES ...Heat and Radiation Transfer, Infrared Radiation, Microwave Radiation, Surface Environments, Temperature, ...**6.0270**

OCEANOGRAPHIC USES OF RADAR ...Electronics - Applied, Radar, Surface Environments, Waves, Wind-water Interaction, ...**6.0273**

OIL SLICK ANALYSES ...Instrumental Services, Oil, Optical Devices, Satellites, Transducers, ...**6.0275**

DOUBTFUL HYDROGRAPHIC DATA ...Data Analysis - General, Hydrology-general, Satellites, Technique Development, ...**6.0278**

COORDINATION AND LIAISON AT MANNED SPACECRAFT CENTER, HOUSTON ...Aeromagnetic, Geography-physical, Hydrology-general, Infrared Radiation, Ultra - Violet Radiation, ...**6.0146**

AIRBORNE RADIOMETRIC SNOW SURVEY ...Composition, Gamma Radiation, Non-electrical Measurements, Radioisotopes, Snowmelt, ...**7.0071**

BASIC HYDROLOGIC RESEARCH IN SELECTED AREAS IN SOUTH DAKOTA ...Aquifers-general, Geophysical Analysis, Reconnaissance, South Dakota, Water Sources -general, ...**2.0976**

REMOTE SENSING, GULF COASTAL AREA, CENTRAL FLORIDA ...Aquifers-general, Fresh Water, Saline Water Systems, Temperature, Tides, ...**2.0327**

REMOTE SENSING OF DELAWARE ESTUARY ...Delaware, Estuaries, Pollutants-general, ...**2.0909**

Automatic Stations

DEVELOP PROTOTYPE PRECIPITATION OCCURRENCE SENSOR - DEVELOP AMOS III-70 (AUTOMATIC WEATHER STATION) ...Automatic Data Aquisition, Precipitation Instruments, Precipitation-other, Technique Development, ...**7.0053**

TEST AND EVALUATION OF TELEMETERING STORAGE PRECIPITATION GAGE ...Amount, Automatic Data Aquisition, Gages, Technique Development, ...**7.0048**

IMPROVE PRECIPITATION MEASURING EQUIPMENT - D-III PRECIPITATION EQUIPMENT ...Amount, Automatic Data Aquisition, Gages, Technique Development, ...**2.0591**

E M Radiation-general

HYDROLOGY PROGRAM ADMINISTRATION AND SUPPORT ...Aerial, Aircraft, Hydrology-general, Satellites, Water Resources - General, ...**6.0141**

REMOTE ELECTRO-MAGNETIC SENSORS FOR DETECTING TRANSPIRATIONAL WATER USE BY PLANTS SUBJECTED TO VARIOUS FOLIAR CHEMICAL TREATMENTS ...Antitranspirants, Heat Flow, Moisture Tension, Remote Sensing, Transpiration, ...**2.1069**

Gamma Radiation

AIRBORNE RADIOMETRIC SNOW SURVEY ...Aircraft, Composition, Non-electrical Measurements, Radioisotopes, Snowmelt, ...**7.0071**

Infrared Radiation

MARINE OIL-WATER MONITORING INSTRUMENTATION SYSTEM SUBGROUP V ...Detectors, Industrial Waste-other, Infrared, Instrumental Services, Oil, Oil - Technological Testing, ...**5.0336**

HYDROLOGIC ANALYSIS OF LAKE SYSTEMS AND OF GLACIERS ...Climate, Glaciology-general, Lakes, Snowpack, Water Balance-budget, ...**6.0142**

ESTUARIES AND SHORE STUDIES AND WATER SURFACE INVESTIGATIONS ...Continental Shelf, Effluents-waste Water, Evaporation, Shoreline - Coastline, Thermal Pollution, Visible Light, ...**6.0143**

SURFACE TEMPERATURE STUDIES USING RADIOMETRY TECHNIQUES ...Aircraft, Heat and Radiation Transfer, Microwave Radiation, Surface Environments, Temperature, ...**6.0270**

COORDINATION AND LIAISON AT MANNED SPACECRAFT CENTER, HOUSTON ...Aeromagnetic, Aircraft, Geography-physical, Hydrology-general, Ultra - Violet Radiation, ...**6.0146**

INFRARED IMAGER STUDIES ...Detectors, Geophysical Equipment, Image Amp, Instrumental Services, Mineralogy, ...**6.0299**

HYDROLOGICAL DATA ACQUISITION THROUGH REMOTE RECONNAISSANCE SYSTEMS ...Aerial, Data Acquisition-other, Hydrology-general, Mapping, Moisture Content, Reflectance, ...**7.0075**

USE OF INFRARED AND OTHER RADIATION TECHNIQUES TO EVALUATE DROUGHT IN IOWA AND ADJACENT AREAS ...Drought, Iowa, Photography-other, Spectral Reflectance, ...**2.0483**

MEASUREMENT OF WATER VAPOR FLUX ABOVE A LAKE SURFACE BY MEANS OF OPTICAL TECHNIQUES ...Absorption Spectra, Humidity Instruments, Infrared, Optical Systems, Water, ...**2.0811**

AERIAL MEASUREMENT OF HYDROLOGIC PHENOMENA ...Aerial, Data Acquisition-general, Geophysical Analysis, Humidity Instruments, Hydrology-general, ...**7.0003**

Lasers-masers

WATER QUALITY, STUDIES AND AERIAL MEASUREMENTS ...Aircraft, Biological-general, Chemical-general, Pollutants-general, Remote Sensing-general, ...**6.0145**

THEORETICAL AND EXPERIMENTAL STUDIES OF TURBULENCE AND MIXING NEAR ROUGH SURFACES ...Fluid Mixing, Meters, Turbulent, ...**3.0459**

WAVE RECORDING AND ANALYSIS ...Pressure, Radar, Sonar, Statistics-general, System Development, Water Motion Recorders, Waves, ...**2.0262**

Microwave Radiation

SURFACE TEMPERATURE STUDIES USING RADIOMETRY TECHNIQUES ...Aircraft, Heat and Radiation Transfer, Infrared Radiation, Surface Environments, Temperature, ...**6.0270**

Radar

OCEANOGRAPHIC USES OF RADAR ...Aircraft, Electronics - Applied, Surface Environments, Waves, Wind-water Interaction, ...**6.0273**

RADAR DATA ACQUISITION OVER OCEANOGRAPHIC TEST SITES ...Data Acquisition Systems, Electronics - Applied, Icebergs, Optical, Surface Environments, Waves, ...**6.0274**

STUDIES ON THE GEOSCIENCE VALUE OF RADAR IMAGERY ...Bibliography, Mapping, Mountains-alpine, Photogrammetry, River Basins, ...**8.0199**

WAVE RECORDING AND ANALYSIS ...Lasers-masers, Pressure, Sonar, Statistics-general, System Development, Water Motion Recorders, Waves, ...**2.0262**

Remote Sensing -other

REMOTE SENSING OF ESTUARINE WATER AND VEGETATION, MARYLAND ...Aerial, Bioindicators, Chemical-general, Estuaries, Physical-general, ...**2.0268**

INVESTIGATION EVALUATION AND DESIGN OF OPEN AND CLOSED CONDUIT SYSTEMS AS IT RELATES CONVEYANCE AND DISTRIBUTION SYSTEMS ...Conduit, Hydraulic Equipment, Irrigation Engineering, Irrigation-general, Water Distribution Systems, Water Transfer, ...**8.0169**

Remote Sensing-general

WATER QUALITY, STUDIES AND AERIAL MEASUREMENTS ...Aircraft, Biological-general, Chemical-general, Lasers-masers, Pollutants-general, ...**6.0145**

WATER EXPLORATION AND MAPPING ...Geological Exploration, Mapping, Water Resources Development, ...**6.0144**

URBAN AND METROPOLITAN STUDIES ...Aerial, Geography-physical, Planning, Urban, Urban Environments, ...**6.0139**

Satellites

GEOTHERMAL INVESTIGATIONS - YELLOWSTONE PARK ...Gravity Surveys, Hot Springs, Magnetic Surveys, Seismic Surveys, Terrain Analysis, Yellowstone Plateau, ...**6.0147**

HYDROLOGY PROGRAM ADMINISTRATION AND SUPPORT ...Aerial, Aircraft, E M Radiation-general, Hydrology-general, Water Resources - General, ...**6.0141**

OIL SLICK ANALYSES ...Aircraft, Instrumental Services, Oil, Optical Devices, Transducers, ...**6.0275**

DEPTH CONTOURING BY COLOR SEPARATION ...Bathymetry, Electronics - Applied, Marine Photography-television, Optical, Photogrammetry, ...**6.0276**

SATELLITE SEA ICE STUDIES ...Arctic, Sea Ice, ...**6.0277**

CARTOGRAPHIC MAPPING ...Aerial, Aerospatial, Compilation, Resource Inventories, Topographic, ...**6.0140**

DOUBTFUL HYDROGRAPHIC DATA ...Aircraft, Data Analysis - General, Hydrology-general, Technique Development, ...**6.0278**

COORDINATION OF ESTUARINE REMOTE SENSING IN ATLANTIC COAST REGION ...Aerial, Atlantic Ocean-general, Estuaries, ...**2.0910**

Spectral Reflectance

USE OF INFRARED AND OTHER RADIATION TECHNIQUES TO EVALUATE DROUGHT IN IOWA AND ADJACENT AREAS ...Drought, Infrared Radiation, Iowa, Photography-other, ...**2.0483**

SPECTRAL RECONNAISSANCE FOR DIAGNOSIS OF SOIL AND WATER MANAGEMENT PROBLEMS ...Field, Management, Reflectance, Remote Sensing, Soil Management -nonspecific, Soil-water-plant Relationships, ...**3.0465**

Ultra - Violet Radiation

COORDINATION AND LIAISON AT MANNED SPACECRAFT CENTER, HOUSTON ...Aeromagnetic, Aircraft, Geography-physical, Hydrology-general, Infrared Radiation, ...**6.0146**

Ultrasonics

RESEARCH IN SEDIMENT SAMPLING EQUIPMENT ...Bed Load, Bottom Sampling, Instrumentation-general, Suspension, Turbidity, ...**7.0059**

Visible Light

ESTUARIES AND SHORE STUDIES AND WATER SURFACE INVESTIGATIONS ...Continental Shelf, Effluents-waste Water, Evaporation, Infrared Radiation, Shoreline - Coastline, Thermal Pollution, ...**6.0143**

REMOTE SENSING, EVERGLADES AREA, FLORIDA ...Computers-general, Florida, Remote Areas, Swamps-marshes, Water Properties-general, ...**2.0329**

Reproduction

Gametes

Male Gametes

BIOCHEMISTRY OF FISH SEMEN ...Cutthroat Trout, Endrin, Fertility, Mode of Action -animal, ...**5.0627**

EFFECTS OF ENDRIN & MALATHION ON GONADAL HYDRATION RESPONSE OF MALE GOLDFISH & RAINBOW TROUT. PESTICIDE EFFECTS ON FISH ENDOCRINE FUNCTION ...Endrin, Goldfish, Malathion, Mode of Action -animal, Pesticides, Rainbow Trout, Steelhead Trout, ...**5.0634**

Oviparous Reproduction

Incubation

EFFECT OF INCUBATION TEMPERATURE ON SURVIVAL OF LARGEMOUTH BASS EMBRYOS ...Basic Embryology, Environmental Physiology, Largemouth Bass, Temperature, Warm Water, ...**6.0387**

STATEWIDE FISHERIES RESEARCH ...Basses -sea,white, White Perch, Environmental Physiology, Low Temp. -but Above 32f, Maturity & Growth Stages, Temperature, ...**5.0818**

Reproduction Studies (general)

RELATIONSHIPS BETWEEN SUB-LETHAL PESTICIDES AND REPRODUCTION AND BEHAVIOR OF FISHES ...Behavior - animal, DDT , Killifishs - Cyprinodon, Pesticides -non-specific, Wildlife, ...**5.0292**

OBSERVATIONS ON RED SALMON IN THE KVICHAK RIVER SYSTEM ...Alaska, Aquatic Ecology, Population Dynamics, Salmon -coho,chinook,sockeye..., Streams, ...**6.0628**

FLATHEAD CATFISH STUDY ...Aquatic Ecology, Behavior - animal, Food Supply, Growth Rate, Ictaluridae -other, Texas, ...**6.0539**

DDT RESIDUE ACCUMULATION IN WISCONSIN FISH AND THE EFFECT ON REPRODUCTION ...DDT , Maturity & Growth Stages, Walleyes, Wildlife, Wisconsin, ...**5.1292**

SPOTTED BASS REPRODUCTION IN BULL SHOALS ...Arkansas, Biological Rhythms, Centrarchidae -other, Environmental Ecology, Reservoirs and Impoundments, ...**6.0023**

EFFECTS OF CHRONIC EXPOSURE TO SUBLETHAL LEVELS OF INSECTICIDES ON REPRODUCTION IN BROOK TROUT. CHRONIC TOXICITY OF PESTICIDES TO FISH ...Carbamates -non-specific, Chlorinated Hydrocarbons, Lake Trout, Brook Trout, Organophosphorous Cpds. , Pollution - Effects of , Wildlife, ...**5.0654**

Reproductive System Female

Ovary

SPAWNING OF YELLOW PERCH ...Biological Rhythms, Reservoirs and Impoundments, South Dakota, Spawn Or Nesting Sites, Yellow Perch, Darters, ...**6.0521**

Reproductive System

COLUMBIA RIVER STUDIES ...Columbia River, Contamination - Water, Invertebrates, Oysters, Pollution Effects, Radioactivity-general, ...**5.1268**

ECOLOGICAL FACTORS AFFECTING REPRODUCTION OF SHELLFISH (PHYSIOECOLOGY OF SHELLFISH PROGRAM) ...Connecticut, Environmental Ecology, Oysters, Spawn Or Nesting Sites, Water Properties-general, ...**6.0114**

Other

SOME EFFECTS OF WATER IMPOUNDMENTS ON WATERFOWL POPULATIONS AND REPRODUCTION ON THE SNAKE RIVER, WASHINGTON ...Pre-impoundment Sites, Reservoirs and Impoundments, Snake River, Washington, Water Utilization -animal, ...**6.0609**

Research Facilities

SUMMER RESEARCH AT THE UNIVERSITY OF OKLAHOMA BIOLOGICAL STATION ...Oklahoma, Personnel, Training Grants, Fellowships, Water Resources - General, ...**9.0011**

LOGISTIC SUPPORT AND MAINTENANCE OF FACILITIES ...Atlantic Ocean-north, Lakes, Maine, Marine Biology, ...**9.0009**

CONTINUATION OF WORLD DATA CENTER A - GLACIOLOGY ...Data & Statistics Info Storage, Data and Statistics Centers, Document & Literature Info, Glaciology-general, Periodicals, ...**7.0083**

PREPARE AN OPERATIONAL PLAN, CONCEPTUAL DESIGN AND PLANS AND SPECIFICATIONS FOR A SEAWATER CORROSION TEST FACILITY ...Construction-general, Desalination, Manufacturing, Test Methods, Water, ...**3.0297**

DRAINAGE FARM SERVICE ...Agriculture Industry, Drainage Engineering, Land Use, Utah, ...**4.0254**

CONTINUATION OF FIELD EXPOSURE STATIONS ...Cement, Concrete, Florida, Maine, Water, Weathering, ...**8.0241**

Reservoirs and Impoundments

RECREATIONAL IMPACT OF FEDERAL MULTI-PURPOSE RESERVOIRS ...Highway Classification-other, Planning, Projected Demand, Recreation Sites, Reservoirs, Touring, Transportation Needs, ...**6.0219**

ZOOPLANKTON NUTRITION IN LARGE RESERVOIRS ...Nutrition - Invertebrate, Population Dynamics, Productivity - Food Chain, Water Bacteria, Zooplankton, ...**2.0515**

PHREATOPHYTE CONTROL - LAHONTAN AND HUMBOLDT BASINS ...Phenology, Phreatophytes, Root, Saltcedar, Tamarisk, Weed Control -other, ...**3.0317**

SEASONAL VARIATIONS IN THE PHYTOPLANKTON - BACTERIA POPULATIONS AND THE NUTRIENT CONCENTRATION IN BEAVER RESERVOIR ...Nitrogen, Phosphorus, Phytoplankton, Temporal Distribution, Water Bacteria, ...**6.0027**

DISTRIBUTION AND GROWTH PATTERNS OF THE GIZZARD SHAD (DOROSOMA CEPEDIANU) AND THREADFIN SHAD (DOROSOMA PETENENSE) IN RESERVOIRS ...Alewife,menhaden,shad,herring, Arkansas, Growth Rate, Number Or Density, Temporal Distribution, ...**6.0029**

THE FEASIBILITY OF COLD WATER FISHES FOR LAKE SHARPE, SOUTH DAKOTA ...Bottom Sampling, Fish -non-specific, Low Temp. -but Above 32f, South Dakota, Temperature, ...**7.0041**

COLONIZATION RATES OF BENTHIC INVERTEBRATES IN AN OHIO RESERVOIR ...Benthic Fauna, Intertidal Areas, Ohio, Productivity - Food Chain, Water Level Fluctuation, ...**6.0424**

INVESTIGATE THE FEASIBILITY OF INTRODUCING SOCKEYE SALMON INTO RESERVOIRS ...Oregon, Salmon - coho,chinook,sockeye..., Stocking of Fish & Shellfish, ...**6.0464**

A STUDY OF THE BENTHIC FAUNA OF MERLE COLLINS RESERVOIR (VIRGINIA RANCH RESERVOIR) ...California, Food Supply, Number Or Density, Productivity - Food Chain, ...**6.0071**

ECOLOGY OF THE FISHES OF THE KASKASKIA RIVER ...Fish -non-specific, Habitat Studies, Life History Studies, Population Dynamics, Streams, ...**4.0094**

DETERMINE ECOLOGICAL CHANGES RESULTING FROM IMPOUNDMENT ...Cover Crops, Flooding, Freshwater Ecology, Mapping, Plant Succession, Water Level Fluctuation, ...**6.0355**

WEED AND ALGAE CONTROL, SMALL IMPOUNDMENT INVESTIGATIONS ...Georgia, of Aquatic Plants, Plant Pollutants, Soil Sterilants, ...**5.0304**

EVALUATION OF CLEARED SEINING AREAS ...Land Use, Nets, Pre-impoundment Sites, Texas, ...**6.0540**

STABILIZATION STUDY OF FALCON RESERVOIR ...Biological-general, Chemical-general, Fish -non-specific, Physical-general, Population Dynamics, ...**4.0229**

FISH POPULATION STUDIES. (DEWEY RESERVOIR) ...Alewife,menhaden,shad,herring, Aquatic Ecology, Fertilizers - aquatic, Kentucky, Population Dynamics, ...**5.0437**

ASSESSMENT OF ENVIRONMENT FACTORS INFLUENCING THE DISTRIBUTION OF BOTTOM FISHES IN RESERVOIRS ...Nets, Oklahoma, Organic, Physical Properties-general, Turbidity & Suspended Matter, ...**5.0924**

LIFE HISTORY OF THE GOLDEYE (HIODON ALOSOIDES) IN GARRISON RESERVOIR NORTH DAKOTA ...Biological Rhythms, Life History Studies, Nets, North Dakota, Spawn Or Nesting Sites, ...**5.0827**

THE RELATIONSHIP BETWEEN TURBIDITY CURRENTS AND FISH MOVEMENTS IN GARRISON RESERVOIR ...Currents - water, Nets, North Dakota, Turbidity, Turbidity & Suspended Matter, ...**5.0829**

SMALL RESERVOIR SEALING ...Linings-pavings, Sealant Materials, Seepage, ...**8.0288**

EFFECTS OF HEATED WATER, ACID MINE DRAINAGE & ALKALINE ASH DRAINAGE ON WATER QUALITY & RESERVOIR COMMUNITY METABOLISM (ABBREV) ...Mine Drainage Control, Mining Activities, Pollution - Effects of , Pollution Effects, Thermal Pollution, ...**5.0668**

THE ECONOMIC IMPACT OF FLOOD CONTROL RESERVOIRS ...Benefit-cost Analysis, Economic Impact, Floodproofing, Kentucky, Project Post-evaluation, ...**6.0241**

SOME EFFECTS OF WATER IMPOUNDMENTS ON WATERFOWL POPULATIONS AND REPRODUCTION ON THE SNAKE RIVER, WASHINGTON ...Other, Pre-impoundment Sites, Snake River, Washington, Water Utilization -animal, ...**6.0609**

IMPACT OF WATER BASED RECREATION ...Benefit-cost Analysis, Lakes, New York, Planning, Recreation Sites, ...**6.0384**

PHOSPHORUS BUDGETS OF LAKES SIDNEY, LANIER AND HARTWELL ...Chemical-general, Georgia, Nutrients, Phosphorus, Pollutants - Path of , ...**5.0293**

ECOLOGICAL RELATIONSHIPS OF ORGANIC MATTER AND BACTERIA IN TUTTLE CREEK RESERVOIR ...Food Chains, Freshwater Ecology, Kansas, Organic Matter, Water Bacteria, ...**5.0428**

MANIPULATION OF RESERVOIR WATER FOR IMPROVED QUALITY AND FISH POPULATION RESPONSE ...Environmental Ecology, Eutrophication, Fish -non-specific, Flow Augmentation, Freshwater Ecology, Population Dynamics, ...**5.1294**

LIMNOLOGICAL STUDIES OF LENTIC WATERS IN IDAHO ...Alpine, Idaho, Lakes, Phytoplankton, Primary Productivity, Productivity i Food Chain, ...2.0398

BOUNDARY EFFECTS ON JET FLOW PATTERNS RELATED TO WATER QUALITY AND POLLUTION PROBLEMS ...Flow Characteristics -water, Jet Flow-other, Velocity, Velocity -water, Water Quality Control-general, ...8.0180

EFFECTS OF WATER DIVERSION ON BIOTA AND WATER QUALITY IN THE STATE OF ARKANSAS ...Environmental Ecology, Fish -non-specific, Population Dynamics, Temperature, Water Quality-general, ...6.0030

IMPOUNDMENT EFFECTS ON WATER QUALITY AS REFLECTED IN PARASITISM OF RESERVOIR BASSES ...Copepods, Pathology, Pre-impoundment Sites, Water Level Fluctuation, Water Quality-general, ...6.0024

THE DISTRIBUTION OF TRACE ELEMENTS IN IMPOUNDMENTS ...Arkansas, Electric Power Plants, Trace Elements, Water Quality Control-general, Water Sampling, ...2.0068

INTERNAL CURRENTS RESULTING FROM INTERMEDIATE DENSITY INFLOWS INTO STRATIFIED RESERVOIRS ...Inflow, Model Studies, Stratification, Stratified Flow, Temperature, ...5.1264

ECONOMIC IMPACT OF WATER IMPOUNDMENT - VALIDITY TESTING OF A COMPARATIVE- PROJECTION MODEL ...Economic Impact, Model Studies, Projections and Estimations, Recreation Sites, Texas, ...6.0554

LIMNOLOGICAL INVESTIGATIONS OF TEXAS IMPOUNDMENTS FOR WATER QUALITY MANAGEMENT PURPOSES ...Chemical-general, Management, Nutrients, Texas, Water Quality Control-general, ...5.1148

PRIMARY PRODUCTIVITY, AND STANDING CROPS IN RELATION TO WATER QUALITY IN LAKE ASHTABULA RESERVOIR, NORTH DAKOTA ...North Dakota, Phytoplankton, Productivity - Food Chain, Water Quality-general, Zooplankton, ...6.0414

A THREE DIMENSIONAL STUDY OF PARAMETERS RELATED TO THE CURRENT DISTRIBUTION IN LAKE ROOSEVELT ...Currents -water, Model Studies, Stratification, Temperature, Water Quality-general, ...5.1245

WATER RESERVOIR SYSTEMS ...Drainage, Runoff, Sewerage Systems-other, Storage of Water, Storm Water, Urban Environments, ...4.0031

THE IMPACT OF IMPOSING A WATER QUALITY STANDARD ON A LIVE STREAM ...Flow Augmentation, Low Flow, Multiple-purpose Projects, Pollution Abatement, Water Standards, ...6.0494

DYNAMICS OF CHEMICAL & PHYSICAL CHARACT OF WATER, BOTTOM MUDS & AQUATIC LIFE IN A LARGE IMPOUNDMENT ON A RIVER %PHASE II..Alabama, Aquatic Soils, Chemical-general, Physical-general, Pollution - Effects of , Pollution Effects, ...5.0008

BIOLOGICAL FIXATION AND TRANSFORMATION OF NITROGEN IN SMALL IMPOUNDMENTS ...Ions and Gases, Nitrogen, Nitrogen Fixation, Radioisotopes, ...2.0881

WATER TEMPERATURE AS A QUALITY FACTOR IN THE USE OF STREAMS AND RESERVOI ...Habitat Studies, Streams, Temperature, Thermal Pollution, Water Fowl, N.s. , ...5.0200

BEHAVIOR OF WATER IN AN SOUTHWEST IMPOUNDMENT - LAKE THUNDERBIRD ...Chemical-general, Climatography, Land Use, Physical-general, Water Quality-general, ...5.0918

A EUTROPHICATION MODEL OF THE WHITE RIVER BASIN ABOVE BEAVER RESERVOIR IN NORTHWEST ARKANSAS ...Arkansas, Eutrophication, Forecasting-prediction, Nutrients, Simulation, ...5.0053

INVESTIGATION OF THE INFLUENCE OF VALENCE STATES OF IRON AND MANGANESE UPON THE BIOTA OF THE HYPOLIMNION ...Biological-general, Chemical-general, Electron Spin, Ions and Gases, Model Studies, ...5.0298

THE OPTIMUM RELEASE POLICY FOR A MULTIPURPOSE RESERVOIR USING STOCHASTIC HYDROLOGY ...Flow Augmentation, Multiple-purpose Projects, Stochastic Models, Stochastic Processes, Synthetic Hydrology-general, ...6.0337

WATERSHED RESPONSE TO HYDROLOGIC INFLUENCES ...Evaporation, Massachusetts, Prediction Models, Stratification, ...2.0608

A PRELIMINARY ECOLOGICAL STUDY OF AREAS TO BE IMPOUNDED IN THE SALT RIVER BASIN OF KENTUCKY ...Economic Impact, Floodproofing, Kentucky, Social Aspects, Urban Environments, ...6.0244

RELATIONSHIP BETWEEN THE ERODIBILITY OF SOILS AND THE SEDIMENTATION RATE OF RESERVOIRS ...Erosion-general, Physical Properties-general, Rate of Deposition, Sediment Yield, Soil Erosion -non-specific, ...2.0463

RELATION OF FLOODPLAIN POOLS TO THE BIOLOGICAL PRODUCTION OF THE KASKASKIA RIVER AND ITS MAINSTEM RESERVOIRS ...Food Supply, Habitat Studies, Illinois, Productivity - Food Chain, Streams, ...2.0411

RECHARGE IN RIVER VALLEYS OF CENTRAL AND EASTERN KANSAS - EFFECT OF TUTTLE CREEK RESERVOIR ON GROUNDWATER LEVELS ...Aquifers-general, Chemical-general, Geophysical Analysis, Natural Recharge, Water Table Fluctuation, ...2.0509

INCREASING WATER SUPPLIES BY SUPPRESSION OF RESERVIOR EVAPORATION ...Evaporation, Membranes-other, Monolayers, Organic, Water Loss Control, ...3.0397

AN ECONOMIC EVALUATION OF THE TOLEDO BEND RESERVOIR PROJECT ...Benefit-cost Analysis, Louisiana, Multiple-purpose Projects, Policy Making, Texas, Water Law-general, Welfare Economics, ...6.0246

THE IMPACT OF RESERVOIRS ON LAND VALUES - A CASE STUDY ...Economic Impact, Land, Price & Value, ...6.0313

SELECTIVE WITHDRAWAL AT LAKE LIVINGSTON ...Flow Augmentation, Management, Stratification, Water Properties-general, ...2.1009

FLUCTUATION OF RESERVOIR LEVELS AND THE RELATED CAUSE OF LANDSLIDES (THE OHIO RIVER VALLEY) ...Force, Land and Rock Slides, Slopes, Soil Stability Analysis, Water Level Fluctuation, ...8.0191

EFFECTS OF LIMNOLOGICAL FACTORS ON WATER TREATMENT ...Iowa, Other, Public Utilities, Reservoirs, Water Quality-general, ...5.0415

LIMNOLOGICAL FACTORS AFFECTING PESTICIDE RESIDUES IN SURFACE WATERS ...Chlorinated Hydrocarbons, Iowa, Persistance of Residues, Phytoplankton, Runoff, Surface Water, ...5.0416

THE EVALUATION OF ENVIRONMENTAL ALTERATION BY THERMAL LOADING AND ACID POLLUTION IN THE COOLING RESERVOIR OF A STEAM-ELECTRIC STATION ...Acidity, Growth Rate, Mining Activities, Thermal Pollution, Warm Water, ...5.0681

SOCIAL CHANGE IN A WATER RESOURCE DEVELOPMENT AREA - SOCIAL ASPECTS OF THE CONSTRUCTION PHASE OF LIBBY DAM ...Attitudes & Attitude Change, Construction Sites, Recreation Sites, Social Aspects, Social Change, User Patterns, ...6.0329

MODELING AND OPTIMIZATION OF WATER RESOURCES SYSTEMS ...Management, Mathematical Analysis, Model Studies, Multiple-purpose Projects, Optimization, ...6.0234

SOCIO-CULTURAL IMPACTS OF WATER RESOURCE DEVELOPMENT IN THE SANTIAM ...Attitudes & Attitude Change, Economic Impact, Oregon, Social Aspects, Water Resources Development, ...6.0457

RESERVOIR WATER QUALITY PREDICTION BASED ON LIMNOLOGICAL PARAMETERS ...Model Studies, Nutrients, Primary Productivity, Water Properties-general, ...5.1102

WATER QUALITY MANAGEMENT OF IMPOUNDMENTS ...Destratification, Eutrophication, Management, North Carolina, Water Quality Control-general, ...5.0813

ECONOMIC EVALUATION OF CHANGES IN LAND USE OF A MUNICIPAL WATERSHED AS A GUIDE TO DECISION-MAKING ...Discharge-general, Land Use, North Carolina, Urban Environments, Water Costs, ...6.0408

MULTIPURPOSE RESERVOIRS AND URBAN DEVELOPMENT ...Land Use, Model Studies, Urban Environments, ...2.0823

SOCIOLOGICAL IMPACT OF A FLOOD-CONTROL RESERVOIR ...Attitudes & Attitude Change, Floodproofing, Social Aspects, Social Change, ...6.0476

MIXING AND DISPERSION OF CONTAMINANTS IN RESERVOIRS ...Currents -water, Dispersion -water, Mixing, Tracers-general, Velocity -water, ...5.1153

LIMNOLOGY OF THE JOHN REDMOND RESERVOIR ...Chemical-general, Physical-general, Streams, ...5.0419

WATER RIGHTS RELATED TO WATER QUALITY STORAGE ...Alternative Planning, Conflicts, Flow Augmentation, Riparian Rights, Storage of Water, ...6.0606

USE OF NEW ANALYTICAL METHODS FOR WATER RESOURCES DEVELOPMENT ...Mathematical Analysis, Optimization, Optimization Technique, Planning, Water Resources Development, ...6.0545

THERMAL STRATIFICATION IN RESERVOIRS ...Forecasting-prediction, Mathematical Analysis, Model Studies, Stratification, Temperature, ...2.0616

COMPLEMENTARY - COMPETITIVE ASPECTS OF WATER STORAGE ...Benefitscost Analysis, Computers-general, Model Studies, Storage of Water, Water - Alternative Uses, ...5.0144

OCCURRENCE OF PESTICIDES IN AQUATIC ENVIRONMENTS ...Aquatic Or Soil-aquatic Cycles, Food Chains, Animal And/or Man, Irrigation-general, Runoff, ...5.1237

FIELD EVALUATION OF REAERATING SURFACE WATERS ...Aeration, Florida, ...5.0267

FORMULATION OF A GENERAL MATHEMATICAL MODEL FOR THE PREDICTION OF THERMAL ENERGY CHANGES IN IMPOUNDMENTS ...Columbia River, Forecasting-prediction, Mathematical Analysis, Model Studies, Thermal Pollution, ...5.0163

AN ECONOMIC STUDY OF THE DEMAND FOR OUTDOOR RECREATION ...Arid and Desert, Methods, Projected Demand, Recreation Sites, Standards, ...6.0014

THE PERSISTENCE, ACCUMULATION AND FATE OF PESTICIDES IN CRANBERRY SOILS AND RESERVOIRS ...Blueberries, Cranberries, Chlorinated Hydrocarbons, Organophosphorous Cpds. , Persistence in Soils, Swamps-marshes, ...5.0533

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INTERAGENCY FRAIL LANDS STUDY - MONTANA IV. WATER QUANTITY MANAGEMENT ...Conservation, Erosion-general, Montana, Slopes, Soil Erosion -non-specific, ...**4.0161**

CORRELATION OF SOIL SURFACE AND RAINFALL-RUNOFF-*MOISTURE RELATIONSHIPS ON AGRICULTURAL* WATERSHEDS ON COASTAL PLAINS SOILS (ABBREV) ...Antecedent Moisture, Recharge -general, Small Watersheds, Soil Environment, Water Yield, ...**2.0002**

RUNOFF STUDIES ON SMALL WATERSHEDS ...Hydrographs, Small Watersheds, Subsurface Flow, Surface Water, Water Yield, ...**2.1138**

HYDROLOGY OF SUBURAN AREAS ...Amount, Conservation-general, Land, New Jersey, Surburban Areas, ...**4.0173**

TRACING STORM AND BASE FLOW TO VARIABLE SOURCE AREAS ON FORESTED HEADWATERS ...Baseflow, Floods, Forest Watersheds, Georgia, Hydraulic Structures, Subsurface Flow, ...**2.0339**

REVIEW AND ANALYSIS OF PRECIPITATION AND RUNOFF DATA FOR SELECTED WATERSHEDS IN MINNESOTA ...Floods, Hydrographs, Infiltration, Precipitation-general, Watersheds-general, ...**4.0140**

CHARACTERISTICS OF MAJOR FOREST AND RANGE WATERSHED TYPES IN IDAHO ...Erosion-general, Forest Watersheds, Idaho, Land Use, Water Yield, ...**6.0176**

HYDROLOGY OF FROZEN GROUND FLOODS ...Floods, Hydrographs, Infiltration, Moisture Content, Permafrost-frozen, ...**2.0399**

AVAILABILITY, DISTRIBUTION, QUANTITY AND QUALITY OF WATER RESOURCES IN CARBONATE KARST TERRAIN ...Available Water, Carbonate Aquifers, Groundwater, Karst Topography, Water Balance-budget, Water Quality-general, ...**4.0155**

POLLUTION FROM ANIMAL FEEDLOTS ...Animal Wastes - Feed Lots, Filtration, Rainfall Simulators, Solid Waste, Waste Disposal -underground, ...**4.0118**

CHEMICAL CONTAMINANTS FOUND IN SURFACE AND SUBSURFACE WATER AS RELATED TO SOIL AND CLIMATIC CONDITIONS ...Agricultural Chemicals-general, Hardness-minerals, Pollutants - Path of , Soil and Rock Leaching, Soil Environment, ...**5.0476**

URBAN HYDROLOGIC RELATIONSHIPS ...Drainage, Forecasting-prediction, Hydrographs, Urban Environments, Variation in Time, ...**2.0554**

THE EFFECT OF URBANIZATION ON RUNOFF IN SMALL WATERSHEDS ...Indiana, Land Use, Model Studies, Small Watersheds, Urban Environments, ...**2.0458**

ENGINEERING PHASES OF LAND SHAPING FOR SOIL AND WATER CONSERVATION ...Available Water, Conservation & Management Eng, Nebraska, Soil Environment, Water Loss Control, ...3.0312

STUDY OF FACTORS AFFECTING THE CHANNEL PHASE OF RUNOFF FROM SMALL WATERSHEDS BY MATHEMATICAL MODELING ...Development of Models, Finite Differences, Flow Characteristics -water, Small Watersheds, Streams, ...2.0665

MATHEMATICAL SIMULATION OF HYDROLOGIC EVENTS ON UNGAGED WATERSHEDS ...Digital Computers, Hydrographs, Sensitivity Problems, Testing of Models, Watersheds-general, ...2.0461

HYDROLOGY OF SMALL DRAINAGE BASINS FOR DEVELOPING HYDRAULIC DESIGN ...Amount, Flow Characteristics -water, Hydrographs, Small Watersheds, South Dakota, ...2.0972

MATHEMATICAL SIMULATION OF RAINFALL RUNOFF PROCESSES ...Computers-general, Hydrographs, Model Studies, Optimization, Other Computers, Storms-general, ...2.1015

OPTIMIZING SALVAGEABLE WATER RESOURCES IN A SEMI-ARID INLAND BASIN ...Natural Recharge, Optimization, Semi - Arid, Water - Alternative Uses, Water Quality-general, Water Reuse, ...3.0019

EFFECTS OF AREAL AND TIME DISTRIBUTION OF RUNOFF SUPPLY ON WATERSHED HYDROGRAPHS ...Hydrographs, Mathematical Analysis, Model Studies, Other Model Modif, Watersheds-general, ...2.0666

A STUDY OF SERIAL CORRELATION IN ANNUAL STREAM RUNOFF ...Annual, Correlation, Stochastic Models, Streams, ...2.1132

OPTIMUM LINEAR SYNTHESIS IN URBAN HYDROLOGY ...Error Analysis, Hydrographs, Optimization Technique, Prediction, Urban Environments, ...6.0287

EVALUATION OF HYDROLOGIC EFFECTS OF URBANIZATION ...Hydrology-general, Land Use, Regression Analysis, Small Watersheds, Storm Water, Urban Environments, ...4.0231

WATER RESERVOIR SYSTEMS ...Drainage, Reservoirs and Impoundments, Sewerage Systems-other, Storage of Water, Storm Water, Urban Environments, ...4.0031

STOCHASTIC MODELS FOR WATER RESOURCES MANAGEMENT ...Alternative Planning, Application, Management, Stochastic Models, Streams, ...6.0383

SPATIAL BEHAVIOR OF ROUGHNESS IN LABORATORY WATERSHED, PHASE II ...Energy Loss -water, Model Studies, Roughness, Structure-size, Surface Flow, Synthetic Hydrology-general, ...2.0703

THE DETERMINATION OF ZONES OF INTENSE CONTRIBUTION TO STREAM FLOW AS RELATED TO THE CONCEPT OF PARTIAL AREA CONTRIBUTIONS ...Development of Models, Digital Computers, Model Studies, Synthetic Hydrology-general, Watersheds-general, ...2.0580

DEVELOPMENT AND EVALUATION OF HYDROLOGIC SIMULATION MODELS ...Model Studies, South Carolina, Synthetic Hydrology-general, Technique Development, Watersheds-general, ...2.0954

PARAMETERIZATION OF THE OBSERVED HYDROGRAPH AS A MEANS OF UNDERSTANDING RUNOFF PHENOMENA FROM SMALL WATERSHEDS ...Forecasting-prediction, Hydrographs, Model Studies, Small Watersheds, Vermont, ...2.1085

INVESTIGATION OF A LINEAR MODEL TO DESCRIBE THE HYDROLOGIC PHENOMENON OF DRAINAGE BASINS ...Amount, Hydrographs, Model Studies, Small Watersheds, Testing of Models, ...2.1041

HYDROLOGIC CHARACTERIZATION OF FORESTED WATERSHEDS IN ARIZONA ...Dendrochronology, Forecasting-prediction, Forest Watersheds, Management, Snowpack, Water Yield, ...2.0051

DEVELOPMENT OF A MATHEMATICAL MODEL TO PREDICT THE ROLE OF SURFACE RUNOFF AND GROUND WATER FLOW IN OVERFERTILIZATION OF SURFACE WATERS ...Eutrophication, Mathematical Analysis, Minnesota, Nutrients, Surface Water, ...5.0606

ATMOSPHERIC WATER BALANCE AND THE FORECAST OF ANNUAL RUNOFF FROM THE UPPER COLORADO RIVER BASIN ...Colorado River, Evaporation, Forecasting-predict ion, Water Balance-budget, ...2.0222

PHASE TWO - EXPERIMENTAL INVESTIGATION OF SMALL WATERSHED FLOODS ...Floods, Mathematical Analysis, Model Studies, Rain-general, Small Watersheds, ...2.0233

EVALUATION OF SELECTED COMPUTER PROGRAMS IN HYDROLOGY ...Hydrology-general, Model Studies, Routing, Spillways, Storm Water, ...2.0659

QUALITY OF STORM WATER DRAINAGE FROM URBAN LAND AREAS IN NORTH CAROLINA ...Land Use, North Carolina, Storm Water, Urban Environments, Water Quality-general, ...5.0815

OVERLAND FLOW ANALYSIS FOR A SIMULATED VEGETATED SURFACE ...Flume Studies, Hydrographs, Rainfall Simulators, Streams, Unsteady Flow, ...2.0879

RUNOFF GENERATION AS A FUNCTION OF PRECIPITATION AND WATERSHED CHARACTERISTICS ...Amount, Hydrographs, Washington, Watersheds-general, ...2.1120

COMPUTER SIMULATION OF URBAN HYDROLOGIC SYSTEMS ...Analog Computers, Hydrographs, Texas, Urban Environments, Watersheds-other, ...4.0258

A HYDROMETEOROLOGICAL STUDY RELATED TO THE DISTRIBUTION OF PRECIPITATION AND RUNOFF OVER SMALL DRAINAGE BASINS - URBAN VERSUS RURAL AREAS ...Amount, Patterns, Small Watersheds, Texas, Urban Environments, ...2.1024

PARTIAL AREA CONTRIBUTION TO STREAM FLOW ...Digital Computers, Flow Characteristics -water, Model Studies, Water Yield, Watersheds-general, ...2.0581

LIMNOLOGICAL FACTORS AFFECTING PESTICIDE RESIDUES IN SURFACE WATERS ...Chlorinated Hydrocarbons, Iowa, Persistance of Residues, Phytoplankton, Reservoirs and Impoundments, Surface Water, ...5.0416

A GENERALIZED, PROBABILISTIC APPROACH TO REGIONAL WATER SUPPLY ASSESSMENT ...Available Water, Confidence Intervals, Model Studies, Patterns, Regional Areas, ...6.0059

PRECIPITATION AND RUNOFF DISTRIBUTIONS - ANALYSIS AND COMPARISONS ...Data Analysis - General, Discharge-general, Forecasting-prediction, Other Probability, Patterns, ...2.0739

WATER CONTAMINATION BY FERTILIZER NITROGEN AND PHOSPHORUS ...Agricultural Watersheds, Fertilizers, Nitrogen, North Carolina, Phosphorus, Subsurface Flow, ...5.0823

HYDROLOGIC AND PHOTOGEOLOGIC DETERMINATION OF RAINFALL, RUNOFF, AND GROUNDWATER RELATIONSHIPS IN A DOLOMITE AREA ...Amount, Dolomite, Groundwater, Hydrology-general, Photogrammetry, ...2.0702

EUTROPHICATION OF SURFACE WATERS - LAKE TAHOE ...California, Effluents-waste Water, Eutrophication, Lakes, ...5.0088

EVALUATION OF DISPERSED POLLUTIONAL LOAD ...Combined Sewer, Land Use, Pollutants-general, Pollution Sources-general, Sewage Treatment Plant, ...5.0921

AMMONIA REMOVAL FROM AGRICULTURAL RUNOFF BY SELECTIVE ION EXCHANGE ...Ammonia, Ammonium, Ion Exchange-other, Process Design, Waste Water Treatment-general, Zeolite, ...5.1247

OCCURRENCE OF PESTICIDES IN AQUATIC ENVIRONMENTS ...Aquatic Or Soil-aquatic Cycles, Food Chains, Animal And/or Man, Irrigation-general, Reservoirs and Impoundments, ...5.1237

ROLE OF ANIMAL WASTES IN AGRICULTURAL LAND RUNOFF ...Agricultural Watersheds, Animal Wastes - Feed Lots, Small Watersheds, ...5.0822

EFFECT OF RANGE MANAGEMENT ON INFILTRATION, RUNOFF, AND EROSION ...Cover Crops, Infiltration, Management and Fertility, ...2.0105

SOIL-WATER-VEGETATION RELATIONS IN THE DOUGLAS FIR ZONE ...Flow Characteristics -water, Forest Watersheds, Moisture Content, Patterns, Water Balance-budget, Water Cycle, ...3.0027

FACTORS AFFECTING WATER YIELDS FROM SMALL WATERSHEDS IN GEORGIA ...Baseflow, Georgia, Small Watersheds, Statistics-general, Water Yield, ...4.0083

THE INTERRELATIONSHIP BETWEEN WATERSHED FACTORS THAT AFFECT RUNOFF RATES AND VOLUME YIELDS IN THE SOUTHERN COASTAL PLAINS ...Agricultural Watersheds, Georgia, Hydrology-general, Morphology-general, Water Yield, ...3.0193

RUNOFF FROM SMALL AGRICULTURAL AREAS IN ILLINOIS ...Agricultural Watersheds, Conservation, Conservation & Management Eng, Illinois, ...3.0220

RUNOFF OF SMALL WATERSHEDS ...Agricultural Watersheds, Gaging, General Synoptic Observations, Moisture Retention, Soil Types-general, ...2.0531

THE USE OF NUCLEAR METHODS FOR DETERMINING FOREST SOIL SITE INDEX ...Geophysical Analysis, Site Index and Site Quality, Soil Depth, Soil Morphology, Profiles, Soil Profile, ...3.0249

EFFECTS OF COARSE SKELETON ON PHYSICAL PROPERTIES OF SOIL ...Maine, Physical Properties-general, Potatoes, Soil Compaction Or Density, ...2.0553

THE MOVEMENT OF HERBICIDES OFF, INTO, AND THROUGH SOILS ...Agricultural Watersheds, Herbicides -non-specific, Movement, Leaching, Persistance of Residues, Soil Sampling, ...5.0487

SMALL AGRICULTURAL WATERSHED HYDROLOGY ...Agricultural Watersheds, Floods, Gages, Patterns, Sediment Yield, ...4.0138

HYDROLOGIC CHARACTERIZATION OF SMALL WATERSHEDS ...Cold - Climates, Mathematical Analysis, Model Studies, Peak Flow, Small Watersheds, ...4.0143

SMALL WATERSHED YIELDS ...Amount, Aquifers-general, Land Use, Small Watersheds, Water Yield, ...4.0149

FERTILITY RUNOFF ...Erosion-general, Irrigation, Tillage, Cropping Systems, ...4.0154

HYDROLOGY OF SMALL AGRICULTURAL WATERSHEDS ...Hydrology-general, Missouri, Reservoirs and Impoundments, Small Watersheds, Water Loss-general, ...4.0151

ISOTOPES IN THE BIOSPHERE ...Erosion-general, Management, Pollutants - Path of , Radioactive Fallout, Strontium, Washout, ...5.0670

LAND SHAPING FOR WATER CONSERVATION ...Floods, Land Use, Moisture Content, Natural Recharge, Production & Processing, Water Harvesting, ...3.0311

EVALUATION OF EXTENSIVE IRRIGATION ...Automated Equipment, Economic Efficiency, Irrigation Engineering, Sprinkler Irrigation, Tillage, Cropping Systems, ...3.0381

IRRIGATION WATER USE EVALUATION ...Border Irrigation, Furrow Irrigation, Irrigation Engineering, Management, Water Table Fluctuation, ...3.0383

HYDROLOGIC CHARACTERIZATION OF SMALL WATERSHEDS ...Hydrology-general, Mathematical Analysis, Model Studies, Small Watersheds, Stochastic Models, ...4.0197

DEVELOPMENT OF TILLAGE-REPLACING HERBICIDE SYSTEMS ...Contamination, Pollution-water, Pesticides, Tillage, Cropping Systems, ...5.0884

FACTORS AFFECTING WATER YIELDS FROM SMALL WATERSHEDS IN TENNESSEE ...Conservation & Management Eng, Instrumentation-general, Small Watersheds, Soil Conditions, Water Harvesting, Water Yield, ...4.0225

DEVELOPMENT OF A CHEMICAL FALLOW SYSTEM OF FARMING ...Great Plains Province, Herbicides -non-specific, Moisture Retention, Rotations, Tillage, Cropping Systems, ...4.0236

WATER YIELDS FROM SMALL WATERSHEDS ...Climate, Shape, Small Watersheds, Virginia, Water Yield, ...4.0265

HYDROLOGY OF WATERSHEDS ON SHALE SOILS ...Fine-grained Clastics, Hydrology-general, Moisture Content, Moisture Tension, Small Watersheds, Soil Properties - Other, ...4.0273

FACTORS AFFECTING WATER YIELDS FROM SMALL WATERSHEDS AND SHALLOW GROUND AQUIFERS ...Amount, Applied Climatology, Aquifers-general, Small Watersheds, Soil Types-general, Water Yield, ...4.0207

RUNOFF INDUCEMENT IN ARID LANDS ...Arid and Desert, Infiltration, Linings-pavings, Stabilization-general, Storage of Water, Synthetic Hydrology-general, ...3.0238

MODEL STUDY OF SEWER DROPSHAFT ...Conduit, Design-other, Discharge-general, Flow Regulations, Two-phase-other, ...8.0218

TREATING AN INADEQUACY OF THE UNIT HYDROGRAPH HYPOTHESIS BY STORAGE ROUTING WITH VARIABLE EMPIRICAL VALUES OF LAG AND STORAGE ...Amount, Arizona, Hydrographs, Model Studies, Storage of Water, ...2.0063

SYSTEM ANALYSIS OF RAINFALL-RUNOFF RELATIONSHIP ...Amount, Digital Computers, Digital Computers, Ordinary, Systems Analysis, ...2.0427

STOCHASTIC ANALYSIS OF RAINFALL-RUNOFF RELATIONSHIP ...Amount, Mathematical Analysis, North Carolina, Stochastic Processes, ...2.0428

STUDY OF THE HYDROLOGY FOR MODELS OF THE GREAT LAKES ...Evaporation, Great Lakes-general, Management, Precipitation-general, Systems Analysis, ...2.0435

FACTORS AFFECTING WATER YIELDS FROM SMALL WATERSHEDS AND SHALLOW GROUND AQUIFERS ...Atlases-maps, Moisture Content, Patterns, Puerto Rico, Water Yield, ...4.0208

REGIONAL CORRELATIONS IN HYDROLOGIC VARIABLES ...Annual, Correlation, Data Analysis - General, Evaporation, Patterns, ...7.0097

NITROGEN TRANSFORMATIONS IN SOIL ...Agricultural Watersheds, Fertilizers, Nitrate, Nitrite, Pollutants - Path of , Soil-water-plant Relationships, ...5.0045

COOPERATIVE WATERSHED MANAGEMENT ON BRUSHLANDS OF CALIFORNIA ...Amount, California, Management, Management and Fertility, Sediment Yield, ...4.0036

DISPOSAL OF SURFACE WATER ...Drainage, Infiltration, Right-of-way, Standards & Criteria, Surface Water, ...2.0150

MATHEMATICAL MODELING OF SMALL WATERSHED FLOODS ...Floods, Mathematical Analysis, Model Studies, Rain-general, Small Watersheds, ...4.0073

EXPERIMENTAL INVESTIGATION OF SMALL WATERSHED FLOODS ...Amount, Floods, Small Watersheds, Synthetic Hydrology-general, ...2.0232

INVESTIGATION OF SOIL AND WATER LOSSES THROUGH CROPPING SYSTEMS AND SOIL MANAGEMENT PRACTICES ...Soil - Crop Relationships, Soil Environment, Surface Flow, Tillage, Cropping Systems, ...3.0195

PILOT-STUDY OF SMALL WATERSHED HYDROLOGY ...Data Analysis - General, Floods, Instrumentation-general, Mathematical Analysis, Rain-general, Small Watersheds, ...2.0379

GROUND-WATER STUDIES - PILOT DRAINAGE BASIN STUDY ...Carbonate Aquifers, Groundwater Basins, Groundwater Movement, Land Use, Natural Recharge, Water Cycle, ...2.0418

STREAMFLOW HYDROGRAPH SEPARATION ...Electrical, Geophysical Analysis, Groundwater, Hardness-minerals, Hydrographs, Surface Water, ...2.0420

TRACER STUDIES - URBAN RUNOFF ...Dyes, Peak Flow, Urban Environments, Urban Research, Velocity -water, ...4.0101

THE EFFECT OF SUBSOIL TREATMENT ON SOIL CONDITIONS, CROP GROWTH, AND RUNOFF ...Modified Water Use, Soil Conditions, Stubble Mulching, ...3.0222

PREDICTING RUNOFF AND GROSS EROSION FROM FARMLAND AND DISTURBED AREAS ...Agricultural Watersheds, Conservation, Conservation-general, Erosion-general, Forecasting-prediction, ...3.0224

MATHEMATICAL SIMULATION OF HYDROLOGIC EVENTS ON UNGAGED WATERSHEDS ...Hydrographs, Hydrology-general, Mathematical Analysis, Model Studies, Research - Development, Watersheds-general, ...2.0462

INVESTIGATIONS OF EROSION CONTROL AND WATER CONSERVATION ...Amount, Conservation-general, Erosion, Gullys - Arroyos, Land Use, Sediment Yield, Stabilization-general, ...3.0226

MANAGEMENT OF SOILS IN DRYLAND REGIONS ...Tillage, Cropping Systems, ...4.0112

EFFECT OF URBANIZATION ON WATER QUALITY ...Kansas, Pollution Sources-general, Urban Environments, Water Quality-general, ...5.0425

WATERSHED VALUES AS AFFECTED BY FOREST MANAGEMENT ...Cover Crops, Erosion-general, Forest Watersheds, Forests, Moisture Content, Swamps-marshes, ...4.0142

WATER SUPPLY FROM AGRICULTURAL WATERSHEDS AND UTILIZATION IN IRRIGATION ...Agricultural Watersheds, Forecasting-prediction, Irrigation-general, Moisture Content, Patterns, Water Yield, ...4.0187

SOD AND STUBBLE MULCH PLANTING - VEGETATION CONTROL ...Evaporation, Management, Soil Erosion -non-specific, Southeast, Stubble Mulching, ...2.0827

PHYSICAL AND CHEMICAL CHANGES IN WEATHERING COAL SPOILS-EFFECT ON WATER SUPPLY AND PLANT GROWTH ...Coal-general, Growth Rate, Regeneration & Seed Production, Soil and Rock Leaching, Spoil Banks, Spoil Banks, Strip Mine Soils, ...5.0903

STRIP-MINING AND WATER QUALITY ...Chemical-general, Erosion-general, Mining Activities, Rainfall Simulators, Spoil Banks, ...5.0889

IMPROVING IRRIGATION WATER SUPPLY FORECASTS AND THEIR USE ...Forecasting-prediction, Frost and Permafrost, Irrigation-general, Moisture Content, Moisture Meters, Water Yield, ...3.0401

HYDROLOGIC BEHAVIOR OF SELECTED WATERSHEDS IN THE NORTHERN APPALACHIAN REGION ...Clouds-precipitation, Forecasting-prediction, Mathematical Analysis, Model Studies, Valley and Ridge Province, Watersheds-general, ...2.0922

CONSERVATION AND UTILIZATION OF RAINFALL AND IRRIGATION WATER ...Conservation & Management Eng, Irrigation, Slopes, Tillage, Cropping Systems, Water Harvesting, ...3.0451

RUNOFF PRODUCTION FROM UNIT SOURCE WATERSHEDS IN THE EDWARDS PLATEAU ...Amount, Forecasting-prediction, Rocks - Bedrock, Small Watersheds, Texas, ...2.1028

RUNOFF PRODUCTION BY UNIT SOURCE AREA ...Evaporation, Forecasting-prediction, Land Use, Moisture Content, Rain-general, ...2.1029
RELATION OF CLIMATIC AND WATERSHED CHARACTERISTICS TO STORM RUNOFF IN THE EDWARDS PLATEAU ...Amount, Small Watersheds, Storm Water, Storms-general, Texas, ...2.1030
PRECIPITATION CHARACTERISTICS INFLUENCING RUNOFF FROM AGRICULTURAL WATERSHEDS IN THE BLACKLANDS AND EDWARDS PLATEAU OF TEXAS ...Agricultural Watersheds, Amount, Drought, Gages, Texas, ...2.1032
GRADED FURROWS FOR RUNOFF AND EROSION CONTROL ...Conservation, Costs, Erosion-general, Soil Preparation & Renovation, ...3.0445
MEASUREMENT OF RUNOFF AND SOIL LOSS DIFFERENCES BETWEEN ESTABLISHED PLOTS ...Artesian Flow, Erosion-general, Observation Wells, Soil Environment, Water Table Fluctuation, ...2.1019
SEDIMENT YIELD IN RELATION TO CLIMATIC AND WATERSHED CHARACTERISTICS IN THE EDWARDS PLATEAU ...Floods, Reservoirs and Impoundments, Sediment Yield, Texas, Watersheds-general, ...2.1020
RUNOFF AND WATER YIELD AS AFFECTED BY CLIMATIC AND WATERSHED CONDITIONS IN THE BLACKLANDS OF TEXAS ...Agricultural Watersheds, Amount, Floods, Texas, Water Yield, ...2.1021
ELECTRONIC ANALOG MODEL STUDIES OF RIVER BASINS ...Analog Computers, Groundwater, Management, Model Studies, Precipitation-general, River Basins, Water Cycle, Water Resources Development, ...2.1059
WATERSHED WATER BUDGET ...Agricultural Watersheds, Evapotranspiration, Mathematical Analysis, Moisture Content, Water Balance-budget, ...2.1157
INVESTIGATION OF RAINFALL DISTRIBUTION ON URBAN RUNOFF FOR IMPERVIOUS AREAS ...Drainage, Hydrographs, Model Studies, Patterns, Urban Environments, ...2.0306
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PRECIPITATION ...Amount, Forecasting-prediction, Gages, Snowpack, Water Yield, ...2.0601
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COMBINED INDUSTRIAL AND MUNICIPAL WASTE TREATMENT ...Biological Treatment-other, Pilot Plant, Process Design, Pulp and Paper Wastes, Waste Water Treatment-general, ...5.1289

STORM SEWER TREATMENT BY A SELF-CLEANING STRAINER, FILTER CONCEPT ...Adsorption-absorption-general, Coagulation, Filter-other, ...5.1078

MICROSTRAINING PILOT TESTS OF STORM WATER OVERFLOWS FROM COMBINED STORM AND SANITARY SEWER SYSTEMS ...Chlorination, Ozonization, Pilot Plants, Screening, ...5.1003

TRANSPORT OF SOLID SUSPENSION IN CONDUITS ...Conduit, Design Criteria, Flow of Dispersed Solids, Measurement, Transportation, ...5.0988

SEPARATION OF SANITARY SEWAGE FROM COMBINED SYSTEMS OF SEWERAGE ...Design-other, Sewage, Storm Water, Waste Treatment-economics, ...5.0781

AN ENGINEERING INVESTIGATION OF STORM AND COMBINED SEWER PROBLEMS ...Land Use, Non-structural Alternative, Pollution Abatement, Runoff, Storm Water, ...5.0229

A METHOD FOR ASSESSING THE EXTENT OF POLLUTION FROM STORMWATER RUNOFF FROM AN URBAN AREA ...Construction-other, Runoff, Storm Water, Urban Environments, Urban Research, Waste Treatment-economics, ...5.0090

ROLE OF SOLIDS IN COMBINED SEWAGE POLLUTION ...Chemical Analysis, Disinfection, Screening, Solid Waste, ...5.0091

DEVELOP AND DEMONSTRATE A METHOD FOR ASSESSING THE EXTENT OF POLLUTION FROM STORM WATER RUNOFF IN AN URBAN AREA ...Alternative Planning, Iowa, Nutrients, Storm Water, Urban Environments, ...5.0705

A PILOT FACILITY TO DEMONSTRATE OFF-SHORE, UNDERWATER, TEMPORARY STORAGE OF STORM OVERFLOW FROM A COMBINED SEWER ...Pumping Stations, Storage of Water, Storage-retention-facilities, Storm Water, Tanks, ...5.0838

PRIMARY TREATMENT OF STORM WATER OVERFLOW FROM COMBINED SEWERS BY HIGH RATE FINE MESH SCREENS ...Filtration, Industrial Waste-other, Primary Treatment, Screening, Storm Water, ...5.0931

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DEMONSTRATION UNDERWATER FACILITY - STORM OVERFLOW ...Elastomers Rubber, Polyamides, Pressure Ussel Materials, Storage-retention-facilities, Storm Water, ...5.0246

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SPRING CREEK AUXILIARY WATER POLLUTION CONTROL PROJECT ...Bays, Effluents-waste Water, New York, Overflow, ...5.0759

STORM WATER DEMONSTRATION PROJECT - CITY OF SOMERSWORTH, NEW HAMPSHIRE ...Additives, Chlorination, Polymer Type-other, Storm Water, ...5.0710

A COMBINED SEWERAGE COLLECTION AND TREATMENT FACILITY ...Aeration, Lakes, Sand, Storm Water, ...5.0581

A PROGRAM FOR DEMONSTRATING COMBINED SEWER OVERFLOW CONTROL TECHNIQUE FOR WATER QUALITY IMPROVEMENTS AND BEACH PROTECTION ...Chlorination, Disinfection, Lake Erie, Polyelectrolytes, Potable Water, Shoreline - Coastline, ...5.0867

DISPATCHING SYSTEM FOR CONTROL OF COMBINED SEWER LOSSES ...Control Gate, Energy Losses-general, Hydraulics-general, Hydrology-general, Meteorological Studies-general, ...5.0609

INVESTIGATION FOR CONTROL OF WATER POLLUTION FROM COMBINED SEWERS IN ROANOKE, VIRGINIA ...Alternative Planning, Model Studies, Rain Fall Intensity, Runoff, Sanitary Sewage Quantity-other, Storm Water, Water Quality Control-general, ...5.1220

COMBINED SEWER STUDY FOR WASHINGTON, D.C. ...District of Columbia, Effluent-standards, Filtration, Storage-retention-facilities, Water Quality-general, ...5.1005

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Construction-other

A METHOD FOR ASSESSING THE EXTENT OF POLLUTION FROM STORMWATER RUNOFF FROM AN URBAN AREA ...Combined Sewer, Runoff, Storm Water, Urban Environments, Urban Research, Waste Treatment-economics, ...5.0090

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MODEL STUDY OF SEWER DROPSHAFT ...Conduit, Discharge-general, Flow Regulations, Runoff, Two-phase-other, ...8.0218

MATHEMATICAL MODEL OF STORM AND SANITARY INTERCEPTOR SYSTEM ...Inflow, Model Studies, Peak Flow, Rain Fall Intensity, Storm Water, ...5.0597

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DUWAMISH RIVER-ELLIOTT BAY STORM WATER CONTROL SYSTEM ...Combined Sewer, Loading, Storage-retention-facilities, Valves, ...5.1254

Location

PHOSPHATE REMOVAL BY ACTIVATED SLUDGE PROCESS APPLICATION - PLANT SCALE DEMONSTRATION ...Activated, Mechanisms, Phosphate, Phosphite, Pollutant-other, Sewage Treatment Plant, ...5.0912

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METHODS TO REDUCE WATER POLLUTION CAUSED BY STORM WATER SEWER LOADING BY USING FLUID FLOW FRICTION REDUCERS ...Friction, Molecular Weight-other, Polyelectrolytes, Storm Sewer Quantity-other, Storm Water, ...5.1185

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DISTRIBUTION OF LIQUIDS IN POLAR CAMPS ...Maintenance, Permafrost-frozen, Pipes, Polar, Sewage, ...5.0134

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DEVELOPMENT AND DEMONSTRATION OF MATERIALS TO REDUCE OR ELIMINATE WATER INFILTRATION INTO SEWERAGE ...Groundwater Movement, Joining, Bonding-general, Linings-pavings, Other, Sealant Materials, ...5.1186

DEVELOPMENT PROGRAM FOR TREATMENT OF WASTEWATER BY AERATION ...Aeration, Flushing Devices, Methods, Process Design, ...5.0076

Shape

FLOW IN ECCENTRIC ANNULAR PIPES ...Configuration of Body, Friction, Pipes, Turbulent, ...8.0182

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IMPROVEMENTS TO THE BOROUGH OF NEW PROVIDENCE SEWAGE PUMPING STATION AND TREATMENT FACILITIES ...Chlorination, Pilot Plant, Plastics - General, Polyelectrolytes, Sedimentation, Trickling, ...6.0353

A PILOT FACILITY TO DEMONSTRATE OFF-SHORE, UNDERWATER, TEMPORARY STORAGE OF STORM OVERFLOW FROM A COMBINED SEWER ...Combined Sewer, Storage of Water, Storage-retention-facilities, Storm Water, Tanks, ...5.0838

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REMOVAL OF TRACE METALS FROM WATER BY ION FLOTATION ...Concentration, Flotation, Foam, Industrial Waste-other, Trace Elements, ...5.0878

MYCOLOGICAL PHENOMENA IN SEWAGE SPREADING BASINS ...Activated, Biological, ...5.0128

USE OF COAL AS ADSORBENT FOR TREATING WASTE WATER ...Adsorption-absorption-other, Anaerobic, Coal-general, Material Recovery Wastes, Secondary Treatment, ...5.1017

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INVESTIGATION FOR CONTROL OF WATER POLLUTION FROM COMBINED SEWERS IN ROANOKE, VIRGINIA ...Alternative Planning, Combined Sewer, Model Studies, Rain Fall Intensity, Runoff, Storm Water, Water Quality Control-general, ...5.1220

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COOK STREET STORM WATER OXIDATION POND ...Pond, Storage-retention-facilities, Storm Water, Urban Environments, ...5.0346

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INDIVIDUAL WASTE DISPOSAL SYSTEMS ...Inspection, Waste Disposal-general, ...5.0218

DISPOSAL OF WASTE FROM SWINE FEEDING FLOORS TO MINIMIZE OR ELIMINATE STREAM POLLUTION ...Animal Wastes - Feed Lots, Underground Waste Disposal, ...5.0499

SECONDARY TREATMENT OF HOG WASTE IN AN ANAEROBIC STABLIZATION POND ...Anaerobic, Animal Wastes - Feed Lots, North Dakota, Secondary Treatment, Sewage Lagoons, ...5.0830

WATER QUALITY DEGRADATION BY SEPTIK TANK DRAINAGE ...Degradation, Drainage, Lakes, Nitrogen, Phosphorus, ...5.0468

WASTE DISPOSAL IN RURAL AREAS ...Aerobic, Animal Waste Removal-treatment, Chemical Analysis (water), Effluents-waste Water, Farm Wastes, Rural Areas, ...5.0219

CONTROL OF INSECTS ASSOCIATED WITH SWINE PRODUCTION WITHOUT THE USE OF INSECTICIDES ...Animal Waste Removal-treatment, Control -non-specific, Ectoparasitic, Farm Wastes, Flies -house,face,horn,stable, ...5.0488

WATER POLLUTION ...Bacterial Pollutant Sources, Cell. env (non-specific & Ot.), Identification, Self-purification, Streams, ...5.0730

WASTE TREATMENT FOR AN INDIVIDUAL HOME WITH REUSE OF THE WATER ...Aeration, Carbon, Filtration, Flushing Devices, Recycle, ...5.0391

WATER QUALITY ASPECTS OF RECREATIONAL LAKES ...Lakes, Nitrogen, Phosphorus, Recreation Sites, Waste Water Treatment-general, ...5.0469

SUITABILITY FOR SEPTIC TANK DISPOSAL SYSTEMS AND PRODUCTIVITY POTENTIALS OF PENNSYLVANIA SOILS ...Animal Wastes - Feed Lots, Percolation, Soil, Waste Water Treatment-general, Water Table Fluctuation, ...5.1039

BIODEGRADABLE DETERGENTS FROM ANIMAL FATS ...Biodegradation, Esters, Sulfonates (rso3na), Surfactants, ...5.0992

Sewage

SANITATION, WASTE DISPOSAL AND PEST AND VECTOR CONTROL ...Nuclear Explosion, Pollution - Effects of , Radioactive Fallout, Radiologic Warfare, Requirement, Urban Environments, ...5.0059

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SEPARATION OF SANITARY SEWAGE FROM COMBINED SYSTEMS OF SEWERAGE ...Combined Sewer, Design-other, Storm Water, Waste Treatment-economics, ...5.0781

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A MATHEMATICAL MODEL FOR REGIONAL TREATMENT OF WATER POLLUTION SYSTEMS ...Estuaries, Mathematical

Analysis, Public Utilities, Public Works, Regional Areas, Value Analysis, ...5.0114

OPTIMAL DESIGN OF SEWER AND DRAINAGE SYSTEMS ...Digital Computers, Open Channel, Process Design, Unsteady, ...5.0530

ENGINEERING ANALYSIS OF WASTE TREATMENT ...Activated Carbon, Development of Models, Digital Computers, Electrodialysis, Optimization, ...5.0861

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INVESTIGATION FOR CONTROL OF WATER POLLUTION FROM COMBINED SEWERS IN ROANOKE, VIRGINIA ...Alternative Planning, Combined Sewer, Model Studies, Runoff, Sanitary Sewage Quantity-other, Storm Water, Water Quality Control-general, ...5.1220

MATHEMATICAL MODEL OF STORM AND SANITARY INTERCEPTOR SYSTEM ...Design-other, Inflow, Model Studies, Peak Flow, Storm Water, ...5.0597

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AN ENGINEERING INVESTIGATION OF STORM AND COMBINED SEWER PROBLEMS ...Combined Sewer, Land Use, Nonstructural Alternative, Pollution Abatement, Storm Water, ...5.0229

A METHOD FOR ASSESSING THE EXTENT OF POLLUTION FROM STORMWATER RUNOFF FROM AN URBAN AREA ...Combined Sewer, Construction-other, Storm Water, Urban Environments, Urban Research, Waste Treatment-economics, ...5.0090

MODIFICATION OF WHITTIER STREET STORM STANDBY TANKS ...Appurtenances, Combined Sewer, Ohio, Pump, Storm Water, ...5.0873

THE CONSTRUCTION OF THE STORM DETENTION AND CHLORINATION STATION ...Chlorination, Combustible, Effluent-standards, Storage-retention-facilities, Water Purification Plants, ...5.0519

INVESTIGATION FOR CONTROL OF WATER POLLUTION FROM COMBINED SEWERS IN ROANOKE, VIRGINIA ...Alternative Planning, Combined Sewer, Model Studies, Rain Fall Intensity, Sanitary Sewage Quantity-other, Storm Water, Water Quality Control-general, ...5.1220

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CHLORINATION AND HYPOCHLORINATION OF POLLUTED STORM WATER PUMPAGE ...Bacteria, Chlorination, Chlorites,hypochlorites, Disinfection, Water Purification Plants, ...5.0458

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DISTRIBUTION OF YOUNG STAGES OF COASTAL FISHES ...Continental Shelf, Estuaries, Fish -non-specific, Maturity & Growth Stages, Number Or Density, ...6.0345

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ESTUARIES AND SHORE STUDIES AND WATER SURFACE INVESTIGATIONS ...Continental Shelf, Effluents-waste Water, Evaporation, Infrared Radiation, Thermal Pollution, Visible Light, ...6.0143

A RECONNAISSANCE STUDY OF THE CHEAPEAKE BAY ...Chesapeake Bay, Erosion-general, Floods, Sedimentology-general, Survey Studies, Thermal Pollution, ...6.0254

ECOLOGY OF LOUISIANAS ESTUARINE WATERS - MARINE LABORATRY ...Aquatic Ecology, Estuaries, Louisiana, Marine Biology (non-specific), ...2.0542

UTILIZATION OF PHYSICAL AND MATHEMATICAL MODELS IN ESTUARINE WATER RESOURCES RESEARCH AND MANAGEMENT ...Computers-general, Estuaries, Management, Model Studies, Tides, ...6.0607

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PHYSICAL FACTORS AFFECTING OREGON COASTAL POLLUTION ...Circulation General, Density, Pollution-general, Tidewater Areas, Water Quality-general, ...5.0951

A PROGRAM FOR DEMONSTRATING COMBINED SEWER OVERFLOW CONTROL TECHNIQUE FOR WATER QUALITY IMPROVEMENTS AND BEACH PROTECTION ...Chlorination, Combined Sewer, Disinfection, Lake Erie, Polyelectrolytes, Potable Water, ...5.0867

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IMPACT OF LAGOONS AND SAND BLANKETS ON FISH, AQUATIC LIFE AND WATER EQUALITY ...Aquatic Ecology, Blankets, Lagoons, Lakes, Water Quality-general, ...6.0637

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STABILIZATION OF SHORES BY GROINS AND JETTIES ...Groin, Jetty, Models, Sedimentation, Wave Action, ...2.0263

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THE EFFECTS OF DREDGING AND SILTATION ON DIVING DUCK FOODS AND FEEDING HABITS ON THE MISSISSIPPI RIVER ...Food Supply, Mississippi River, Sediments, Water Fowl, N.s. , ...5.0411

A QUANTITATIVE STUDY OF TRACE ELEMENTS ON ABIOTIC AND BIOTIC AGGREGATES IN THE MISSOURI RIVER ...Bacterial Pollutant Sources, Food Pyramids, Missouri River, Trace Elements, ...5.0688

A STUDY TO EVALUATE THE EFFECT OF SILT AND SILT REMOVAL IN A NORTHERN PRAIRIE LAKE ...Domestic Wastes-general, Eutrophication, Hardness-minerals, Lakes, ...5.1116

CHANNELIZATION STUDIES ...Channel Geometry, Channels, Control and Protection, New Mexico, Sedimentation, ...8.0053

THE NATURE AND PROCESSES OF RESERVOIR SEDIMENTATION IN THE SOUTHERN BRANCH AND AT THE USDA SEDIMENTATION LABORATORY ...Agricultural Watersheds, General Deposition, Reservoirs and Impoundments, Sediment Yield, Southern, ...2.0676

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PREDICTION OF ENVIRONMENT ...Biological-general, Columbia River, Environmental Ecology, Low Temp. -but Above 32f, Physical-general, Reservoirs and Impoundments, Salmon & Trout - Non-specific, Temperature, Thermal Pollution, ...6.0617

PROTECTION OF FINGERLING SALMON IN TURBINES ...Construction Land Use Effects, Engineering Structures-general, Migration, Mortality Rates, Salmon & Trout - Non-specific, ...8.0306

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HYDROLOGIC STUDY OF A SMALL ALASKAN WATERSHED ...Alaska, General Synoptic Observations, Hydrology-general, Small Watersheds, Water Sampling, ...2.0749

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CHARACTERIZATION OF DYNAMIC PROPERTIES AND PHYSICAL CONDITIONS OF SOIL IN RELATION TO TILLAGE AND TRACTION ...Load Behavior, Management Effects, Soil Conditions, Soil Preparation & Renovation, Tillage, Cropping Systems, ...**2.0001**

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CHARACTERIZATION OF WATER TABLES IN OREGON SOILS WITH REFERENCE TO TRAFFICABILITY ...Dynamic, Moisture Content, Rain-general, Trafficability, Water Table Fluctuation, ...**2.0887**

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CONTROL OF EROSION AND SEDIMENTATION ASSOCIATED BUILDING AND LOGGING ...Erosion-general, Forest Watersheds, Logging, Transport, Equipment, Sediment Yield, Streams, ...**2.0027**

DEVELOPMENT OF SPECIAL REHABILITATION TECHNIQUES AND FOREST MANAGEMENT PRACTICES FOR USE ON SEVERELY ERODED OR HIGHLY EROSIVE WATERSHEDS ...Cover Crops, Erosion-general, Floods, Runoff, Site Index and Site Quality, ...**2.0674**

RUNOFF PRODUCTION BY UNIT SOURCE AREA FOR AGRICULTURAL WATERSHEDS IN THE SOUTH ...Agricultural Watersheds, Land Use, Precipitation -non-specific, Runoff, Southern, ...**2.0335**

DETERMINATION AND EVALUATION OF FACTORS AFFECTING WATER RUNOFF AND EROSION IN THE DIFFERENT LAND RESOURCE AREAS OF THE NORTHEAST ...Erosion-general, Management, Northeast, Runoff, Seedbed Preparation, ...**5.0489**

EFFECTS OF SOIL, TOPOGRAPHY, CLIMATE, CROPPING AND MANAGEMENT PROCEDURES ON RUNOFF AND EROSION, AND ON THE PREDICTION OF SOIL LOSSES ...Rain, Runoff, Slope - Degree of , Tillage, Cropping Systems, ...**2.0337**

DEVELOPMENT OF SUPPORTING PRACTICES, SYSTEMS, TECHNIQUES AND DEVICES FOR RUNOFF AND EROSION CONTROL IN THE SOUTH ...Conservation & Management Eng, Erosion-general, Flow Characteristics -water, Land Use, Runoff, Tillage, Cropping Systems, ...**5.0275**

DEVELOPMENT AND REFINEMENT OF METHODS FOR PREDICTING FIELD RUNOFF AND SOIL LOSS ...Erosion-general, Forecasting-prediction, Mathematical Analysis, Runoff, Sediment Yield, Soil Environment, Soil Erosion -non-specific, ...**2.0477**

EROSION AND RUNOFF CONTROL PRACTICES AND SYSTEMS TO CONSERVE SOIL AND WATER RESOURCES IN THE PACIFIC NORTHWEST ...Conservation-general, Design Flow-flood, Erosion-general, Runoff, Southern, ...**4.0087**

Cover Crops

EROSION CONTROL STUDY ...Drainage, Erosion Control, Soil Erosion -non-specific, ...**2.0532**

ROADSIDE DEVELOPMENT AND BEAUTIFICATION ...Aesthetic, Erosion-general, Plant Growth, Roads and Highways, ...**2.0109**

COOPERATIVE RESEARCH PROJECT IN WESTERN NORTH CAROLINA ...Agricultural Watersheds, Agriculture Industry, Land Use, Modified Water Use, North Carolina, ...**2.0830**

BADGER WASH COOPERATIVE STUDY ...Erosion-general, Forest Grazing, Runoff, Sediment Yield, Water Cycle, ...**2.0176**

AN ANALYSIS OF THE VEGETATION AND SOIL CHARACTERISTICS OF RANGE WATERSHEDS IN NEVADA ...Infiltration, Mapping, Runoff, Soil-water-plant Relationships, Species and Species Evaluation, ...**2.0740**

EFFECTS OF PINYON-JUNIPER CONVERSION ON WATERSHED VALUES IN UTAH ...Forest Watersheds, Juniperus, Moisture Budgets, Pines, Water Balance-budget, ...**2.1067**

STRATTON SAGEBRUSH HYDROLOGY STUDY ...Hydrology-general, Range, Runoff, Sediment Yield, Soil Environment, ...**2.0221**

DETERMINE ECOLOGICAL CHANGES RESULTING FROM IMPOUNDMENT ...Flooding, Freshwater Ecology, Mapping, Plant Succession, Reservoirs and Impoundments, Water Level Fluctuation, ...**6.0355**

EFFECTS OF WATERSHED MANIPULATION ON DEER AND ELK USE ...Habitat Studies, Management, Population Dynamics, Water Yield, Watersheds-general, ...**4.0003**

FACTORS AFFECTING WATER YIELD FROM SMALL WATERSHEDS IN TENNESSEE ...Correlation, General Synoptic Observations, Small Watersheds, Tennessee, Water Yield, ...**4.0224**

DEVELOPMENT OF ECONOMIC WATER HARVEST SYSTEMS FOR INCREASING WATER SUPPL ...Arizona, Economic Efficiency, Erosion-general, Saline Soils, Water Harvesting, ...**3.0012**

EFFECT OF RANGE MANAGEMENT ON INFILTRATION, RUNOFF, AND EROSION ...Infiltration, Management and Fertility, Runoff, ...**2.0105**

TEMPORARY LININGS FOR WATERWAYS AND EMBANKMENTS ...Design Criteria, Embankments, Erosion Control, Florida, Hydrology-general, Lining, ...**3.0178**

ESTIMATING SOIL MOISTURE FROM METEOROLOGICAL MEASUREMENTS ...Evapotranspiration, General Synoptic Observations, Indiana, Moisture-other, Soil Types, ...**2.0474**

FOREST COVER ...Forest Watersheds, Forests, Interception, Missouri, Soils and Fertilizer, ...**4.0156**

DETACHABILITY OF SOIL PARTICLES ...Management Effects, Nebraska, Rain, Soil Analysis, ...**2.0723**

EVAPOTRANSPIRATION LOSSES AS RELATED TO SITE AND VEGETATION DIFFERENCES ...Evapotranspiration, Forest Watersheds, Interception, Rhode Island, Soil Environment, ...**2.0939**

HYDROLOGY OF PIEDMONT AGRICULTURAL WATERSHEDS ...Agricultural Watersheds, General Synoptic Observations, Groundwater, Management, Piedmont Province, Soil-water-plant Relationships, Water Yield, ...**2.0958**

DIFFERENCE IN EFFECTS OF FOREST AND OTHER VEGETATIVE COVERS ON WATER YIELD ...Evapotranspiration, Israel, Moisture Tension, Precipitation -non-specific, Water Yield, ...**3.0235**

INFILTRATION CAPACITIES UNDER VARIOUS VEGETATION TYPES AS INFLUENCED BY WATERSHED MANAGEMENT PRACTICES ...Environment, Infiltration, Management, Water Yield, Watersheds-general, ...**4.0013**

MOISTURE CONTENT OF VARIOUSLY TREATED CHAPARRAL SOILS IN RELATION TO SEEDLING ESTABLISHMENT OF ADAPTED PERENNIAL GRASSES ...Adaptation, California, Grasses -non-specific, Moisture Tension, Soil-water-plant Relationships, ...2.0142

WATERSHED VALUES AS AFFECTED BY FOREST MANAGEMENT ...Erosion-general, Forest Watersheds, Forests, Moisture Content, Runoff, Swamps-marshes, ...4.0142

ESTABLISHMENT AND MAINTENANCE OF VEGETATION ON HIGHWAY RIGHTS-OF-WAY ...Erosion Control, Highway Sites, Plant Growth, Right-of-way, Roads and Highways, ...2.1035

THE ROLE OF VEGETATION AND SOIL IN WATERSHED YIELD ...Dendroclimatology, Soil Properties - General, Soil-water-plant Relationships, Water Balance-budget, Water Yield, Watersheds-general, ...4.0256

PARTIAL CUTTINGS OF FOREST PLANTATIONS, INCLUDING EFFECT OF GROUND VEGETATION ON SUPPLY OF SOIL MOISTURE ...Consumptive Use, Forests, Moisture Competition, Soil Environment, Soil-water-plant Relationships, ...2.1168

INFLUENCE OF VEGETATION IN SOIL MOISTURE FLOW ...Groundwater Movement, Infiltration, Soil Environment, Tracers-general, ...2.0946

UPPER BEAR CREEK EXPERIMENTAL PROJECT ...Alabama, Discharge-general, Forecasting-prediction, Small Watersheds, Technique Development, ...2.0987

VEGETATION MANIPULATION EFFECTS ON RUNOFF - SYCAMORE CREEK, ARIZ ...Conservation-general, Runoff, Sediment Yield, Water Yield, Watersheds-general, ...3.0008

WEED CONTROL AND REVEGETATION ...Control and Protection, Plant Pollutants, Rio Grande River, Weed Control -other, ...3.0119

IMPROVEMENT OF WATER YIELDS AND SOIL STABILIZATION IN RIVER BASINS ...Artemisia, Erosion-general, Forest Watersheds, Management, Soil-water-plant Relationships, Water Yield, ...3.0495

DEVELOPMENT OF SPECIAL REHABILITATION TECHNIQUES AND FOREST MANAGEMENT PRACTICES FOR USE ON SEVERELY ERODED OR HIGHLY EROSIVE WATERSHEDS ...Conservation, Erosion-general, Floods, Runoff, Site Index and Site Quality, ...2.0674

WATER YIELD IMPROVEMENT FROM SOIL TREATMENTS AND PLANT-COVER ALTERATIONS (ABBREV) ...Precipitation -non-specific, Soil Management -other, Soil-water-plant Relationships, Water Yield, Watersheds-general, ...4.0249

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UREA TRANSFORMATIONS AND RETENTION IN FLOODED SOILS ...Fertilizer Losses, Nitrogen, Soil and Rock Leaching, Soil Environment, ...4.0123

PHYSICAL, CHEMICAL AND MICROBIOLOGICAL FACTORS AFFECTING THE DISCHARGE OF WATER INTO DRAIN TILE ...Drainage Engineering, Water Properties-general, ...2.0145

SOIL DRAINAGE ...Amount, New Jersey, Soil Morphology, Profiles, Water Table Fluctuation, ...4.0171

DRAINAGE DESIGN IN RELATION TO SOIL SALINITY ...California, Drainage Engineering, Movement, Availability, Saline and Alkaline Soils, Soil and Rock Leaching, ...3.0046

THE PROCESSES AND CONDITIONS CONTRIBUTING TO THE ACCUMULATION OF NUTRIENTS IN DRAINAGE WATER FROM IRRIGATED AREA AND SOIL RECLAMATION ...Boron, Nitrogen, ...4.0027

DRAINAGE REQUIREMENTS AND PRACTICES FOR CROP PRODUCTION ...Virginia, ...4.0266

DRAINAGE SYSTEMS FOR THE IMPERIAL VALLEY ...Analog Computers, Digital Computers, Groundwater Movement, ...4.0026

Erosion Control

Erosion -other

DESIGN, INSTALLATION, AND MAINTENANCE OF SURFACE AND SUBSURFACE DRAINAGE SYSTEMS WITH OR WITHOUT LANDFORMING AND CONDITIONING ...Drainage, Drainage Engineering, Runoff, Southern, Tillage, Cropping Systems, ...4.0081

Gully Or Channel Erosion

WATER YIELD IMPROVEMENT IN THE SNOWPACK TIMBER ZONE, RUNOFF FROM RANGELANDS ...Erosion-general, Mountains-alpine, Radiation-general, Snowmelt, Water Yield, ...3.0143

Soil Erosion -non-specific

EROSION CONTROL STUDY ...Cover Crops, Drainage, Erosion Control, ...2.0532

INTERAGENCY FRAIL LANDS STUDY - MONTANA IV. WATER QUANTITY MANAGEMENT ...Conservation, Erosion-general, Montana, Runoff, Slopes, ...4.0161

RELATIONSHIP BETWEEN THE ERODIBILITY OF SOILS AND THE SEDIMENTATION RATE OF RESERVOIRS ...Erosion-general, Physical Properties-general, Rate of Deposition, Reservoirs and Impoundments, Sediment Yield, ...2.0463

ENGINEERING DESIGN CRITERIA FOR SOIL AND WATER MANAGEMENT ...Conservation & Management Eng, Management, Soil Preparation & Renovation, ...6.0002

SOIL AND WATER CONSERVATION MANAGEMENT ...Conservation-general, Erosion-general, Tillage, Cropping Systems, Yield, ...4.0150

SOD AND STUBBLE MULCH PLANTING - VEGETATION CONTROL ...Evaporation, Management, Runoff, Southeast, Stubble Mulching, ...2.0827

LONG TERM CHANNEL CHANGES ...Channels, Cross-section, Gaging, Morphology-general, ...2.0284

SEDIMENTATION IN SMALL FORESTED DRAINAGE BASINS ...Forest Watersheds, Logging, Transport, Equipment, Oregon, Runoff, ...2.0901

CONTROLLING WEEDS ON DITCHBANKS AND OTHER NON-CROP AREAS ...Biocontrol, Persistence in Soils, Physical Control, Phytotoxicity, ...5.1328

DEVELOPMENT AND REFINEMENT OF METHODS FOR PREDICTING FIELD RUNOFF AND SOIL LOSS ...Conservation, Erosion-general, Forecasting-prediction, Mathematical Analysis, Runoff, Sediment Yield, Soil Environment, ...2.0477

MECHANICS AND PRINCIPLES OF WATER EROSION AND THEIR APPLICATION FOR EROSION CONTROL IN THE SOUTHERN PLAINS ...Erosion-general, Great Plains Province, Runoff, Soil Environment, ...5.0435

FUNDAMENTAL ASPECTS OF WATER EROSION IN THE PACIFIC NORTHWEST ...Erosion-general, Infiltration, Permafrost-frozen, Southern, Synthetic Hydrology-general, ...2.0389

Wind Erosion

DRYLAND SOIL MANAGEMENT ...Colorado, Evapotranspiration, Management Effects, Modified Water Use, Soil-water-plant Relationships, Tillage, Cropping Systems, ...2.0208

DRYLAND SOIL MANAGEMENT ...Conservation & Management Eng, Erosion-general, Soil Preparation & Renovation, ...4.0111

EVALUATION OF CLIMATIC, TOPOGRAPHIC, SOIL AND CROP MANAGEMENT FACTORS IN RELATION TO WATER MANAGEMENT AND EROSION CONTROL IN THE CORN BELT ...Climate, Corn Belt, Erosion-general, Runoff, Slopes, ...2.0476

WATER AND WIND EROSION AND ITS CONTROL ON IRRIGATED AND NONIRRIGATED LANDS IN THE NORTHERN PLAINS ...Erosion-general, Great Plains Province, Irrigation-general, Runoff, Soil Tillage Methods -other, ...5.0195

Forests

FOREST COVER ...Cover Crops, Forest Watersheds, Interception, Missouri, Soils and Fertilizer, ...4.0156

WATER CONTROL FOR FOREST PRODUCTION ...Drainage, Irrigation-general, Moisture Content, Palms, Water Table Fluctuation, ...2.0314

WATERSHED VALUES AS AFFECTED BY FOREST MANAGEMENT ...Cover Crops, Erosion-general, Forest Watersheds, Moisture Content, Runoff, Swamps-marshes, ...4.0142

THE IMPROVEMENT OF SOILS DEVELOPED UNDER FOREST VEGETATION ...Mineralogy, Minnesota, Soil Morphology, Profiles, Soils and Fertilizer, ...2.0662

EFFECTS OF TREE ROOTS ON HYDRAULIC CONDUCTIVITY AND POROSITY OF FOREST SOILS IN THE ALLEGHENY-CUMBERLAND PLATEAU ...Roots, Soil Compaction Or Density, Soil Environment, Soils and Fertilizer, Subsurface Flow, ...2.0855

PARTIAL CUTTINGS OF FOREST PLANTATIONS, INCLUDING EFFECT OF GROUND VEGETATION ON SUPPLY OF SOIL MOISTURE ...Consumptive Use, Cover Crops, Moisture Competition, Soil Environment, Soil-water-plant Relationships, ...2.1168

HYDROLOGY AND MANAGEMENT OF WETLAND FORESTS ...Soils and Fertilizer, ...3.0431

Irrigation

HYDRAULIC OPERATING CHARACTERISTICS OF LOW GRADIENT BORDER SYSTEMS PHASE II ...Border Irrigation, Infiltration, Irrigation Engineering, Water Application Methods, ...3.0139

QUALITY OF IRRIGATION RETURN FLOW ...Internal Water Movement, Irrigation-general, Saline and Alkaline Soils, Salinity, Water Quality-general, ...5.1196

LYSIMETER INVESTIGATIONS OF GAINS AND LOSSES OF MINERAL ELEMENTS ...Lysimeters, Mineralogy, Soil and Rock Leaching, ...2.0144

SOIL PHYSICAL CONDITIONS IN RELATION TO IRRIGATION ...Aggregates-other, Furrow Irrigation, Moisture Retention, Moisture Tension, Physical Properties-general, Sprinkler Irrigation, ...2.0146

INFLUENCE OF IRRIGATION PRACTICES ...Soil Structure, ...2.0210

WATER REQUIREMENTS OF CROPS ...Climate-general, Irrigation-general, Management, Moisture Content, Requirements for Water, Soil-water-plant Relationships, ...2.0654

DRAINAGE OF PROPOSED IRRIGATED SOILS IN OAHE UNIT ...Drainage Engineering, Soil-water-plant Relationships, ...4.0217

LOW GRADIENT BORDER CHECK IRRIGATION ...Border Irrigation, Management, Slope - Degree of , ...4.0063

SOIL MANAGEMENT INVESTIGATIONS ON IRRIGATED LAND ...Management, Rotations, Soil Analysis, Soil Comparison, Tillage, Cropping Systems, Water Application Methods, ...4.0114

FARM IRRIGATION EFFICIENCY AS INFLUENCED BY DESIGN, CONSTRUCTION, AND OPERATION OF IRRIGATION SYSTEMS IN SOUTHWESTERN NEW MEXICO ...Irrigation Engineering, Irrigation-general, New Mexico, Rhizosphere, ...2.0775

THE ADAPTATION OF SPRINKLER IRRIGATION TO SOILS OF LOW INTAKE RATE ...Absorption, Fixation, Exchange, Moisture Content, Sprinkler Irrigation, Water Application Methods, ...3.0402

THE INVESTIGATION OF SOIL PROBLEMS IN RELATION TO IRRIGATION DEVELOPMENT IN SUBHUMID AREAS ...Soil-water-plant Relationships, Sub - Humid, ...2.0967

EVALUATION OF SUBIRRIGATION FOR CROP PRODUCTION ...Irrigation Engineering, ...2.1036

THE EFFECTS OF SWEETCLOVER, NITROGEN, SUPPLEMENTAL IRRIGATION, AND PLANT POPULATION ON GRAIN SORGHUM YIELDS OF BLACKLAND SOILS ...Milo and Grain Sorghum, Sweet Clover, ...2.1025

EFFECT OF VARIOUS IRRIGATION TECHNIQUES ON SOIL AERATION, SOIL STRUCTURE, AND CROP RESPONSE ...Soil Aeration, Soil Structure, ...2.1070

THE CHARACTERISTICS AND POLLUTIONAL PROBLEMS OF IRRIGATION RETURN FLOWS ...Effluents-waste Water, Groundwater, Streams, Surface Water, Water Quality-general, ...5.0909

IRRIGATION REQUIREMENTS, PRACTICES AND METHODS OF APPLICATION FOR EFFICIENT PRODUCTION OF CROPS IN THE SOUTHEAST ...Soil-water-plant Relationships, ...3.0191

IRRIGATION PRACTICES, REQUIREMENTS AND DESIGN CRITERIA FOR EFFICIENT USE OF WATER AND SUSTAINED CROP PRODUCTION IN THE NORTHERN PLAINS ...Irrigation Engineering, ...3.0142

IRRIGATION REQUIREMENTS, PRINCIPLES AND PRACTICES FOR EFFICIENT USE OF WATER IN THE PACIFIC NORTHWEST ...Evapotranspiration, Irrigation-general, Management, Physical Property Effects, Southern, ...3.0203

UNDERSTANDING AND IMPROVING SOIL-PLANT-ATMOSPHERIC RELATIONSHIPS FOR MORE EFFICIENT UTILIZATION OF WATER ...Micrometeorology, Root Absorption, Soil-water-plant Relationships, ...2.1057

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A DEMONSTRATION PLANT EVALUATION OF FOUR METHODS FOR PULP AND PAPER MILL SLUDGE UTILIZATION AND DISPOSAL ...Disposal, Disposal Wastes, Pulp and Paper Wastes, Pulp, Paper , and Logging, Pulp, Pulping & Composite, ...5.0152

WATER ABSORPTION BY ASPARAGUS ...Modified Water Use, Root Absorption, Soil-water-plant Relationships, Tillage, Cropping Systems, ...2.0252

EFFECT OF WATER APPLICATIONS TO SOD AND MULCH UPON QUALITY ATTRIBUTES OF APPLE FRUITS ...Apples, Irrigation, Quality -non-specific, Sprinkler Irrigation, Storage Changes, Trees, ...2.0853

THE EFFECT OF TILLAGE AND ORGANIC MULCHES UPON SOIL MOISTURE MOVEMENT AND SOIL TEMPERATURES IN THE LOWER RIO GRANDE ...Evaporation, High Temp. - 85f Or Above, Modified Water Use, Soil Environment, Temperature, ...2.1056

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ROADSIDE DEVELOPMENT AND BEAUTIFICATION ...Aesthetic, Cover Crops, Erosion-general, Plant Growth, ...2.0109

PREPARATION OF A HIGHWAY DRAINAGE POLICY STATEMENT AND PRACTIVE MANUAL FOR THE STATE OF ILLINOIS ...Design Criteria, Drainage, Drainage Systems, Handbooks, Illinois, Water Law-general, ...6.0205

ESTABLISHMENT AND MAINTENANCE OF VEGETATION ON HIGHWAY RIGHTS-OF-WAY ...Cover Crops, Erosion Control, Highway Sites, Plant Growth, Right-of-way, ...2.1035

Saline and Alkaline Soils

THE EFFECTS OF SALINE IRRIGATION WATER ON SODIUM ACTIVITIES AND PHYSICAL PROPERTIES OF LATOSOLIC SOILS ...Hawaii, Irrigation, Irrigation-general, Salinity, Soil Environment, ...3.0199

RECLAMATION AND MANAGEMENT OF SOILS ON IRRIGABLE LAND (MONTANA) ...Internal Water Movement, Irrigation, Management, Saline Soils, Velocity -water, ...4.0159

STUDIES IN SOILS AND AGRONOMIC PRACTICES - SHOSHONE PROJECT, WYOMING ...Air - Water - Plant Relations, Big Horn, Management, Physical Properties-general, Rates Or Levels of Application, ...3.0494

EFFECTS OF MARGINAL QUALITY IRRIGATION WATER ON THE ACCUMULATION OF SALTS AND ALKALI IN SOUTH DAKOTA SOILS ...Irrigation-general, Saline Soils, Soil pH , South Dakota, Use of Impaired Water, ...3.0434

QUALITY OF IRRIGATION RETURN FLOW ...Internal Water Movement, Irrigation, Irrigation-general, Salinity, Water Quality-general, ...5.1196

SOILS AND NUTRIENT CULTURE EXPERIMENTS TO DETERMINE THE EFFECTS OF VARIABLE SALINITY CONDITIONS ON CITRUS BEHAVIOR ...Citrus, Irrigation, Saline Soils, Salinity, Trees, ...3.0086

IMPURITIES OF IRRIGATION WATERS AFFECTING SOIL PROPERTIES ...Irrigation-general, Saline Soils, Soil Environment, Use of Impaired Water, Water Quality-general, ...3.0043

EFFICIENT ESTABLISHMENT AND PRODUCTION OF FORAGE CROPS ON IRRIGATED LANDS ...Irrigation, Management, Soil-water-plant Relationships, Space Competition, Yield, ...2.0733

RECLAMATION OF SALTY LANDS IN PUERTO RICO ...Puerto Rico, Saline Properties, Sodium, Soil Amendments, Soil and Rock Leaching, ...3.0426

MANAGEMENT OF SALINE WATER FOR CROP PRODUCTION ...Arizona, Brackish Water, Management, Use of Impaired Water, Water Quality-general, ...3.0014

DRAINAGE DESIGN IN RELATION TO SOIL SALINITY ...California, Drainage, Drainage Engineering, Movement, Availability, Soil and Rock Leaching, ...3.0046

IMPROVEMENT OF IRRIGATION MANAGEMENT AND SALINITY CONTROL IN THE IMPERIAL VALLEY. ...Drainage, Drainage Engineering, Management, Sprinkler Irrigation, Water Table Fluctuation, ...3.0048

RELATIONSHIP BETWEEN IRRIGATION WATER COMPOSITION AND SOIL PROPERTIES ...California, Clovers -red,alsike,ladino... , Irrigation-general, Movement, Availability, Salinity, ...3.0034

FEASIBILITY OF THE ESTABLISHMENT OF PERMANENT SALINE-TYPE AGRICULTURE ON ALLUVIAL SOILS OF THE PECOS RIVER VALLEY OF TEXAS ...Irrigation, Irrigation-general, Soil Chemical Properties, Soil Conditions, Soil-water-plant Relationships, Texas, ...3.0447

THE IMPROVED USE OF WET AND SALTED SOILS FOR FORAGE PRODUCTION ...Cultivation Methods, Ns, Excessive Moisture, Management, Saline Soils, Utah, ...3.0474

IRRIGABLE LAND SUITABILITY STUDY ...Analog Computers, Irrigation-general, Percolation, Water Quality-general, ...6.0092

EFFECTS OF USING SALINE AND INDUSTRIAL WASTE WATERS ON YIELD AND QUALITY OF PLANTS ...Brackish

Water, Industrial Wastes, Irrigation, Irrigation-general, Soil and Rock Leaching, Soil-water-plant Relationships, ...**3.0258**

THE EFFECT OF BRACKISH WATER ON PLANTS AND SOIL IN THE SOUTH ...Brackish Water, Irrigation, Soil-water-plant Relationships, Southern, ...**3.0192**

IMPROVEMENT AND MANAGEMENT OF SALINE AND SODIC SOILS OF THE NORTHERN PLAINS ...Growth Rate, Saline Soils, Soil - Alkaline, Soil Amendments, ...**3.0385**

SALINE AND SODIC SOILS AND IRRIGATION WATER QUALITY PROBLEMS IN THE RIO GRANDE RIVER BASIN ...Irrigation-general, Management, Saline Soils, Soil and Rock Leaching, Water Quality-general, Yield, ...**3.0466**

SURFACE AND SUBSURFACE IRRIGATION SYSTEMS FOR COASTAL CALIFORNIA ...Agricultural Watersheds, Citrus, Salinity, Subsurface Irrigation, Surface Irrigation -general, ...**3.0091**

MOVEMENT OF WATER AND AIR TO AND INTO PLANT ROOTS IN SOILS OF THE GREAT BASIN ...Air - Water - Plant Relations, Root Absorption, Soil Amendments, Soil Analysis, Soil-water-plant Relationships, ...**2.0729**

Soil Management -non-specific

CHEMISTRY OF BORON IN CALIFORNIA SOILS ...Absorption, Fixation, Exchange, Boron, Phytotoxic, Soil Amendments, Soil and Rock Leaching, Soil Morphology, Profiles, ...**5.0080**

BORON CHARACTERISTICS AND RECLAMATION NEEDS OF SOILS IN WESTERN KERN COUNTY ...Boron, ...**3.0087**

COAL STRIP MINE WATERSHED STUDY ...Aquatic Ecology, Coal-general, Mining Activities, Pollution - Effects of , Stream Rehabilitation, Strip Mines, ...**2.0980**

SPECTRAL RECONNAISSANCE FOR DIAGNOSIS OF SOIL AND WATER MANAGEMENT PROBLEMS ...Field, Management, Reflectance, Remote Sensing, Soil-water-plant Relationships, Spectral Reflectance, ...**3.0465**

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THE EFFECT OF BENCH LEVELING AND CONTRIBUTING WATERSHED AREAS ON SOIL MOISTURE STORAGE AND CROP YIELDS IN THE ROLLING PLAINS ...Agricultural Watersheds, Clay, Conservation & Management Eng, Water Costs, Yield, ...**3.0449**

WATER YIELD IMPROVEMENT FROM SOIL TREATMENTS AND PLANT-COVER ALTERATIONS (ABBREV) ...Cover Crops, Precipitation -non-specific, Soil-water-plant Relationships, Water Yield, Watersheds-general, ...**4.0249**

Stubble Mulching

THE EFFECT OF SUBSOIL TREATMENT ON SOIL CONDITIONS, CROP GROWTH, AND RUNOFF ...Modified Water Use, Runoff, Soil Conditions, ...**3.0222**

Tillage, Cropping Systems

CULTURAL PRACTICES ON EASTGATE BASIN ...Cultivated Soils, Moisture Content, Sediment Yield, Sheetflow, Surface Flow, ...**4.0168**

FRAIL LANDS STUDIES NEAR CISCO, UTAH (ABBREV) ...Erosion-general, Land, Sediment Yield, Soil Environment, Utah, ...**4.0255**

WATER MOVEMENT CONTROL AND CULTURAL PRACTICES IN COTTON PRODUCTION ...Conservation & Management Eng, Cotton, Management, Soil Tillage Methods -other, Sub - Humid, Water Yield, ...**2.0003**

DRYLAND SOIL MANAGEMENT ...Colorado, Evapotranspiration, Management Effects, Modified Water Use, Soil-water-plant Relationships, Wind Erosion, ...**2.0208**

WATER ABSORPTION BY ASPARAGUS ...Modified Water Use, Mulches -other, Root Absorption, Soil-water-plant Relationships, ...**2.0252**

MANAGEMENT OF FLATWOOD SOILS ...Depth, Sand, Water Table - Depth of , Water Table Fluctuation, ...**6.0153**

THE PERSISTENCE IN AN ERODED SOIL OF TILTH IMPROVEMENT ENGENDERED BY A SOD-BASED ROTATION ...Infiltration, Physical Properties-general, Soil Environment, Soil Physical Properties, Soil Tillage Methods -other, ...**2.0343**

DEVELOPMENT OF LAND USE EQUATIONS FOR THE SLOPING SOILS OF INDIANA ...Development of Models, Erosion-general, Indiana, Land Use, Slopes, ...**2.0464**

EFFECT OF SOIL DISTURBANCE ON THE PRESSURE HEAD OF SOIL WATER ...Disturbed/undisturbed, Moisture Tension, ...**2.0680**

SOIL AND WATER CONSERVATION MANAGEMENT ...Conservation-general, Erosion-general, Soil Erosion -non-specific, Yield, ...**4.0150**

FERTILITY RUNOFF ...Erosion-general, Irrigation, Runoff, ...**4.0154**

ENGINEERING AND AGRONOMIC STUDIES ASSOCIATED WITH LAND SHAPING, ETC. ...Conservation & Management Eng, Erosion-general, Nebraska, Water Loss Control, ...**4.0163**

EVALUATION OF EXTENSIVE IRRIGATION ...Automated Equipment, Economic Efficiency, Irrigation Engineering, Runoff, Sprinkler Irrigation, ...**3.0381**

DEVELOPMENT OF TILLAGE-REPLACING HERBICIDE SYSTEMS ...Contamination, Pollution-water, Pesticides, Runoff, ...**5.0884**

SOIL SURFACE MANAGEMENT PROCEDURES FOR SOIL AND WATER CONSERVATION ...Conservation, Conservation-general, Plant Residues, Humus, Compost, Yield, ...**2.0878**

SOIL MOISTURE EVAPORATION AND ITS CONTROL ...Alcohols, Antitranspirants, Evaporation, Organometallic, Soil Environment, Soil Physical Properties, Water Loss Control, ...**2.0969**

DEVELOPMENT OF A CHEMICAL FALLOW SYSTEM OF FARMING ...Great Plains Province, Herbicides -non-specific, Moisture Retention, Rotations, Runoff, ...**4.0236**

SOIL PHYSICAL CHANGES DUE TO MANAGEMENT PRACTICES ...Arizona, Management, Management Effects, Yield, ...**2.0050**

INVESTIGATION OF SOIL AND WATER LOSSES THROUGH CROPPING SYSTEMS AND SOIL MANAGEMENT PRACTICES ...Runoff, Soil - Crop Relationships, Soil Environment, Surface Flow, ...**3.0195**

MANAGEMENT OF SOILS IN DRYLAND REGIONS ...Runoff, ...**4.0112**

SOIL MANAGEMENT UNDER DRYLAND CONDITIONS ...Erosion-general, Management, Modified Water Use, Soil Conditions, Storage of Water, ...**4.0113**

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INVESTIGATION OF PLANE STRAIN ...Deformation, Granular-general, Shear Strength, Soil Testing-other, Triaxial, ...**8.0233**

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WATER ADSORPTION AND ITS INTERACTIONS WITH CLAY AND QUARTZ ...Adsorption Capacity, Clay, Internal Water Movement, Quartz, Subsurface Flow, ...**2.0663**

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SOIL-WATER RELATIONS OF HAWAIIAN SOILS ...Hawaii, Irrigation-general, Mineralogy, Moisture Retention, Permeability, Soil Tests, ...**2.0374**

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STUDIES OF EQUATIONS FOR SEEPAGE LOSS FROM CANALS ...Canals, Lining, Loss, Open Channel, Permeability, ...**8.0129**

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EVALUATION OF SOIL MECHANICS LABORATORY EQUIPMENT AND RESTING PROCEDURES ...Cohesive Soil-general, Direct Shear and Plane Shear, Pore Water, Soil Sampling, Triaxial, ...**7.0067**

SHEAR STRENGTH OF ROCK FILL ...Earth & Rockfill Dams, Engineering Structures-general, Granular-general, Shear Strength, Triaxial, ...**8.0016**

APPLICATIONS OF RESEARCH TO VARIATIONS IN SHEAR AND CONSOLIDATION TESTING ...Capillarity, Density, Pore Water, Shear Strength, Triaxial, ...**8.0060**

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DEVELOPMENT OF SOIL TESTING PROCEDURES AND ANALYSIS OF RESULTS ...Compaction, Petrography, Soil Sampling, Triaxial, Vane, ...**8.0084**

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DRAINAGE INVESTIGATIONS OF PROPOSED IRRIGATED SOILS IN ...Drainage, Irrigation-general, Soil Environment, ...**2.0974**

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FACTORS INFLUENCING THE FLOW OF SUBSOIL WATER IN THE IMMEDIATE PROXIMITY OF AND INTO DRAINAGE FACILITIES ...Design Criteria, Drainage Systems, Filters, Other, Seepage, ...**4.0200**

VARIATION OF SATURATED HYDRAULIC CONDUCTIVITY OF HOUSTON BLACK CLAY WITH SOIL DEPTH AND WITH DIAMETER OF SOIL COVES ...Clay, Density, Texas, ...**2.1022**

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SOIL SAMPLING MANUAL ...Disturbed/undisturbed, Handbooks, Soil Exploration, Soil Sampling, Soil Test - Insitu, ...**8.0238**

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CHARACTERISTICS OF SOILS UNDER SUSTAINED STRESS ...Clay, Creep and Rheology, Pore Water, Shear Strength, Soil Environment, ...**8.0007**

INVESTIGATION OF PLANE STRAIN ...Deformation, Granular-general, Shear Strength, Soil Stresses, Triaxial, ...**8.0233**

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SHEAR STRENGTH OF ROCK FILL ...Consolidation, Earth & Rockfill Dams, Engineering Structures-general, Granular-general, Shear Strength, ...**8.0016**

PORE-PRESSURE MEASURING REFINEMENTS IN SOILS FOR SHEAR AND CONSOLIDATION ...Capillarity, Cohesive Soil-general, Pore Water, Pressure, Technique Development, ...**8.0080**

SOIL PRESSURES ON FLEXIBLE STEEL PIPE ...Model Studies, Pipes, Pressure-general, Soil-structure Interaction, ...**8.0072**

DEVELOPMENT OF SOIL TESTING PROCEDURES AND ANALYSIS OF RESULTS ...Compaction, Direct Shear and Plane Shear, Petrography, Soil Sampling, Vane, ...**8.0084**

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EFFECTS OF EARTHQUAKES ON SOIL PERFORMANCE ...Earthquakes, Foundations-general, Pore Water, Soil Dynamics, Soil Liquefaction, ...**8.0061**

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ENGINEERING CHARACTERISTICS OF THE BOTTOM SEDIMENTS OF GREAT SALT LAKE ...Engineering Structures-general, Great Salt Lake, Soil - Bearing Capacity, Soil Exploration, Soil Test - Insitu, ...**8.0294**

FACTORS AFFECTING STABILITY OF ARTIFICIAL AND NATURAL CHANNELS ...Channels, Cohesive Soil-general, Hydraulic Gradient, Open Channel, Soil Stability Analysis, ...**8.0034**

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INVESTIGATION OF CONCRETING MATERIAL (OTHER THAN AGGREGATE AND CEMENTITIOUS MATERIALS) ...Cement, Concrete, Construction Materials-other, Test Methods, ...**8.0247**

RESEARCH IN MASS CONCRETE ...Aggregates, Extenders, Fillers, Cement, Concrete, ...**8.0250**

TENSILE CRACK EXPOSURE TESTS ...Beams - Bars, Cement, Concrete, Crack Initiation, Propagation, Reinforcing Steel, Weathering, ...**8.0252**

CONCRETE AGGREGATE RESEARCH ...Aggregates, Extenders, Fillers, Cement, Concrete, Chert, Non-foliated Rocks, Sandstones, Test Methods, ...**8.0237**

RESEARCH ON PROPERTIES OF CEMENTITIOUS MATERIAL ...Cement, Concrete, Mechanical Properties-general, Physical Properties-general, Test Methods, ...**8.0249**

EVALUATION AND DEVELOPMENT OF SPECIFICATIONS AND TEST METHODS FOR CEMENT AND POZZOLAN ...Cement, Concrete, Composition Parameters-other, Compression, Quality Control-materials, Test Methods, ...**8.0101**

COATING TECHNOLOGY ...Coatings-general, Humid, Paint - General, Sealant Materials, Surface Cleaning, Finishing, ...**8.0131**

NEW ROOFING SYSTEMS ...Domestic Structural, Elastomers Rubber, Roofs, Weathering, ...**8.0078**

SCREENING TESTS ON NEW ASPHALTIC, PLASTIC, AND RUBBER PRODUCTS ...Bituminous, Elastomers Rubber, Test Methods, ...**8.0079**

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AN ECONOMIC ANALYSIS OF THE PUBLIC WATER SUPPLY DISTRICT ...Economics-general, Management, Social Aspects, Water Supply-general, ...**6.0322**

SYSTEMATIC ANALYSIS OF MANAGEMENT EFFECTIVENESS OF THE WATER QUALITY CONTROL BOARD SYSTEM OF CALIFORNIA ...California, Management, Model Studies, Operations Research, Water Quality Control-general, ...**6.0035**

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EVALUATION OF PHYSICAL AND ECONOMIC EFFECTS OF IMPOUNDMENTS AND RELEASES ON UPSTREAM AND DOWNSTREAM WATER QUALITY ...Benefit-cost Analysis, Productivity - Food Chain, Reservoirs and Impoundments, Stratification, Water Quality Control-general, ...**6.0128**

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TERTIARY TREATMENT OF COMBINED STORM WATER, SANITARY RELIEF DISCHARGE AND SEWAGE TREATMENT PLANT EFFLUENT ...Activated Carbon, Combined Sewer, Filtration, Pilot Plant, Process Design, Sedimentation, ...**5.0387**

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AN ENGINEERING INVESTIGATION OF STORM AND COMBINED SEWER PROBLEMS ...Combined Sewer, Land Use, Nonstructural Alternative, Pollution Abatement, Runoff, ...**5.0229**

A METHOD FOR ASSESSING THE EXTENT OF POLLUTION FROM STORMWATER RUNOFF FROM AN URBAN AREA ...Combined Sewer, Construction-other, Runoff, Urban Environments, Urban Research, Waste Treatment-economics, ...**5.0090**

DEVELOP AND DEMONSTRATE A METHOD FOR ASSESSING THE EXTENT OF POLLUTION FROM STORM WATER RUNOFF IN AN URBAN AREA ...Alternative Planning, Combined Sewer, Iowa, Nutrients, Urban Environments, ...**5.0705**

A PILOT FACILITY TO DEMONSTRATE OFF-SHORE, UNDERWATER, TEMPORARY STORAGE OF STORM OVERFLOW FROM A COMBINED SEWER ...Combined Sewer, Pumping Stations, Storage of Water, Storage-retention-facilities, Tanks, ...**5.0838**

PRIMARY TREATMENT OF STORM WATER OVERFLOW FROM COMBINED SEWERS BY HIGH RATE FINE MESH SCREENS ...Combined Sewer, Filtration, Industrial Waste-other, Primary Treatment, Screening, ...**5.0931**

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ENGINEERING INVESTIGATION OF STORM WATER INFILTRATION INTO SANITARY SEWERS OF THE EAST BAY MUNICIPAL UTILITY DISTRICT ...Benefit-cost Analysis, Combined Sewer, Infiltration, San Francisco Bay, Water Quality Control-general, ...**5.0123**

DEMONSTRATION UNDERWATER FACILITY - STORM OVERFLOW ...Combined Sewer, Elastomers Rubber, Polyamides, Pressure Ussel Materials, Storage-retention-facilities, ...**5.0246**

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STORM WATER DEMONSTRATION PROJECT - CITY OF SOMERSWORTH, NEW HAMPSHIRE ...Additives, Chlorination, Combined Sewer, Polymer Type-other, ...**5.0710**

A COMBINED SEWERAGE COLLECTION AND TREATMENT FACILITY ...Aeration, Combined Sewer, Lakes, Sand, ...**5.0581**

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COOK STREET STORM WATER OXIDATION POND ...Pond, Separated-sewers, Storage-retention-facilities, Urban Environments, ...**5.0346**

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STORM RUNOFF AND FLOODS AS RELATED TO INTEGRATED CLIMATIC AND WATERSHED CHARACTERISTICS ...Climate, Floods, Land Use, Morphology-general, Runoff, ...**4.0071**

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APPLICATION OF SEISMIC SHEAR WAVE STUDIES TO THE INVESTIGATION OF AQUIFERS ...Aquifers-general, Geophysical Analysis, Shear, Technique Development, Velocity, ...**4.0137**

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THE WILCOX GROUP IN TEXAS ...Clastic Aquifers, Groundwater, Sedimentary History, Specific Rock Unit, Texas, ...**2.1007**

GEOLOGY AND HYDROLOGY OF THE PRESIDIO BOLSON, TEXAS AND ADJACENT MEXICO ...Bolsons, Groundwater, Hydrology-general, Sedimentary Basins, Water Yield, ...**2.1011**

GROUND-WATER GEOLOGY OF DEKALB AND BOONE COUNTIES, ILLINOIS ...Aerial, Clastic Aquifers, Deposits, Geophysical Analysis, Groundwater, Mapping, ...**4.0096**

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STRUCTURAL CONTROL OF SPRINGS FROM THE MUAV AQUIFER IN WESTERN GRAND CANYON NATIONAL PARK, ARIZONA ...Carbonate Aquifers, Groundwater Movement, Seasonal, Springs, Tectonics-general, ...**2.0054**

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HYDROLOGY OF THE COLUMBIA RIVER BASALT ...Columbia Plateaus, Hydrology-general, Igneous Rocks, Infiltration, Runoff, Tectonics-general, ...**2.0905**

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HYDROGEOLOGIC MAPPING OF PALEOCENE SEDIMENTS, WESTERN TENNESSEE ...Clastic Aquifers, Mapping, Surficial Geology, Tennessee, Tertiary Period, ...**2.0995**

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CHARACTERISTICS OF RIVER BANKS RELATED TO VEHICLE PERFORMANCE WHEN ENTERING & EXITING STREAMS ...Amphibious Vehicles, Statistics-general, Streams, Synthetic Hydrology-general, Water Vessel, ...**7.0058**

EFFECTS OF BANK SEEPAGE ON FLOOD HYDROGRAPHS ...Floods, Hydrographs, Leekage, Seepage, Storage of Water, ...**2.0504**

EFFECTS OF VARIOUS FOREST TYPES AND STAND TREATMENTS ON GROUNDWATER RECHARGE AND STREAMBANK EROSION IN AREAS OF DEEP GLACIAL DRIFT ...Erosion Control, Erosion-general, Forest Watersheds, Natural Recharge, Open Channel, ...**5.0573**

MORPHOLOGY AND STABILITY OF STREAM CHANNELS IN SOUTHWESTERN SEMIARID RANGELAND WATERSHEDS ...Channel Filling, Channels, Cross-section, Gullys - Arroyos, Sediment Yield, ...**5.0757**

MORPHOLOGY AND STABILITY OF STREAM CHANNELS IN SOUTHERN CALIFORNIA ...Channel Filling, Channels, Cross-section, Gullys - Arroyos, Sediment Yield, ...**5.0103**

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INVESTIGATION OF WATER RESOURCES IN ALASKA ...Gaging, Hydrology-general, Measurement, Open Channel, ...**2.0269**

OPERATION RIVERPORTS ...Canals, Harbors, Mississippi River, Missouri River, Water Transportation, ...**6.0183**

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MODEL RIVER SYSTEM STUDIES ...Flume Studies, Mathematical Analysis, Model Studies, Radioactivity-general, Turbidity, ...**2.1010**

RESEARCH AND BASIC DATA ON THERMAL POLLUTION ...Diffusion, Dissipation, Eddies, General Synoptic Observations, Mixed Modes, Thermal Pollution, ...**4.0058**

REPOPULATION OF EXPERIMENTALLY DECIMATED AREAS BY STREAM FISHES ...Aquatic Ecology, Control of Nuisance Species, Fish -non-specific, Louisiana, Population Dynamics, Stream Rehabilitation, ...**5.0460**

THE PREDICTION AND OPTIMIZATION OF STREAM RESPONSES TO POLLUTANT WASTES ...Forecasting-prediction, Mathematical Analysis, Model Studies, Physical Parameters, Pollution - Effects of , ...**5.0743**

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WATERFOWL UTILIZATION OF SAGO PONDWEED (POTAMOGETON PECTINATUS) ON A SELECTED MARSH IN NORTHERN UTAH ...Food Supply, Mallard, Potamogeton, Ruppia, Zostera.., Storage, Utah, ...**6.0588**

EFFECTS OF RESTORATION AND MANAGEMENT OF THE SAN SIMON MARSH ON ITS UTILIZATION BY MEXICAN DUCKS ...Food Supply, Management, Mexican Duck, Spawn Or Nesting Sites, Water Utilization -animal, ...**6.0364**

AN ANALYSIS OF PHOSPHORUS AND NITROGEN COMPOUNDS IN TIDAL MARSHLAND DRAINAGE - LABORATORY PROCEDURES ...Colorimetric, Computers-general, Conductrometry, Management, Nitrogen, Phosphate, Phosphite, ...**1.0024**

SPECIES AND SUCCESSIONAL CONTROL OF UNDESIRABLE VEGETATION ...Control By Burning, Cultural Control, in Wetlands, Physical Control, Plant Succession, ...**6.0403**

ANALYSIS OF VEGETATIVE CHANGES RESULTING FROM WATER LEVEL CONTROL ...Biomes (non-specific), Mapping, North Carolina, Water Level Fluctuation, ...**4.0184**

BIOCHEMICAL EFFECTS OF MICROORGANISMS UPON THE SALT MARSH ENVIRONMENT -...Bacterial Pollutant Sources, Identification, Laboratory, Marine Bacteria (non-specific), Salinity, ...**1.0025**

BIOCHEMICAL EFFECTS OF MICROORGANISMS UPON THE SALT MARSH ENVIRONMENT -...Aquatic Soils, Chemical, Core Analysis, Microorganisms (non-specific), Salinity, Tidewater Areas, ...**1.0026**

MARSH HABITAT STUDY ...Centrarchidae -other, Chemical-general, Florida, Habitat Studies, Life History Studies, ...**6.0157**

VEGETATIVE SUCCESSION IN NEWLY CONTROLLED MARSHES ...Environmental Ecology, Growth Rate, Plant Succession, South Carolina, Water Level Fluctuation, ...**4.0215**

WATERFOWL STUDY-EVALUATION OF PHYSICAL CHANGES IN MARSH PONDS ON THE WISNER AND BILOXI DEVELOPMENT ...Land Use, Management, Mississippi, Physical-general, Survey Studies, Water Fowl, N.s. , ...**4.0128**

UPDATING AND REPUBLICATION OF FACTORS INFLUENCING THE RESTORATION AND DEVELOPMENT OF OGDEN BAY REFUGE ...Mans Activities, Pubilications -other, Water Demand, Water Fowl, N.s. , Water Utilization -animal, ...**6.0594**

ECOLOGICAL PERIODICITIES OF NITROGEN AND PHOSPHORUS IN SALT MARSH FLORA AND SURROUNDING WATERS ...Mineral Composition, ...**6.0118**

THE BIOLOGY AND CONTROL OF TABANIDAE IN MARSHLANDS ALONG THE EASTERN SHORE OF THE GREAT SALT LAKE, UTAH ...Flies -horse,deer, Great Salt Lake, Habitat Studies, Management, Survey Methods, ...**6.0596**

THE PERSISTENCE, ACCUMULATION AND FATE OF PESTICIDES IN CRANBERRY SOILS AND RESERVOIRS ...Blueberries, Cranberries, Chlorinated Hydrocarbons, Organophosphorous Cpds. , Persistence in Soils, Reservoirs and Impoundments, ...**5.0533**

AN EVALUATION OF SOME MARSH MANAGEMENT TECHNIQUES ...Management, Potholes, Spawn Or Nesting Sites, Water Fowl, N.s. , Water Utilization -animal, ...**4.0107**

WATER QUANTITY AND QUALITY REQUIREMENTS ON WESTERN SALINE MARSHLANDS ...Habitat Studies, Utah, Water Allocation, Water Fowl, N.s. , Water Quality-general, ...**6.0582**

ECOLOGICAL STUDIES OF MANIPULATED MARSHES AT DELTA, MANITOBA, CANADA ...Amphibious Plants, Canada, Submerged Plants, Water Depth, Water Levels, Water Fowl, N.s. , ...**4.0257**

THE EFFECTIVENESS OF WATERFOWL IN CARRYING PATHOGENIC MICRO-ORGANISMS ...Sewage, Utah, Vertebrates, Water Fowl, N.s. , ...**5.1193**

FACTORS LIMITING WATERFOWL PRODUCTION ON THE SPRING-FED SALT MARSHES WEST OF THE GREAT SALT LAKE ...Mallard, Nutrition -other, Productivity (agricultural), Utah, Viremia, ...**5.1194**

REHABILITATION, SCOTSBURN MARSH, NOVA SCOTIA, CANADA ...Canada, Engineering Structures-general, Habitat Studies, Water Level Fluctuation, ...**4.0053**

ECOLOGICAL STUDIES OF WILDLIFE MANAGEMENT PRACTICES ...Delaware, Depth,water Level, Fluctuation, Habitat Studies, Management, Wildlife -non-specific, ...**6.0119**

WATER TABLE CONTROL IN ORGANIC SOILS ...Drainage, Linings-pavings, Moisture Retention, Soil-water-plant Relationships, Water Table Fluctuation, ...**4.0079**

WATER RELATIONS WITH CITRUS ON THE FLATWOODS AND MARSHES OF THE EAST COAST ...Citrus, Drainage, Saline Soils, Sprinkler Irrigation, Water Table Fluctuation, ...**2.0310**

WATERSHED VALUES AS AFFECTED BY FOREST MANAGEMENT ...Cover Crops, Erosion-general, Forest Watersheds, Forests, Moisture Content, Runoff, ...4.0142

EFFECTS OF PESTICIDES ON ESTUARINE ORGANISMS ...Bioassay, Estuaries, Persistance of Residues, Pollution - Effects of , Sevin, ...5.0950

EFFECTS OF REGULATED GRAZING ON WATERFOWL PRODUCTION ...Cutting &/or Grazing Effects, Productivity - Food Chain, Soil (wildlife) Cover, Water Fowl, N.s. , ...6.0584

BIOLOGICAL PRODUCTIVITY RELATED TO HYDROLOGIC CONDITIONS ...Aquatic Ecology, Plant Prod. (non-specific), Productivity - Food Chain, Water Level Fluctuation, Water Quality-general, ...2.0317

REMOTE SENSING, EVERGLADES AREA, FLORIDA ...Computers-general, Florida, Remote Areas, Visible Light, Water Properties-general, ...2.0329

BIOLOGY AND CONTROL OF SALT-MARSH AND RICE-FIELD MOSQUITOES IN GULF COAST AREAS ...Aquatic Ecology, Computer Matching Code, Louisiana, Mosquitoes -non-specific, Predators and Parasite, ...2.0576

CONTROL OF INSECT VECTORS ON WATERFOWL MARSHES ...Cultural Control, Great Salt Lake, Insecticides -non-specific, Land Use, Management, ...4.0263

THE EFFECT OF SELECTED PESTICIDES ON INTERTIDAL BIOTA ...Insecticides -non-specific, Intertidal Areas, Pesticides - non-specific, Pollutants-general, Pollution Effects, Productivity - Food Chain, ...5.0522

Swimming Pools

TREATMENT AND CONDITIONING OF WADING AND SWIMPOOL WATERS ...Chlorination, Economic Efficiency, Filtration, ...5.0172

Swine Husbandry

Management

DISPOSAL OF WASTES FROM SWINE FEEDING FLOORS TO MINIMIZE STREAM POLLUTION ...Animal Waste Removal-treatment, Animal Wastes - Feed Lots, Farm Wastes, Process Design, Streams, ...5.0500

Synthetic Hydrology

Design Flow-flood

ANALYSIS OF RUN-OFF FROM SMALL DRAINAGE AREAS ...Drainage, Floods, Massachusetts, Runoff, Small Watersheds, ...2.0612

INVESTIGATION AND ANALYSIS OF FLOODS FROM SMALL DRAINAGE AREAS IN SOUTH CAROLINA ...Culvert, Drainage, Floods, Small Watersheds, South Carolina, ...2.0301

PROGRAM FOR HYDROLOGIC INVESTIGATION OF SMALL DRAINAGE AREAS IN TEXAS ...Drainage, Floods, Hydraulic Structures, Small Watersheds, Texas, ...2.0296

PROBABLE MAXIMUM PRECIPITATION FOR SOUTHWEST STATES ...Amount, Floods, Patterns, Snowmelt, Southwest, Weather Forecasting, ...2.0597

RAINFALL FREQUENCY RELATIONS FOR PENNSYLVANIA ...Amount, Gages, Hydrographic, Pennsylvania, Weather Charts-maps, ...2.0926

FLOOD FREQUENCY STUDIES ...Floods, Tennessee, ...2.0982

WATER DISPATCHING OPERATIONS BY ELECTRONIC COMPUTER ...Daily, Dynamic Control System, Electric Power Plants, Inflow, Power Generation, Reservoirs and Impoundments, ...2.0984

BEECH RIVER WATERSHED PROJECT ...Forest Watersheds, Land Use, Reservoirs and Impoundments, Sediment Yield, Tennessee, ...4.0222

HYDROLOGIC SIMULATION - DAILY STREAMFLOW ...Antecedent Moisture, Floods, Forecasting-prediction, Hydrology-general, Reservoirs and Impoundments, ...6.0073

FLOOD INUNDATION MAPPING - JEFFERSON COUNTY, MISSOURI ...Floodproofing, Floods, Flow Characteristics -water, Mapping, Missouri, ...4.0157

CHANNEL CAPACITY IN STONY CREEK NEAR ORLAND, CALIFORNIA ...California, Channels, Peak Flow, Reservoirs and Impoundments, Water Transfer, ...2.0122

FLOOD INUNDATION STUDY, WISCONSIN ...Channels, Floodproofing, Floods, Mapping, Wisconsin, ...4.0278

HYDRAULIC DESIGN OF STRUCTURES FOR WATER USE AND CONTROL IN THE SOUTHERN PLAINS ...Agricultural Watersheds, Design Criteria, Hydraulic Structures, Models, Water Loss Control, ...8.0277

EROSION AND RUNOFF CONTROL PRACTICES AND SYSTEMS TO CONSERVE SOIL AND WATER RESOURCES IN THE PACIFIC NORTHWEST ...Conservation, Conservation-general, Erosion-general, Runoff, Southern, ...4.0087

Hydrographs

FLOOD FREQUENCY OF SMALL STREAMS IN LOUISIANA ...Drainage, Floods, Louisiana, ...2.0541

INFLOW HYDROGRAPH STUDY ...Floods, Inflow, Shape, Small Watersheds, Wyoming, ...2.0302

SMALL STREAMS INVESTIGATIONS IN OREGON ...Data Analysis - General, Discharge-general, Floods, Gaging, Peak Flow, ...2.0293

INVESTIGATION AND ANALYSIS OF FLOOD HYDROGRAPHS FROM SMALL DRAINAGE BASINS IN SOUTH DAKOTA ...Bridges & Culverts, Culvert, Drainage, Floods, Rain-general, Small Watersheds, ...2.0294

SURFACE WATER MANAGEMENT ...Channels, Forest Watersheds, Mountains-alpine, Seepage, Soil-water-plant Relationships, ...4.0060

RUNOFF STUDIES ON SMALL WATERSHEDS ...Runoff, Small Watersheds, Subsurface Flow, Surface Water, Water Yield, ...2.1138

REVIEW AND ANALYSIS OF PRECIPITATION AND RUNOFF DATA FOR SELECTED WATERSHEDS IN MINNESOTA ...Floods, Infiltration, Precipitation-general, Runoff, Watersheds-general, ...4.0140

HYDROLOGY OF FROZEN GROUND FLOODS ...Floods, Infiltration, Moisture Content, Permafrost-frozen, Runoff, ...2.0399

URBAN HYDROLOGIC RELATIONSHIPS ...Drainage, Forecasting-prediction, Runoff, Urban Environments, Variation in Time, ...2.0554

MATHEMATICAL SIMULATION OF HYDROLOGIC EVENTS ON UNGAGED WATERSHEDS ...Digital Computers, Runoff, Sensitivity Problems, Testing of Models, Watersheds-general, ...2.0461

HYDROLOGY OF SMALL DRAINAGE BASINS FOR DEVELOPING HYDRAULIC DESIGN ...Amount, Flow Characteristics - water, Runoff, Small Watersheds, South Dakota, ...2.0972

MATHEMATICAL SIMULATION OF RAINFALL RUNOFF PROCESSES ...Computers-general, Model Studies, Optimization, Other Computers, Runoff, Storms-general, ...2.1015

EFFECTS OF AREAL AND TIME DISTRIBUTION OF RUNOFF SUPPLY ON WATERSHED HYDROGRAPHS ...Mathematical Analysis, Model Studies, Other Model Modif, Runoff, Watersheds-general, ...2.0666

OPTIMUM LINEAR SYNTHESIS IN URBAN HYDROLOGY ...Error Analysis, Optimization Technique, Prediction, Runoff, Urban Environments, ...6.0287

EFFECTS OF BANK SEEPAGE ON FLOOD HYDROGRAPHS ...Floods, Leekage, Seepage, Storage of Water, Stream Banks, ...2.0504

PARAMETERIZATION OF THE OBSERVED HYDROGRAPH AS A MEANS OF UNDERSTANDING RUNOFF PHENOMENA FROM SMALL WATERSHEDS ...Forecasting-prediction, Model Studies, Runoff, Small Watersheds, Vermont, ...2.1085

INVESTIGATION OF A LINEAR MODEL TO DESCRIBE THE HYDROLOGIC PHENOMENON OF DRAINAGE BASINS ...Amount, Model Studies, Runoff, Small Watersheds, Testing of Models, ...2.1041

OVERLAND FLOW ANALYSIS FOR A SIMULATED VEGETATED SURFACE ...Flume Studies, Rainfall Simulators, Runoff, Streams, Unsteady Flow, ...2.0879

RUNOFF GENERATION AS A FUNCTION OF PRECIPITATION AND WATERSHED CHARACTERISTICS ...Amount, Runoff, Washington, Watersheds-general, ...2.1120

COMPUTER SIMULATION OF URBAN HYDROLOGIC SYSTEMS ...Analog Computers, Runoff, Texas, Urban Environments, Watersheds-other, ...4.0258

QUANTIFICATION AND PREDICTION OF THE INFILTRATION PHASE OF THE HYDROLOGIC CYCLE ...Infiltration, Internal Water Movement, Mathematical Analysis, Soil Environment, ...2.0468

ASSEMBLY AND ANALYSIS OF HYDROLOGIC AND GEOMORPHOLOGIC DATA FOR SMALL WATERSHEDS IN INDIANA ...Data Analysis - General, Geomorphology-general, Indiana, Small Watersheds, Streams, ...2.0459

DEVELOPING COMPUTER PROGRAMS FOR SOLUTION OF HYDROLOGIC PROBLEMS RELATED TO SMALL WATERSHEDS ...Climate-general, Forecasting-prediction, Physiography-general, Small Watersheds, Water Yield, ...**7.0102**

TREATING AN INADEQUACY OF THE UNIT HYDROGRAPH HYPOTHESIS BY STORAGE ROUTING WITH VARIABLE EMPIRICAL VALUES OF LAG AND STORAGE ...Amount, Arizona, Model Studies, Runoff, Storage of Water, ...**2.0063**

HYDROLOGIC ANALYSIS BY ANALOG COMPUTERS ...Analog Computers, Groundwater, Hydrology-general, Reservoirs and Impoundments, Routing, Surface Water, ...**2.0429**

FLOODS FROM SMALL DRAINAGE AREAS ...California, Floods, Gaging, Small Watersheds, ...**4.0039**

STREAMFLOW HYDROGRAPH SEPARATION ...Electrical, Geophysical Analysis, Groundwater, Hardness-minerals, Runoff, Surface Water, ...**2.0420**

MATHEMATICAL SIMULATION OF HYDROLOGIC EVENTS ON UNGAGED WATERSHEDS ...Hydrology-general, Mathematical Analysis, Model Studies, Research - Development, Runoff, Watersheds-general, ...**2.0462**

INVESTIGATION OF RAINFALL DISTRIBUTION ON URBAN RUNOFF FOR IMPERVIOUS AREAS ...Drainage, Model Studies, Patterns, Runoff, Urban Environments, ...**2.0306**

HYDROLOGIC MODEL FOR STREAMFLOW FORECASTING ...Flow Characteristics -water, Forecasting-prediction, Model Studies, Peak Flow, Precipitation-general, Runoff, ...**2.0600**

FLOOD HYDROGRAPH SYNTHESIS - UNGAGED WATERSHEDS ...Floods, Small Watersheds, Tennessee, ...**2.0981**

OPTIMIZATION TECHNIQUES FOR HYDROLOGIC ENGINEERING ...Floods, Hydrology-general, Optimization, Reservoirs, Reservoirs and Impoundments, Routing, ...**6.0075**

LOW-FLOW ANALYSIS, WASHINGTON STREAMS ...Baseflow, Discharge-general, Gaging, Low Flow, Washington, ...**2.1134**

UNIT HYDROGRAPHS FOR SOUTHWESTERN LOUISIANA ...Floods, Forecasting-prediction, Gaging, Louisiana, ...**2.0539**

UNIT HYDROGRAPHS FOR NORTHERN LOUISIANA ...Floods, Forecasting-prediction, Gaging, Louisiana, ...**2.0540**

WATER REOURCES OF SOUTHEASTERN WISCONSIN - RACINE AND KENOSHA COUNTIES ...Groundwater, Stratigraphy-general, Water Quality-general, Water Supply-general, Wisconsin, ...**2.1151**

STORM RUNOFF AND FLOOD FLOWS IN RELATION TO CLIMATIC AND WATERSHED CHARACTERISTICS ...Channels, Water Yield, Watersheds-general, ...**4.0206**

WATER ACCUMULATION, FLOOD-WAVE MOVEMENT AND WATER YIELD FROM COMPLEX WATERSHEDS OF THE PACIFIC NORTHWEST ...Channels, Floods, Forecasting-prediction, Idaho, Peak Flow, Storage of Water, Water Yield, Watersheds-general, ...**3.0202**

STREAM FLOW REGIMES ON A SEMIARID RANGELAND WATERSHED ...Agricultural Watersheds, Channels, Hydraulics-general, Runoff, Storms-general, ...**4.0178**

Routing

THE HYDRAULICS AND GEOMORPHOLOGY OF MEANDERING RIVERS WITH FLOOD PLAINS ...Floodplains, Floods, Flow Characteristics -water, Land Use, Meanders, ...**2.0473**

PHYSICAL, LEGAL AND ECONOMIC ASPECTS OF ASSESSMENT OF COSTS AMONG DRAINAGE DISTRICTS ...Drainage, Floodproofing, Floods, Flow Characteristics -water, Legal Review, ...**6.0228**

EVALUATION OF SELECTED COMPUTER PROGRAMS IN HYDROLOGY ...Hydrology-general, Model Studies, Runoff, Spillways, Storm Water, ...**2.0659**

LABORATORY TESTING OF HYDRAULIC FORMULATIONS FOR OPEN CHANNEL FLOW ...Channel Geometry, Channel Roughness, Open Channel, Systems of Equations, Transition Sections, Velocity, ...**2.0573**

HYDRAULICS OF FLOOD MOVEMENTS ...Analog Computers, Floods, Mathematical Analysis, Open Channel Flow, Partial, Unsteady Flow, ...**2.0348**

HYDROLOGIC ANALYSIS BY ANALOG COMPUTERS ...Analog Computers, Groundwater, Hydrographs, Hydrology-general, Reservoirs and Impoundments, Surface Water, ...**2.0429**

OPTIMIZATION TECHNIQUES FOR HYDROLOGIC ENGINEERING ...Floods, Hydrographs, Hydrology-general, Optimization, Reservoirs, Reservoirs and Impoundments, ...**6.0075**

HYDRAULIC DESIGN OF STRUCTURES FOR WATER USE AND CONTROL IN THE CORN BELT ...Construction, Corn Belt, Design Criteria, Model Studies, Water Control Works-general, ...**8.0216**

Synthetic Hydrology-general

CHARACTERISTICS OF RIVER BANKS RELATED TO VEHICLE PERFORMANCE WHEN ENTERING & EXITING STREAMS ...Amphibious Vehicles, Statistics-general, Stream Banks, Streams, Water Vessel, ...**7.0058**

FLOODS FROM SMALL WATERSHEDS ...Amount, Floods, Rural Areas, Small Watersheds, Systems Analysis, ...**2.0231**

SPATIAL BEHAVIOR OF ROUGHNESS IN LABORATORY WATERSHED, PHASE II ...Energy Loss -water, Model Studies, Roughness, Runoff, Structure-size, Surface Flow, ...**2.0703**

THE DETERMINATION OF ZONES OF INTENSE CONTRIBUTION TO STREAM FLOW AS RELATED TO THE CONCEPT OF PARTIAL AREA CONTRIBUTIONS ...Development of Models, Digital Computers, Model Studies, Runoff, Watersheds-general, ...**2.0580**

DEVELOPMENT AND EVALUATION OF HYDROLOGIC SIMULATION MODELS ...Model Studies, Runoff, South Carolina, Technique Development, Watersheds-general, ...**2.0954**

THE OPTIMUM RELEASE POLICY FOR A MULTIPURPOSE RESERVOIR USING STOCHASTIC HYDROLOGY ...Flow Augmentation, Multiple-purpose Projects, Reservoirs and Impoundments, Stochastic Models, Stochastic Processes, ...**6.0337**

AQUIFER PERFORMANCE TESTS UNDER TWO PHASE FLOW CONDITIONS ...Aquifers-general, Observation Wells, Subsurface Flow, Two-phase-other, ...**2.0008**

DYNAMIC MODEL STUDY OF LAKE ERIE ...Hydraulics-general, Inflow, Lake Erie, Model Studies, ...**5.0766**

SAND FILTRATION OF DISCRETE SUSPENSIONS ...Filtration, Flow Characteristics -water, Sand, Suspension, ...**5.0549**

MODEL STUDIES FOR DEVELOPMENT AND CALIBRATION OF STREAMFLOW CONTROL DEVICES IN THE SOUTHERN BRANCH ...Channel Regulation-general, Computers-general, Discharge-general, Gaging, Models, ...**3.0189**

RUNOFF INDUCEMENT IN ARID LANDS ...Arid and Desert, Infiltration, Linings-pavings, Runoff, Stabilization-general, Storage of Water, ...**3.0238**

PERFORMANCE CHARACTERISTICS OF LARGE SCALE HYDROMECHANICS LABORATORY EQUIPMENT ...Flume Studies, Inflow, Sedimentation, Turbulent Flow, ...**8.0195**

TURBULENT MIXING IN SURFACE AERATION ...Aeration, Diffuser, Dyes, Mixing, Turbulent Flow, ...**5.1061**

HYDRAULIC STUDIES AND RESEARCH ON CALIFORNIA WATER FACILITIES ...Flow Characteristics -water, Fluid Flow-general, Irrigation, Irrigation-general, Model Studies, ...**7.0010**

EXPERIMENTAL INVESTIGATION OF SMALL WATERSHED FLOODS ...Amount, Floods, Runoff, Small Watersheds, ...**2.0232**

DROUGHT FREQUENCY, INTENSITY & DURATION - ITS CORRELATION TO STREAMFLOW AND ITS IMPACT UPON SYNTHETIC HYDROLOGY ...Climatography, Flow Characteristics -water, Meteorological Extremes, Patterns, Water Loss-general, ...**2.0763**

EFFECTS OF SCALE AND OPERATING TECHNIQUE ON HARBOR MODELS ...Harbors, ...**7.0065**

GENERAL COASTAL INLET STUDIES ...Coastal Engineering-other, Coastlines-shorelines, Discharge-other, Model Studies, Tides, Velocity -water, ...**2.0689**

DISPERSION PROCESSES IN ESTUARIES AND RIVERS ...Dispersion -water, Dyes, Estuaries, Streams, ...**2.0118**

ECOLOGICAL ENGINEERING PROJECT ...Atmosphere Radiation, Nutrients, Temperature, Tracers-general, Velocity -water, ...**6.0159**

FUNDAMENTAL ASPECTS OF WATER EROSION IN THE PACIFIC NORTHWEST ...Erosion-general, Infiltration, Permafrost-frozen, Soil Erosion -non-specific, Southern, ...**2.0389**

Systems Analysis

SYSTEMS ANALYSIS FOR GROUNDWATER MANAGEMENT ...Economic Efficiency, Groundwater Basins, Management, Model Studies, Saline Water Intrusion, ...**5.0071**

FLOODS FROM SMALL WATERSHEDS ...Amount, Floods, Rural Areas, Small Watersheds, Synthetic Hydrology-general, ...**2.0231**

A COMPREHENSIVE WATER RESOURCES ANALYSIS OF A TYPICAL OVERDRAWN BASIN IN AN IRRIGATED SEMIARID AREA - PECOS RIVER BASIN, NEW MEXICO ...Impact, Land, Management, New Mexico, River Basins, ...**6.0366**

PREDICTION MODELS FOR WATER QUALITY PARAMETERS ...Model Studies, Oxygen, Projections and Estimations, Social Aspects, Temperature, Water Standards, ...**6.0164**

A STUDY OF BIOLOGICAL SYSTEMS IN THE SCIOTO RIVER AS INDICES TO WATER QUALITY ...Bioindicators, Chemical-general, Ohio, Physical-general, Water Sampling, ...**5.0875**

THE USE OF SYSTEMS ANALYSIS IN THE DEVELOPMENT OF WATER RESOURCES MANAGEMENT PLANS FOR NEW YORK STATE ...Management, Model Studies, New York, Planning, ...**6.0373**

SYSTEMS APPROACH TO WATER RESOURCE MANAGEMENT ...Administrative Structures, Economics-general, Legal Review, Model Studies, Social Aspects, Water Allocation, ...**6.0080**

AN OPTIMAL WATER MANAGEMENT PLAN FOR THE MIAMI VALLEY ...Alternative Planning, Artificial Recharge, Augmentation-general, Conjunctive Use, Floodproofing, Optimization Technique, ...**6.0467**

ADAPTING THE WATER RESOURCE PLANNING PROCESS TO PROBLEMS AND NEEDS OF METROPOLITAN AREAS ...Model Studies, Planning, River Basins, Urban Environments, Water Resources Development, ...**6.0402**

DEVELOPEMNT AND IMPLEMENTATION OF A MANAGEMENT STRATEGY FOR WATER RESOURCES RESEARCH ...Management, Operations Research, Planning, Projections and Estimations, Water Resources Development, ...**6.0112**

A SYSTEM APPROACH FOR INTEGRATING GROUNDWATER AND SURFACE-WATER USE ...California, Conjunctive Use, Groundwater, Water Quality Control-general, Water Utilization - general, ...**6.0037**

SYSTEMATIC STUDY AND DEVELOPMENT OF LONG-RANGE PROGRAMS OF URBAN WATER RESOURCES RESEARCH ...Data Acquisition-general, Economics-general, Projections and Estimations, Social Aspects, Urban Environments, Water Law-general, ...**6.0392**

OPTIMIZATION OF STEP AERATION WASTE TREATMENT PROCESSES ...Aeration, Development of Models, Dynamic Programming, Optimization, Process Design, ...**5.0426**

SURFACE AND GROUND WATER POTENTIALITIES OF THE MULLICA RIVER BASIN ...Aqueducts, Conjunctive Use, Economic Impact, Water Quality-general, Water Transfer, ...**4.0172**

THE ENGINEERING APPLICATIONS OF DISTRIBUTED AND MULTIVARIABLE SYSTEM THEORY TO THE DYNAMICS OF WATER POLLUTION CONTROL ...Optimization, ...**5.0728**

STOCHASTIC ANALYSIS OF HYDROLOGIC SYSTEMS ...Computers-general, Mathematical Analysis, Model Studies, River Basins, Stochastic Models, ...**6.0203**

A COMPREHENSIVE WATER RESOURCES ANALYSIS OF A TYPICAL OVERDRAWN BASIN IN AN IRRIGATED SEMIARID AREA - PECOS RIVER BASIN, NEW MEXICO ...New Mexico, River Basins, Semi - Arid, ...**6.0362**

DECISION MODELS FOR MINIMIZING COST OF INFORMATION OR ERROR IN ESTIMATING BENEFIT-WATER RELATIONSHIPS IN IRRIGATION. (ABBREV) ...Benefit-cost Analysis, Irrigation-general, Mathematical Analysis, Model Studies, Reliability, ...**6.0359**

A SYSTEMS ANALYSIS OF THE WESTERN BASIN OF LAKE ERIE ...Aquatic Ecology, Economic Impact, Great Lakes-general, Pollution - Effects of , Water Quality Control-general, ...**6.0426**

ECONOMIC ANALYSIS OF IRRIGATION SYSTEMS APPLICABLE TO THE NORTHERN GREAT PLAINS ...Agriculture, Economic Efficiency, Great Plains Province, Irrigation Engineering, Irrigation-general, ...**6.0496**

SYSTEM IDENTIFICATION AND MULTI-LEVEL OPTIMIZATION OF INTEGRATED GROUND WATER SYSTEMS ...Aquifers-general, Mathematical Analysis, Model Studies, ...**6.0062**

A STUDY OF POTENTIAL INSTITUTIONAL ARRANGEMENTS FOR WATER POLLUTION CONTROL IN THE HUDSON-MOHAWK RIVER BASIN ...Administrative Structures, Government -other, New York, River Basins, Water Quality Control-general, ...**6.0379**

CONSERVATION AND DEVELOPMENT PLANNING FOR THE ESTUARINE ZONE (A CASE STUDY IN THE TOWN OF SOUTHOLD, LONG ISLAND) ...Administrative Structures, Estuaries, Long Island Sound, Planning, Water Resources Development, ...**6.0388**

ECONOMIC EVALUATION OF WATER QUALITY ...Benefit-cost Analysis, Computers-general, Management, Model Studies, Waste Water Treatment-general, ...**6.0046**

A MODEL FOR QUANTIFYING FLOW AUGMENTATION BENEFITS ...Flood Control, Flow Augmentation, Model Studies, Other Methods, River Basins, Water Distribution Systems, ...**6.0152**

EUTROPHICATION FACTORS IN NORTH CENTRAL FLORIDA LAKES ...Administrative Structures, Eutrophication, Florida, Lakes, Model Studies, ...**5.0258**

SEQUENTIAL USE WITHIN A HYDROLOGIC COMPLEX ...Hydrology-general, Management, Model Studies, Other Data Analysis, Water Quality-general, ...**5.1189**

SYSTEM ANALYSIS OF EUTROPHICATION CONTROL BY FLUSHING ...Eutrophication, Flow Augmentation, Lakes, Water Quality Control-general, ...**5.1266**

A PILOT-SCALE STUDY OF ACID MINE DRAINAGE ...Acidity, Data Acquisition-general, Mining Industry, Pollution Abatement, ...**5.0881**

EVALUATION OF POLLUTION ABATEMENT PROCEDURES IN THE MORAINE STATE PARK, BULTER COUNTY, PENNSYLVANIA ...Pennsylvania, Pollution Abatement, Water Quality-general, Water Quantity-general, ...**5.1002**

SYSTEM ANALYSIS OF RAINFALL-RUNOFF RELATIONSHIP ...Amount, Digital Computers, Digital Computers, Ordinary, Runoff, ...**2.0427**

STUDY OF THE HYDROLOGY FOR MODELS OF THE GREAT LAKES ...Evaporation, Great Lakes-general, Management, Precipitation-general, Runoff, ...**2.0435**

SYSTEMS METHODOLOGY FOR WATER-RESOURCE PLANNING IN A REGIONAL DEVELOPMENT CONTEXT ...Economics-general, Mathematical Analysis, Regional Areas, Social Aspects, Water Resources Development, ...**6.0288**

PLANNING ALGORITHMS FOR REGIONAL WATER RESOURCE SYSTEMS ...Algorithms, Digital Computers, Economic Efficiency, Planning, Water Resources Development, ...**7.0012**

A SALT BALANCE INVESTIGATION ON THE SANTA ANA RIVER BASIN ABOVE PRADO DA ...California, Forecasting-prediction, Groundwater Basins, Salinity, Water Quality Control-general, ...**5.0098**

WATER RESOURCE DEVELOPMENT AND MANAGEMENT MODEL ...Alternative Planning, Available Water, Model Studies, State-local Government, Water Resources Development, ...**6.0201**

WATER QUALITY MODEL DERIVED FROM SYSTEM ANALYSES ...Management, Model Studies, Optimization, Water Quality-general, ...**6.0200**

FLOOD PREDICTION METHODS FOR PENNSYLVANIA HIGHWAY CROSSINGS ...Engineering Properties, Floods, Forecasting-prediction, Highway Sites, Small Watersheds, ...**2.0928**

RESERVOIR SYSTEM ANALYSIS FOR LOW-FLOW REGULATION ...Computers-general, Low Flow, Management, Optimization, Reservoirs and Impoundments, ...**2.0151**

EXPLORATORY DEVELOPMENT OF WATER PROPULSION FOR COMBAT VEHICLES ...Amphibious Vehicles, Marine, Other, Streams, ...**8.0215**

REGIONAL HYDROLOGIC SYSTEM ANALYSES (HYDRODYNAMICS) ...Groundwater Movement, Hydraulics-general, Permeability, ...**2.1092**

USE OF WATER ON FEDERAL IRRIGATION PROJECTS ...Consumptive Use, Engineering Structures-general, Irrigation Engineering, Irrigation-general, Radiation-general, ...**6.0094**

COMPUTERIZED DESIGN AND SYSTEMS ANALYSIS OF WASTEWATER TREATMENT PLANTS ...Application, Development of Models, Digital Computers, Forecasting-prediction, Waste Water Treatment-general, ...**6.0421**

EUTROPHICATION - PILOT OPERATIONS ...Economics-general, Eutrophication, Pilot Plants, Water Quality Control-general, ...**5.0981**

LABORATORY CATCHMENT INVESTIGATIONS RELATING TO HYDROLOGIC SYSTEMS ANALYSIS ...Gaging, Hydrology-general, Model Studies, Morphology-general, ...**(0574**

Tanzania

DOMESTIC WATER USE IN EAST AFRICA ...Kenya, Uganda, Water Costs, Water Sources -general, Water Utilization - domestic, ...**4.0092**

Teaching and Research

SUPPORT OF THE COMMITTEE ON WATER ...Committee-support, Hydrology-general, Management, ...**9.0003**

Technique Development

COALESCING MARINE OIL-WATER SEPARATOR ...Boat Discharges, Fluid-device-other, Two-phase-other, Waste Water Treatment-general, ...**5.0747**

DOUBTFUL HYDROGRAPHIC DATA ...Aircraft, Data Analysis - General, Hydrology-general, Satellites, ...**6.0278**

RADIOISOTOPE WATER FLOW MEASUREMENT IN HIGH-HEAD TURBINES AND PUMPS ...Fluids, Open Channel Flow, Pump-other, Radioisotopes, Turbine-other, ...**4.0057**

DEVELOPMENT OF FIELD TEST FOR FREE CHLORINE ...Bromine, Chlorine, Colorimetric, Membranes-other, Sterilants, ...**5.0808**

DEVELOPMENT OF A COULOMETRIC METHOD FOR THE MEASUREMENT OF DISSOLVED OXYGEN IN SEA WATER ...Analysis and Detection, Coulometry, Electrolytic, Gases, Oxygen, ...**2.0914**

NEW SYNTHETIC MEMBRANES FOR REVERSE OSMOSIS DESALINATION ...Copolymers, Desalination, Membranes-other, Reverse Osmosis, ...**3.0468**

DEVELOPMENT OF REVERSE OSMOSIS MEMBRANES ...Acids, Casting of Materials, Cellulose Acetate, Desalination, Nitrogen, ...**3.0050**

ION SELECTIVE ELECTROCHEMICAL SENSORS ...Brackish Water, Brines, Detectors and Sensors, Electroanalyses-other, Electrode, ...**5.1166**

DEVELOPMENT OF HOLLOW FILAMENT TECHNOLOGY FOR REVERSE OSMOSIS DESALINATION SYSTEMS ...Desalination, Membranes-other, Morphology-other, Reverse Osmosis, ...**3.0165**

DEVELOPMENT OF A CALIBRATION MODULE FOR TRACE OXYGEN ANALYZERS ...Analyzing, Calibration Devices, Chemical Analysis (water), Inorganic, Oxygen, ...**3.0055**

ASSEMBLY AND EVALUATION OF AN IMPROVED PPB OXYGEN ANALYZER FOR SEA WATER ...Automatic, Calibration Devices, Gases, Inorganic, Oxygen, ...**3.0453**

TELEMETERING OF HYDROLOGIC DATA FROM REMOTE AREAS ...Automatic Data Aquisition, Data Transmission Systems, Mountains-alpine, Other Telemetry, Remote Areas, ...**7.0026**

DEVELOPMENT AND EVALUATION OF IMPROVED TECHNIQUES TO MEASURE WATER-CONTENT OF SNOW ...Composition, Instrumental Services, Moisture Meters, Other Telemetry, Transducers, ...**7.0103**

DEVELOPMENT OF SYSTEMS FOR GROUND WATER RECHARGE INTO THE OGALLALA FORMATION ...Aquifers-general, Artificial Recharge, Filtration, Recharge Pits - Wells, Turbidity, ...**4.0247**

INTERNAL WATER STATUS OF PLANTS ...Dielectric Parameters, Instrumental Services, Plant Water Use-other, Refractometry, Translocation, ...**2.0722**

APPLICATION OF MAGNETOHYDRODYNAMICS TO MEASUREMENT OF LIQUID VELOCITY AND TURBULENCE ...Analog Computers, Analog Computers Math, Turbulent, Turbulent Flow, Velocity, Velocity -water, ...**2.1166**

METHODOLOGY FOR INTEGRATING WATER QUALITY MANAGEMENT WITH THE MANAGEMENT OF THE TOTAL WATER RESOURCES IN MINNESOTA ...Data Acquisition-general, Management, Minnesota, Water Quality Control-general, ...**5.0605**

DIGITAL SYSTEMS FOR ON-SITE DATA COLLECTION FOR WATER QUALITY ANALYSIS ...Automatic Data Aquisition, Data Networks, Digital Computers, Water Quality-general, ...**7.0005**

DETECTION AND ENUMERATION OF VIRUS IN NATURAL WATERS ...Assay, Bioindicators, Detection, Enteroviruses of Animals, Viral Pollutant Sources, ...**5.0713**

DESIGNING AND TESTING A WATER MONITORING SYSTEM FOR PESTICIDES IN NORTH CAROLINA ...Agricultural Watersheds, Chemical Identification, DDT , Endrin, Monitoring Systems, North Carolina, ...**7.0087**

APPLICATION OF SEISMIC SHEAR WAVE STUDIES TO THE INVESTIGATION OF AQUIFERS ...Aquifers-general, Geophysical Analysis, Lithology, Shear, Velocity, ...**4.0137**

IRON AND MANGANESE REMOVAL FROM SMALL GOUND WATER SUPPLIES ...Demineralization, Filtration, Groundwater, Iron, Manganese, ...**5.1053**

DEVELOPMENT AND EVALUATION OF HYDROLOGIC SIMULATION MODELS ...Model Studies, Runoff, South Carolina, Synthetic Hydrology-general, Watersheds-general, ...**2.0954**

AUTOMATED POTENTIOMETRIC TECHNIQUES FOR THE ON-SITE MONITROING OF ANION CONCENTRATIONS IN WATER ...Analysis and Detection, Automatic Systems, Electrode, Nitrate, Nitrite, Potentiometry, ...**5.0676**

ULTRAVIOLET ABSORPTION AND ITS POSSIBLE RELATION TO EUTROPHICATION IN LARGE NEW HAMPSHIRE LAKES ...Eutrophication, Filtration, Lakes, New Hampshire, Ultraviolet, ...**5.0714**

DEVELOPMENT OF A MATHEMATICAL MODEL FOR THE SIMULATION OF FLAT-LAND WATERSHED HYDRAULICS ...Development of Models, Hydraulics-general, Mathematical Analysis, Model Studies, Wetlands, ...**4.0102**

DISSOLVED OXYGEN DETERMINATION IN NATURAL AND WASTE WATERS ...Chemical Analysis (water), Ions and Gases, Oxygen, Potentiometry, Voltammetry, ...**5.0553**

AUTOMATIC RECORDING OF SHORT TERM B.O.D. ...Automatic Systems, Biochemical Oxygen Demand, Effluent-standards, Sewage Testing, ...**7.0039**

DELAWARE ESTUARY AND BAY WATER QUALITY SAMPLING AND MATHEMATICAL MODELING PROJECT ...Data Analysis - General, Delaware Bay, Mathematical Analysis, Model Studies, Pollution Abatement, ...**5.0749**

APPLICATION OF IMMUNOCHEMICAL TECHNIQUES TO THE DETECTION AND IDENTIFICATION OF CHEMICAL AND BIOLOGICAL POLLUTANTS ...Biological Pollutants -general, Chemical Identification, Immunology Methods, Mineralization, ...**5.0260**

EFFECT OF RANGE MANAGEMENT ON INFILTRATION, RUNOFF, AND EROSION ...Cover Crops, Infiltration, Management and Fertility, Runoff, ...**2.0105**

EQUIPMENT TO AGITATE POND SOILS FOR RELEASE OF NUTRIENTS ...Aquatic Soils, Limestone - General, Nutrients, Ponds, Soil Environment, ...**5.0774**

ANALYTICAL METHODS FOR PESTICIDES AND PESTICIDE DEGRADATION PRODUCTS ...Biodegradation, Persistance of Residues, Residue Analysis -other, Soil Degradation -other, ...**5.1031**

DEVELOPMENT OF METHODS FOR MEASURING PARTIAL VAPOR PRESSURE OF SOIL WATER ...Krypton, Moisture Tension, Osmotic Pressure, Soil Environment, Soil-water-plant Relationships, Vapor Pressure, ...**2.0495**

ANALYSIS AND SYNTHESIS OF HYDROLOGIC SYSTEMS ...Computers-general, Flow Characteristics -water, Hydrology-general, Open Channel Flow, Patterns, ...**2.0615**

HYDROLOGIC MEASUREMENT SYSTEMS ...Amount, Data Networks, Error Analysis, Gages, Hydrology-general, Instrumentation-general, Rain-general, Urban Environments, ...**7.0056**

LOW ENERGY MECHANICAL OXYGENATION OF WATER ...Aeration, Chemical Treatment, Water, ...**5.0331**

AERATED SEWAGE LAGOON INVESTIGATION - BOISSEVAIN ...Aeration, Canada, Economic Efficiency, Sewage Lagoons, ...**5.0170**

GROUND WATER RESOURCES ...Colorado, Groundwater, Management, Model Studies, Water Resources Development, ...**4.0067**

SIPHON TYPE TRICKLE TUBE FOR FARM PONDS AND RESERVOIRS ...Conduit, Design Criteria, Farm Pond, Reservoirs, Siphon, Water Level Fluctuation, ...**8.0203**

METEOROLOGICAL DROUGHT ...Meteorological Extremes, Weather Forecasting, ...**2.0593**

FIRE WEATHER FORECAST TECHNIQUES ...Fire Behavior - Identification, Fire Prevention, Regulation of Weather & Veg-, Thunderstorms, Weather Forecasting, ...**2.0587**

SNOW METAMORPHOSIS AND SNOWMELT ...Forecasting-prediction, Snowmelt, Snowpack, Streams, Water Yield, ...**2.0602**

DEVELOP PROTOTYPE PRECIPITATION OCCURRENCE SENSOR - DEVELOP AMOS III-70 (AUTOMATIC WEATHER STATION) ...Automatic Data Aquisition, Automatic Stations, Precipitation Instruments, Precipitation-other, ...**7.0053**

TEST AND EVALUATION OF TELEMETERING STORAGE PRECIPITATION GAGE ...Amount, Automatic Data Aquisition, Automatic Stations, Gages, ...**7.0048**

IMPROVE PRECIPITATION MEASURING EQUIPMENT - HYDROLOGIC EQUIPMENT IMPROVEMENT ...Atmospheric Pressure, Data Acquisition Systems, Gages, Instrumental Services, Transducers, ...**7.0051**

IMPROVE PRECIPITATION MEASURING EQUIPMENT - D-III PRECIPITATION EQUIPMENT ...Amount, Automatic Data Aquisition, Automatic Stations, Gages, ...**2.0591**

FISHER AND PORTER INSTALLATION METHODS ...Evaporation, Gages, Testing Devices, ...**7.0049**

DEVELOP DESIGN DATA FOR LIGHT WEIGHT WATER PURIFICATION UNIT ...Filtration, Mobile, Potable, Potable Water, Waste Water Treatment-other, ...**8.0297**

LIGHTWEIGHT WATER PURIFICATION UNIT ...Brackish Water, Density, Desalination, Distillation-other, Distilling Units, Mobile, Plastic Matrix, Waste Water Treatment-general, ...**3.0250**

INDIVIDUAL WATER FILTRATION DEVICE ...Filtration, Porous Media - Flow Through, Pump-other, Sediments, Waste Water Treatment-general, ...**3.0252**

UPPER BEAR CREEK EXPERIMENTAL PROJECT ...Alabama, Cover Crops, Discharge-general, Forecasting-prediction, Small Watersheds, ...**2.0987**

DEVELOPMENT OF HYDROLOGIC ANALYSIS TECHNIQUES ...Computers-general, Data Analysis - General, Hydrology-general, Land Use, Model Studies, ...**2.0988**

GENERALIZED HYDROLOGIC DESIGN CRITERIA ...Amount, Hydrology-general, Reservoirs and Impoundments, Water Resources Development, ...**6.0079**

MODEL STUDIES OF MASS CONCRETE STRUCTURES ...Cement, Concrete, Dimension-three, Mass, Model Studies, Stress Recorders, ...**8.0227**

HYDRAULIC INSTRUMENTATION ...Instrumentation-general, Model Studies, Turbulent Flow, Water Level Fluctuation, ...**7.0063**

GROUND WATER PREDICTION STUDIES ...Forecasting-prediction, Frost Heaving, Moisture Content, Permafrost-frozen, ...**2.0752**

INSTRUMENTATION DEVELOPMENT FOR HYDROLOGIC DATA COLLECTION ...Electromechanical Design, Field Testing, Instrumental Services, Instrumentation-general, ...**7.0089**

ELECTRONIC EQUIPMENT DEVELOPMENT ...Geophysical Analysis, Groundwater Movement, Switches, Transducers, ...**7.0021**

BOREHOLE GEOPHYSICS AS APPLIED TO GEOHYDROLOGY ...Aquifers-general, Borehole Geophysics, Geophysical Analysis, Groundwater Movement, Instrumentation-general, ...**7.0018**

ENERGY DISSIPATORS ...Energy Dissipators, Fluid Dynamics, Model Studies, ...**8.0114**

WATER MEASUREMENT ...Discharge-general, Dyes and Coloring, Fluids, Measurement, Water Quantity-general, ...**8.0128**

PORE-PRESSURE MEASURING REFINEMENTS IN SOILS FOR SHEAR AND CONSOLIDATION ...Capillarity, Cohesive Soil-general, Pore Water, Pressure, Triaxial, ...**8.0080**

ATMOSPHERIC WATER RESOURCES PROGRAM ...Augmentation-general, Clouds-precipitation, Modification, Reservoirs and Impoundments, Water Quantity-general, ...**2.0163**

ENGINEERING GEOLOGIC PROPERTIES OF ROCK ...Aerial, Borehole Geophysics, Foundations-general, Geology - Engineering, Microstructure, ...**8.0098**

PARK RANGE ATMOSPHERIC WATER RESOURCES PROGRAM ...Clouds-precipitation, Colorado, Nucleation Physics, Orographic Effects, Patterns, ...**2.0164**

ATMOSPHERIC WATER RESOURCES RESEARCH ...Augmentation-general, California, Clouds-precipitation, Modification, ...**2.0206**

EXPERIMENTAL DESIGN & STATISTICAL EVALUATION OF WEATHER MODIFICATION EXPERIMENTS ...Computers-general, Data Analysis - General, Data Analysis Applications, Statistics-general, Weather Modification-general, ...**2.0198**

GENERAL WATER QUALITY INVESTIGATIONS ...Control and Protection, Meetings, Pollutants-general, State-local Government, Water Quality-general, ...**5.0186**

PROJECT SKYWATER - NEW MEXICO ...Automatic Stations, Gages, Instrumental Services, New Mexico, Other Telemetry, Snow-general, ...**2.0203**

TECHNIQUES AND INSTRUMENTATION ...Chemical Analysis (water), Mobile, Physical Parameters, Temperature, Water Sampling, ...**5.0187**

RAPID SOILS EXCAVATION ...Construction, Excavation, Machines, Nuclear Excavation, ...**8.0082**

ENGINEERING DEVELOPMENT OF ICE NUCLEI DISPERSION SYSTEMS ...Flow of Dispersed Solids, Nucleation Physics, ...**2.0197**

HYDROGEOLOGIC INVESTIGATION TECHNIQUES ...Leekage Projections and Estimations, Reservoirs and Impoundments, Water Demand, Water Loss Control, ...**8.0058**

RADIOISOTOPE GROUND WATER MEASUREMENTS IN SMALL DIAMETER DRILL HOLES ...Borehole Geophysics, Drilling and Coring, Groundwater, Instrumentation-general, Radioisotopes, ...**8.0066**

POLLUTANTS IN PRODUCT AND PROCESS WATERS FROM OIL-SHALE RETORTING OPERATIONS AND METHODS FOR THEIR REMOVAL ...Material Recovery Wastes, Mining Industry, Oil Shale, Pollutants-general, Waste Water Treatment-general, ...**5.1324**

ANALYTICAL METHODS - OILFIELD WATER CHEMISTRY ...Brines, Chemical Analysis (water), Fluid Properties, General, ...**2.0874**

EARLY LIFE HISTORY OF COREGONIDS ...Cisco, Lake Herring, Environmental Ecology, Life History Studies, Maturity & Growth Stages, Water Environment -other, ...**6.0295**

DEVELOPMENT OF A METHOD FOR CHRONIC TOXICITY BIOASSAY USING MARINE PLANKTONIC ALGAE ...Algal Culture, Bioassays, Marine Plants, Microbiological Analysis, Monitoring (long Term Studies), Phytoplankton, Toxicology, ...**5.1088**

TOTAL ORGANIC CARBON AS A POLLUTION CONTROL PARAMETER IN SUB-ARCTIC WATE ...Alaska, Chemical Identification, Infrared, Organic Matter, Oxidation-general, ...**5.0031**

DEVELOPMENT OF CRITERIA FOR TILLAGE MACHINERY THAT WILL REDUCE SOIL EROSION AND RUNOFF ...Conservation-general, Erosion-general, Moisture Retention, Runoff, Tillage, Cropping Systems, ...**2.0007**

AQUIFER AND SUBSURFACE RELATIONSHIPS IN THE HYDROLOGY OF UPSTREAM AGRICULTURAL WATERSHEDS ...Aquifers-general, Baseflow, Forecasting-prediction, Groundwater Movement, Natural Recharge, Streams, Water Yield, ...**3.0394**

SURFACE AND SPRINKLER IRRIGATION SYSTEM DESIGN AND OPERATION FOR EFFICIENT WATER USE IN THE PACIFIC NORTHWEST ...Evapotranspiration, Irrigation, Model Studies, Sprinkler Irrigation, Surface Irrigation -general, ...**3.0204**

Techniques & Instrumentation

MOISTURE RESPONSE OF SOILS ...Capillarity, Louisiana, Soil Environment, ...**2.0550**

INSTRUMENTATION IN EMBANKMENTS AND FOUNDATIONS ...Dams, Embankments, Foundations-general, Handbooks, ...**7.0062**

Telemetry

Other Telemetry

TELEMETERING OF HYDROLOGIC DATA FROM REMOTE AREAS ...Automatic Data Aquisition, Data Transmission Systems, Mountains-alpine, Remote Areas, Technique Development, ...**7.0026**

DEVELOPMENT AND EVALUATION OF IMPROVED TECHNIQUES TO MEASURE WATER-CONTENT OF SNOW ...Composition, Instrumental Services, Moisture Meters, Technique Development, Transducers, ...**7.0103**

DIGITAL INSTRUMENTATION AND TELEMETRY FOR WATER RESOURCES RESEARCH ...Automatic Data Aquisition, Digital Computers, Electronics - Applied, ...**7.0072**

WATER QUALITY TELEMETRY ...Automatic Data Aquisition, Benefit-cost Analysis, Instrumental Services, Water Quality-general, ...**5.1197**

SYSTEM MONITORING AND REMOTE CONTROL ...Automatic Data Aquisition, Effluents-waste Water, Gages, Instrumental Services, Physical Parameters, ...**5.0559**

DEVELOPMENT OF HYDROLOGIC EQUIPMENT ...Design Instrumentation-other, Hydraulic Engineering-other, Hydrology-general, Instrumental Services, Instrumentation-general, ...**7.0064**

PROJECT SKYWATER - NEW MEXICO ...Automatic Stations, Gages, Instrumental Services, New Mexico, Snow-general, Technique Development, ...**2.0203**

PROJECT SKYWATER - COLORADO - STEAMBOAT SPRINGS ...Automatic Stations, Colorado, Gages, Instrumental Services, Snow-general, ...**2.0204**

Transmitters

VHF PROPAGATION THROUGH FRESH WATER AND ACROSS THE AIR-WATER INTERFACE ...Fish -non-specific, Microwave, Telemetry, Very High Frequency, Water Properties-other, ...**1.0129**

Temperature Effects

High Temperature - 1000-3000

LIME MAGNESIUM CARBONATE PROCESS - SEA WATER SOFTENING PLANT ...Brines , Evaporation, Precipitation, Removal--inorganics, Waste Water Pre-treatment, ...**3.0105**

Temperature Effects

Low Temperature -

EVALUATION OF CORROSION RATE TESTERS ...Corrosion General, Medium Temperature - 300-1000k, Test Methods, Water, ...8.0176

Medium Temperature - 300-1000k

SOLAR HEATING OF WATER TO VERY HIGH TEMPERATURES ...Conductivity , Desalination, Mathematical Analysis, Sunshine, Water, ...3.0331

EVALUATION OF CORROSION RATE TESTERS ...Corrosion General, Low Temperature -, Test Methods, Water, ...8.0176

Variable Temperature

AN INVESTIGATION OF ION MOBILITY IN AQUEOUS SOLUTIONS ...Conductivity, Solution, State Variables - Pvt, Transport, Variational Pressure, ...1.0064

STUDIES OF CONCENTRATED AQUEOUS ELECTROLYTES AND OF MOLTEN ELECTROLYTES BY INFRARED SPECTROSCOPY ...Electrolytes, Infrared, Raman, Solid State, Solution, ...1.0118

Tennessee

INVESTIGATION OF WATER RESOURCES. FLOODS IN SMALL STREAMS IN TENNESSEE ...Drainage, Floods, ...2.0298

AN INVESTIGATION OF THE EFFECT OF CONTROLLED RELEASES ON THE PHYSICAL, CHEMICAL AND BACTERIOLOGICAL CHARACTERISTICS OF FORT LOUDOUN RESERVOIR ...Nitrogen, Phosphate, Phosphite, Stratified Flow, Suspension, Temperature-other, ...5.1128

FACTORS AFFECTING WATER YIELD FROM SMALL WATERSHEDS IN TENNESSEE ...Correlation, Cover Crops, General Synoptic Observations, Small Watersheds, Water Yield, ...4.0224

EFFECT OF INDUST WASTES OF MEMPHIS & SHELBY COUNTY ON PRIMARY PLANKTONIC PRODUCERS ...Cell Cloning, Drainage, Industrial Wastes, Plankton (non-specific), Primary Productivity, ...5.1134

GEOCHEMISTRY AND HYDROLOGY OF A SMALL BASIN IN THE UPPER BUFFALO RIVER WATERSHED, TENNESSEE ...Hydrology-general, Small Watersheds, Water Cycle, Water Properties-general, Weathering Products, ...2.0999

CHANGES IN WATER QUALITY PARAMETERS OF RESERVOIRS DURING REGULATED FLOW CONDITIONS ...Eutrophication, Iron, Manganese, Water Properties-general, Water Quality-general, ...5.1129

SURVIVAL OF INDICATOR ORGANISMS AND ENTERIC BACTERIA IN WATER ...Bacterial Pollutant Sources, Bioindicators, Dyes, Longevity, Nutrients, ...5.1133

NATIONAL SYMPOSIUM ON THERMAL POLLUTION ...Management, Meetings, Oregon, Pollution - Effects of , Thermal Pollution, ...5.1138

PRIMARY PRODUCTION ...Plankton (non-specific), Primary Productivity, Strontium, ...2.1001

FLOOD HYDROGRAPH SYNTHESIS - UNGAGED WATERSHEDS ...Floods, Hydrographs, Small Watersheds, ...2.0981

FLOOD FREQUENCY STUDIES ...Design Flow-flood, Floods, ...2.0982

WHITE HOLLOW WATERSHED RESEARCH ...Forest Watersheds, Other, Seasonal, Sediment Yield, Water Yield, ...4.0221

PINE TREE BRANCH WATERSHED RESEARCH ...Cutting Operations, Erosion-general, Forest Watersheds, Land Use, Other, Sediment Yield, ...6.0536

SIMULATED OPEN CHANNEL HYDRAULICS ...Cumberland River, Mathematical Analysis, Model Studies, Numerical Analysis-other, Open Channel Flow, ...2.0983

FORAGE MANAGEMENT AND PRODUCTION IN THE TENNESSEE VALLEY ...Irrigation-general, Management, ...4.0219

BEECH RIVER WATERSHED PROJECT ...Design Flow-flood, Forest Watersheds, Land Use, Reservoirs and Impoundments, Sediment Yield, ...4.0222

HIGH ANALYSIS FERTILIZER INVESTIGATIONS - FISHERIES ...Fertilizers -aquatic, Fish -non-specific, Productivity (agricultural), Reservoirs and Impoundments, ...6.0535

HYDROLOGY OF UPPER BUFFALO RIVER BASIN ...Discharge-general, Groundwater, River Basins, Surface Water, Water Table Fluctuation, ...2.0996

HYDROGEOLOGIC MAPPING OF PALEOCENE SEDIMENTS, WESTERN TENNESSEE ...Clastic Aquifers, Mapping, Specific Rock Unit, Surficial Geology, Tertiary Period, ...2.0995

LOW FLOW CHARACTERISTICS OF TENNESSEE STREAMS ...Annual, Gaging, Low Flow, Variation in Time, ...2.0997

GEOHYDROLOGY OF SHALLOW AQUIFERS IN HENRY AND WEAKLEY COUNTIES, TENNESSEE ...Aquifers-general, Groundwater, Observation Wells, Pollution Sources-general, Pumping, ...2.0998

FLOODING OF SMALL STREAMS IN NASHVILLE-DAVIDSON CO. AREA, TENN. ...Amount, Discharge-general, Floods, Gaging, Urban Environments, ...2.0994

THE ECOLOGY OF CLOSTRIDUM BOTULINUM IN THE TVA LAKES AREA ...Bacterial Exotoxins, Bacterial Pollutant Sources, Clostridium Botulinum, Food, Microbiological, Range Or Territorial Distr. , ...2.0990

Tennessee River

PROBABLE MAXIMUM PRECIPITATION FOR SMALL BASIN IN THE TENNESSEE RIVER DRAINAGE SYSTEM ...Amount, Drainage, Storms-general, Topographic Influences, Weather Forecasting, ...2.0594

THE EFFECT OF WATER RESOURCES ON ECONOMIC GROWTH IN THE TENNESSEE VALEY ...Available Water, Correlation, Economic Impact, Location, Water Resources Development, ...6.0537

AN HISTORICAL APPRAISAL OF THE TENNESSEE VALLEY AUTHORITY'S FLOOD CONTROL PROJECT AND PROGRAM ...Administrative Structures, Benefit-cost Analysis, Control and Protection, Survey Studies, ...4.0227

TURBINE RATING FRAME INTERFERENCE STUDY ...Electric Power Plants, Gaging, Inflow, Turbine-other, ...8.0287

INVESTIGATION OF LINKAGES OF WATERFRONT MANUFACTURING ...Economic Impact, Industrial-general, Input - Output Analysis, Manufacturing, ...6.0533

Tensiometer

INVESTIGATION OF SEEPAGE REDUCTION BY NATURAL PROCESSES IN IRRIGATION CANALS ...Canals, Irrigation-general, Linings-pavings, Seepage, Soil Environment, ...3.0207

Texas

PROGRAM FOR HYDROLOGIC INVESTIGATION OF SMALL DRAINAGE AREAS IN TEXAS ...Design Flow-flood, Drainage, Floods, Hydraulic Structures, Small Watersheds, ...2.0296

THE ECONOMICS OF A REGIONAL MUNICIPAL DESALTING SYSTEM IN THE LOWER RIO GRANDE VALLEY OF TEXAS ...Desalination, Economic Efficiency, Urban Environments, ...3.0461

EVALUATION OF CLEARED SEINING AREAS ...Land Use, Nets, Pre-impoundment Sites, Reservoirs and Impoundments, ...6.0540

WALLEYE AND NORTHERN PIKE STUDY ...Aquatic Ecology, Life History Studies, Pikes, Pickeral, Muskellunge, Spawn Or Nesting Sites, Walleyes, ...6.0541

LAKE BASTROP NETTING STUDY ...Commercial Fishing, Ictaluridae -other, Lakes, Nets, Population Dynamics, ...6.0570

FLATHEAD CATFISH STUDY ...Aquatic Ecology, Behavior - animal, Food Supply, Growth Rate, Ictaluridae -other, Reproduction Studies (general), ...6.0539

THE EFFECTS OF ENGINEERING PROJECTS ON THE ECOLOGY OF JONES BAY ...Aquatic Ecology, Bays, Construction, Engineering Structures-general, Water Properties-general, ...6.0543

THE EFFECTS OF ENGINEERING PROJECTS ON THE ECOLOGY OF MOSES LAKE ...Aquatic Ecology, Construction, Engineering Structures-general, Lakes, Water Properties-general, ...6.0544

A STUDY OF SELECTED CHEMICAL AND BIOLOGICAL CONDITIONS OF THE LOWER TRINITY RIVER AND THE UPPER TRINITY BAY ...Commercial Fishing, Estuaries, Mans Activities, Pollution - Effects of , Spawn Or Nesting Sites, ...6.0546

EVALUATION OF RESOURCE USE AND ECONOMIC EFFECTS DUE TO IRRIGATION WATER AVAILABILITY IN TEXAS ...Agriculture Industry, Economic Impact, Model Studies, Planning, Projections and Estimations, ...6.0558

A STUDY OF THE ECOLOGY OF THE NAVASOTA RIVER, TEXAS ...Aquatic Ecology, Fish -non-specific, Pre-impoundment Sites, Water Properties-general, Zooplankton, ...6.0547

ECONOMIC IMPACT OF WATER IMPOUNDMENT - VALIDITY TESTING OF A COMPARATIVE- PROJECTION MODEL ...Economic Impact, Model Studies, Projections and Estimations, Recreation Sites, Reservoirs and Impoundments, ...**6.0554**

LIMNOLOGICAL INVESTIGATIONS OF TEXAS IMPOUNDMENTS FOR WATER QUALITY MANAGEMENT PURPOSES ...Chemical-general, Management, Nutrients, Reservoirs and Impoundments, Water Quality Control-general, ...**5.1148**

EFFECT OF UNLINED TREATED SEWAGE STORAGE PONDS ON WATER QUALITY IN THE OGALLALA FORMATION ...Carbonate Aquifers, Effluents-waste Water, Pollution - Effects of , Ponds, Storage of Water, ...**4.0245**

RELATION OF PASS OPENINGS ON PHYSICAL EXCHANGE AND SALINITY IN ESTUARIES ...Estuaries, Mixing, Saline Water Intrusion, Salinity, Shoreline Structures, ...**2.1012**

APPLICATION OF SPECIALIZED OPTIM TECH IN WATER QUANTITY & QUALITY MANAGEMENT WITH RESPECT TO PLANNING FOR THE TRINITY RIVER BASIN ...Optimization, Planning, River Basins, Water Quality-general, Water Quantity-general, ...**6.0551**

INSTITUTIONAL FACTORS INFLUENCING WATER DEVELOPMENT IN TEXAS ...Administrative Structures, Economic Impact, Planning, Water Law-general, Water Resources Development, ...**6.0562**

DEVELOPMENT OF SYSTEMS FOR GROUND WATER RECHARGE INTO THE OGALLALA FORMATION ...Artificial Recharge, Filtration, Playas, Ponds, Water Wells, ...**4.0243**

COMPUTER SIMULATION OF URBAN HYDROLOGIC SYSTEMS ...Analog Computers, Hydrographs, Runoff, Urban Environments, Watersheds-other, ...**4.0258**

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RESEARCH ON HIGH-EFFICIENCY COMBINED EVAPORATIVE AND CONDENSATIVE HEAT TRANSFER SYSTEM ...Condensation, Fluoro Plastics, Heat Transfer, Heat Transfer Coefficients, Other, Tension, ...**3.0266**

A STUDY OF THE STRESS-CORROSION SUSCEPTIBILITY OF CUPRO-NICKEL AND TITANIUM UNDER DESALINATION CONDITIONS ...Copper, Desalination, Stress Corrosion, Temperature General, Water, ...**3.0137**

WATER RESEARCH PROGRAM III CORROSION ...Brines, Composition Parameters-other, Nickel Alloys, Pitting, ...**3.0438**

NEW DEVELOPMENTS IN CATHODIC PROTECTION AND CORROSION STUDIES ...Cathodic Protection, Coatings-general, Dam, Canal, Platinum, ...**8.0024**

Titrimetry

Chelating

AGRICULTURAL SIGNIFICANCE OF CERTAIN TRANSITIONAL ELEMENTS FROM PESTICIDES AND OTHER AGRICULTURAL CHEMICALS ...Extraction-other, Metal Organics -non-specific, Mineralogy, Movement, Availability, Soil Analysis, Soil Chemical Properties, ...**5.0483**

Titrimetry-other

QUALITY IMPROVEMENT OF SWIMMING POOL WATERS - KINETICS AND MECHANISMS OF THE CHLORINATION-DEGRADATION OF UREA AND URIC ACID ...Chlorination, Decomposition-general, Potable, Sterilants, Ultraviolet, ...**5.0832**

PROCEDURES FOR TRACE ANALYSIS OF DISSOLVED INORGANIC AND ORGANIC CONSTITUENTS IN WATER ...Atomic Absorption, Coulometry, Extraction, Trace Analyses-other, ...**5.0442**

Toxic Substances

Algal Toxins

BLUE-GREEN ALGAE POISONING ...Algal Pollutant Sources, Arizona, Cyanophyta (non-specific & Ot), Range Or Territorial Distr. , Vegetable Origin, ...**5.0041**

AN INVESTIGATION OF APHANIZOMENON FLOS-AQUAE, A TOXIC BY-PRODUCT OF EUTROPHICATION ...Algal Metab.(non-specific &ot), Eutrophication, ...**5.0717**

RELATIONS OF NUISANCE ALGAE TO FISH IN KLAMATH LAKE ...Bioassays, Cyanophyta (non-specific & Ot), Fish -non-specific, Lakes, Oregon, ...**5.0937**

LABORATORY STUDIES OF TOXIC DINOFLAGELLATES ...Algal Culture, Gonyaulax, Gulf of Mexico, Gymnodinium, Vegetable Origin, ...**5.1161**

STUDY OF TOXIN SYNTHESIS IN SYNCHRONIZED PRYMNESIUM ...Biosynthesis, Cell Cycle, Hemolysins -non-specific, Prymnesium, Synchronization, ...**1.0089**

COMPARATIVE STUDIES OF DINOFLAGELLATE TOXINS ...Action- & Bioelectrical Pot. , Algal Culture, Dinophyceae (non-specific &ot), Toxicology, ...**5.0716**

INVESTIGATIONS ON CIGUATERA-LIKE BIOTOXINS IN SHELLFISH ...Algal Culture, Bulk Culture -other, Crustacea -non-specific, Gymnodinium, Mollusks -non-specific & Other, ...**5.0018**

Bacterial Exotoxins

SURVEY OF CLOSTRIDIUM BOTULINUM TYPE E ...Clostridium Botulinum, Identification, Infra Red, Mutagens, ...**5.0957**

THE ECOLOGY OF CLOSTRIDUM BOTULINUM IN THE TVA LAKES AREA ...Bacterial Pollutant Sources, Clostridium Botulinum, Food, Microbiological, Range Or Territorial Distr. , Tennessee, ...**2.0990**

SPORULATION AND GERMINATION OF CLOSTRIDIUM BOTULINUM ...Cell. env.(non-specific & Ot.), Clostridium Botulinum, Growth (non-specific & Ot.), Media, Spore Studies, ...**5.0568**

THE ECOLOGY OF CLOSTRIDIUM BOTULINUM TYPE E ...Classification Or Taxonomy, Clostridium Botulinum, Ecology, Estuaries, Serology, ...**5.1070**

Toxic Substances -non-specific

MICROBIAL DEGRADATION OF ORGANIC POLLUTANTS OF INDUSTRIAL ORIGIN ...Chemical , Industrial Wastes, Microbial-bacterial, Organic Matter, Sewage Bacteria, ...**5.0514**

THE ECOLOGY OF THE MICROBIAL POPULATION OF ACTIVATED SLUDGE ...Activated, Degradation, Industrial Processes-other, Mechanisms, Plant Succession, ...**5.0168**

Trace Analysis

Inorganic

DEVELOPMENT OF A CALIBRATION MODULE FOR TRACE OXYGEN ANALYZERS ...Analyzing, Calibration Devices, Chemical Analysis (water), Oxygen, Technique Development, ...**3.0055**

ASSEMBLY AND EVALUATION OF AN IMPROVED PPB OXYGEN ANALYZER FOR SEA WATER ...Automatic, Calibration Devices, Gases, Oxygen, Technique Development, ...**3.0453**

REAGENTS FOR DETERMINATIONS OF TRACE IMPURITIES IN WATER ...Analysis and Detection, Cobalt, Nitrate, Nitrite, Nitroso Compounds, Spectroscopy-general, ...**5.0330**

ANALYSIS OF TRACE ELEMENTS IN WATER ...Activation Analysis, Chemical Analysis (water), Other, Spectroscopy-other, ...**5.1062**

THE ACTIVATION-CHROMATOGRAPHIC ELEMENTAL AND STRUCTURAL ANALYSIS OF FRESH WATER SOURCES ...Activation Analysis, Analysis and Detection, Chromatography-other, Fresh Water, Gamma, Organic, ...**5.0252**

Organic

REMOVAL OF TRACE ORGANICS FROM WATER BY ADSORPTION ON COAL ...Activated Carbon, Adsorption, Coal-general, Isotherm, Waste Water Treatment-general, ...**5.1209**

THE ACTIVATION-CHROMATOGRAPHIC ELEMENTAL AND STRUCTURAL ANALYSIS OF FRESH WATER SOURCES ...Activation Analysis, Analysis and Detection, Chromatography-other, Fresh Water, Gamma, Inorganic, ...**5.0252**

DEVELOPMENT OF INSTRUMENTAL TECHNIQUES FOR THE ANALYSIS OF TRACE ORGANIC CONSTITUENTS IN WATER ...Analyzing, Chromatography-other, Infrared, Odor, Organic Wastes, ...**5.0211**

ORGANIC COMPOUNDS IN ALASKA PERMAFROST GROUNDWATER ...Alaska, Gas, Permafrost-frozen, Spectroscopy-general, Thin Layer, ...**1.0005**

PHYSICAL CHEMISTRY OF RADIOCLEMENTS - RADIOMETRIC METHODS OF ANALYSIS ...Activation Analysis, Electrodeposition, Extraction-other, Precipitation, Radioactivity-general, ...**7.0020**

Trace Analyses-other

APPLICATION OF MODERN ELECTROANALYTICAL TECHNIQUES TO THE ANALYSIS OF HEAVY METALS IN WATER ...Analysis and Detection, Chronopotentiometry, Heavy Elements, Mineralization, Polarography, ...**1.0040**

PROCEDURES FOR TRACE ANALYSIS OF DISSOLVED INORGANIC AND ORGANIC CONSTITUENTS IN WATER ...Atomic Absorption, Coulometry, Extraction, Titrimetry-other, ...**5.0442**

DETERMINATION OF THE PHOSPHATE CONTENT OF NATURAL WATERS, AT THE NUTRIENT LEVEL, BY SOLVENT EXTRACTION ...Automatic Systems, Extraction-other, Fresh Water, Nutrients, Phosphate, Phosphite, ...**1.0015**

TRACE ELEMENT CHEMISTRY OF STREAMS OF THE LOWER KANSAS RIVER BASIN ...Analysis and Detection, Atomic Absorption, Chemical Analysis (water), Trace Element Analysis, ...**1.0055**

MICROBIOLOGICAL TREATMENT OF POTATO WASTES ...Additives, Agricultural Microbiology, Canning Wastes, Industrial Wastes, Material Recovery Wastes, Microbial-bacterial, Plant Waste Removal, Treatment, ...**5.0978**

Trace Elements

TRACE AND TRACER ELEMENTS IN GROUND WATER ...Agricultural Chemicals-general, Arizona, Groundwater, Industrial Wastes, Tracers-general, ...**4.0010**

THE DISTRIBUTION OF TRACE ELEMENTS IN IMPOUNDMENTS ...Arkansas, Electric Power Plants, Reservoirs and Impoundments, Water Quality Control-general, Water Sampling, ...**2.0068**

A QUANTITATIVE STUDY OF TRACE ELEMENTS ON ABIOTIC AND BIOTIC AGGREGATES IN THE MISSOURI RIVER ...Bacterial Pollutant Sources, Food Pyramids, Missouri River, Silting, ...**5.0688**

THE IMPACT OF LEAD-ZINC MINING ON THE QUALITY AND ECOLOGY OF SURFACE WATERS IN SOUTHEAST MISSOURI ...Adsorption-other, Atomic Absorption, Lead, Missouri, Zinc, ...**5.0689**

REMOVAL OF TRACE METALS FROM WATER BY ION FLOTATION ...Concentration, Domestic, Flotation, Foam, Industrial Waste-other, ...**5.0878**

TRACE ELEMENT STUDY OF SOIL-PLANT-WATER SYSTEMS ...Groundwater, Soil - Crop Relationships, Soil-water-plant Relationships, Water Movement, Velocity, ...**1.0013**

BEHAVIOR OF TRACE ELEMENTS IN WATER RECLAMATION TREATMENT PROCESSES ...Chemical Treatment-general, Pollutant-other, Radioisotopes, ...**5.0177**

TRACE ELEMENT CYCLES IN A SOUTHEASTERN RESERVOIR LAKE ...Adsorption Capacity, Radioactivity-general, Rate of Deposition, Reservoirs, Reservoirs and Impoundments, Trace Element Analysis, Water Cycle, ...**2.0945**

THE DEVELOPMENT OF OPERATIONAL SHELLFISH DEPURATION AND RELAYING SYSTEMS ...Bacterial Pollutant Sources, Clams, Salmonella Typhimurium, Thermal Pollution, ...**5.1068**

TRACE AMOUNT SUBSTANCES IN ENVIRONMENTAL HEALTH ...Chemical Analysis (water), Other, Pollutants-general, ...**5.0677**

Tracers

RADIOISOTOPIC TRACER STUDY TO INVESTIGATE THE MECHANICS OF LITTORAL TRANSPORT AROUND POINT CONCEPTION, CALIFORNIA ...California, Distribution, Intertidal Areas, Radioisotopes, Sediment Transport-other, ...**1.0031**

TRITIUM AS A TRACER FOR MIXING PROCESSES ...Mixing, Ocean Currents, Radioactivity, Salinity, Tritium, ...**5.0264**

SAND TRACING AT SPECIFIC INLETS AND AREAS ON THE LOWER EAST COAST OF FLORIDA ...Bays, By-passing, Florida, Longshore Currents, Shoreline - Coastline, ...**8.0161**

RADIONUCLIDES IN THE SAVANNAH RIVER ESTUARY AND ADJACENT COASTAL WATERS ...Atomic Plants, Estuaries, Pollutants - Path of , Radioactivity, Radioactivity-general, ...**5.1098**

UTILIZATION OF RADIOACTIVE TRACERS IN BEACH STUDIES ...Fluorometry, Radioisotopes, ...**8.0153**

Dyes

INVESTIGATIONS ON THE SUBSURFACE DISPOSAL OF WASTE EFFLUENTS AT INLAND SITES ...Artificial Recharge, Groundwater Movement, Pollutants - Path of , Recharge Pits - Wells, Underground Waste Disposal, ...**3.0022**

DETERMINING CHANGES IN PHYTOPLANKTON POPULATIONS IN CLOUDS OF FLUORESCENT DYE MOVING IN THE MISSISSIPPI RIVER ...Fluorometry, Minnesota, Mississippi River, Phytoplankton, Standing Crops, ...**5.0617**

LONGITUDINAL DISPERSION OF THE LOWER KANSAS RIVER BASIN ...Dispersion -water, Kansas, River Basins, ...**2.0507**

SURVIVAL OF INDICATOR ORGANISMS AND ENTERIC BACTERIA IN WATER ...Bacterial Pollutant Sources, Bioindicators, Longevity, Nutrients, Tennessee, ...**5.1133**

EDDY DIFFUSION AND BACTERIAL REDUCTION IN WASTE FIELDS ...Bacterial Pollutant Sources, Diffusion, Dispersion - water, Mixing, Pollutants - Path of , Sewers, ...**5.0111**

TURBULENT MIXING IN SURFACE AERATION ...Aeration, Diffuser, Mixing, Synthetic Hydrology-general, Turbulent Flow, ...**5.1061**

TRACER STUDIES - URBAN RUNOFF ...Peak Flow, Runoff, Urban Environments, Urban Research, Velocity -water, ...**4.0101**

TIME OF TRAVEL - PRINCIPAL MARYLAND STREAMS ...Maryland, Pollutants - Path of , Streams, Velocity -water, ...**2.0565**

TRANSPORT PROCESSES IN FLUID FLOWS ...Clastic Aquifers, Dispersion -water, Mathematical Analysis, Model Studies, Porous Media - Flow Through, ...**2.0368**

DISPERSION PROCESSES IN ESTUARIES AND RIVERS ...Dispersion -water, Estuaries, Streams, Synthetic Hydrology-general, ...**2.0118**

Radioisotopes

THE CYCLING OF C1-36 LABELED DDT IN NATURAL ECOSYSTEMS ...Aquatic Or Soil-aquatic Cycles, DDT , Monitoring Systems, Persistance of Residues, Pollution - Effects of , ...**5.0876**

GEOCHEMICAL STUDIES OF CONTINENTAL WATERS ...Authigenesis, Location, Pore Fluids, ...**1.0081**

STUDIES ON APPLICATION OF RADIOISOTOPE TECHNIQUES IN STREAM POLLUTION PROBLEMS IN THE PULP AND PAPER INDUSTRY ...Iridium, Pollutants - Path of , ...**5.1233**

RADIOISOTOPE WATER FLOW MEASUREMENT IN HIGH-HEAD TURBINES AND PUMPS ...Fluids, Open Channel Flow, Pump-other, Technique Development, Turbine-other, ...**4.0057**

NUCLEAR TECHNIQUES IN SOILS HYDROLOGY, SNOW GAGING, AND RELATED APPLICATIONS ...Gaging, General, Hydrology-general, Soil Environment, Soil-water-plant Relationships, ...**1.0007**

RADIOISOTOPIC TRACER STUDY TO INVESTIGATE THE MECHANICS OF LITTORAL TRANSPORT AROUND POINT CONCEPTION, CALIFORNIA ...California, Distribution, Intertidal Areas, Sediment Transport-other, Tracers, ...**1.0031**

DETERMINATION OF THE DISTRIBUTION OF RADIONUCLIDES DISCHARGED TO THE GROUND AT THE NRTS, IDAHO ...Artesian Flow, Discharge-general, Observation Wells, Pollutants - Path of , Radioactivity-general, ...**5.0318**

WATER TRANSPORT THROUGH HYPERFILTRATION MEMBRANES ...Cellulose Acetate, Desalination, Rate Determination, Reverse Osmosis, ...**3.0239**

A STUDY OF PRESCALING DEPOSITION ...Copper, Desalination, Saline Conversion, Scaling, Encrusting, ...**1.0011**

AIRBORNE RADIOMETRIC SNOW SURVEY ...Aircraft, Composition, Gamma Radiation, Non-electrical Measurements, Snowmelt, ...**7.0071**

ADSORPTION OF IONS IN TRACE CONCENTRATIONS ON SOIL AND SILT PARTICLES ...Adsorption Capacity, Adsorption-other, Size, Soil Environment, Transfer Processes, ...**2.0349**

THE EFFECT OF POTHOLE DRAINAGE UPON GROUNDWATER RESOURCES ...Drainage, Groundwater, Potholes, Unsaturated Flow, ...**4.0144**

APPLICATION OF RADIOISOTOPO TECHNIQUES TO A CRITICAL WATER RESOURCES PROBLEM AREA (NUTRITIONAL POLLUTION) ...Algae, Nutrients, Phosphorus, ...**5.0919**

RADIOTRACER STUDIES ON RAPID SAND FILTRATION ...Ion Exchange-other, Other, Reactors-other, Sand, ...**5.0295**

BIOLOGICAL FIXATION AND TRANSFORMATION OF NITROGEN IN SMALL IMPOUNDMENTS ...Ions and Gases, Nitrogen, Nitrogen Fixation, Reservoirs and Impoundments, ...**2.0881**

WATER TRACING AND DATING IN HAWAII HYDROLOGIC CYCLE ...Carbon-14, Groundwater Movement, Hawaii, Surface Water, Tritium, Water Cycle, ...**2.0375**

URANIUM AND HYDROGEN RADIONUCLIDES AS NATURAL TRACERS IN THE FLORIDAN AQUIFER ...Aquifers-general, Florida, Quaternary Period, Recharge -general, Tritium, Uranium, ...**2.0326**

METAL ION-CATALYZED OXIDATION OF PHENOLS AND AROMATIC AMINES ...Alcohols, Catalytic, Metal Ion, Organic Wastes, ...**5.1159**

CHEMISTRY OF NITROGEN IN NATURAL WATERS ...Analysis and Detection, Denitrification, Fixation, Lakes, Nitrogen, ...**5.0250**

SORPTION AND DESORPTION FACTORS INFLUENCING TRANSPORT, PERSISTENCE, & ALTERATION OF PESTICIDES IN VARIOUS AGRICULTURAL SOILS ...Boundary Process (moisture), Movement, Leaching, Pesticides -non-specific, Physical Properties-general, Soil Chemical Properties, ...**5.0140**

FACTORS INFLUENCING THE FLOW OF SUBSOIL WATER IN THE IMMEDIATE PROXIMITY OF, AND INTO DRAINAGE FACILITIES ...Compressibility, Internal Water Movement, Subsurface Flow, ...**2.0147**

FLOW OF COLLOIDAL SUSPENSIONS IN POROUS MEDIA ...Colloidal Phenomena, Model Studies, Porous Media - Flow Through, Suspension, ...**2.0871**

BEHAVIOR OF TRACE ELEMENTS IN WATER RECLAMATION TREATMENT PROCESSES ...Chemical Treatment-general, Pollutant-other, Trace Elements, ...**5.0177**

RADIOCARBON AS A TRACER IN GROUND WATER PROBLEMS ...Aquifers-general, Groundwater Movement, Laminar Flow, Permeability, Recharge -general, ...**2.0056**

COLUMBIA RIVER ECOLOGY ...Chromium, Columbia River, Phosphorus, Pollutants - Path of , Zinc, ...**6.0613**

RADIONUCLIDE MOVEMENT IN GROUNDWATER ...Flow Characteristics -water, Groundwater Movement, Pollutants - Path of , Radioactivity-general, Seepage, ...**5.1099**

GROUNDWATER FLOW ...Flow Characteristics -water, Groundwater Movement, Permeability, Tritium, Velocity -water, ...**2.0947**

UTILIZATION OF RADIOACTIVE TRACERS IN BEACH STUDIES ...Fluorometry, Tracers, ...**8.0153**

INVESTIGATIONS IN ISOTOPIC HYDROLOGY ...Dispersion - water, Georgia, Tritium, Water Cycle, Water Movement-general, ...**1.0032**

TECHNIQUES FOR USE OF RADIOISOTOPES IN TRACING RESERVOIR LEAKAGE ...Aquifers-general, Faults, Foundations-general, Leekage, Reservoirs and Impoundments, ...**7.0017**

RADIOISOTOPE GROUND WATER MEASUREMENTS IN SMALL DIAMETER DRILL HOLES ...Borehole Geophysics, Drilling and Coring, Groundwater, Instrumentation-general, Technique Development, ...**8.0066**

SOLUBILITIES OF THE SULFATES OF BARIUM AND STRONTIUM IN OILFIELD WATERS ...Barium, Brines, Fluid Properties, Solution Chemistry, Strontium, Thermal Properties-other, ...**1.0097**

CHRONIC EFFECTS OF HEAVY METALS ON FISH ...Computer Matching-code, Contamination - Water, Industrial Wastes, Mineral, Mineral Origin, ...**5.0584**

EFFECT OF NITRILOTRIACETIC ACID (NTA) UPON THE TOXICITY OF METALS TO SELECTED SPECIES OF ESTUARINE PHYTOPLANKTON ...Acids, Carbon, Chemicals (incl. algacides), Estuaries, Phytoplankton, ...**5.1085**

WATER YIELD IMPROVEMENT, EROSION CONTROL, AND SEDIMENT REDUCTION IN FORESTS ...Erosion-general, Forest Watersheds, Land Use, Moisture Content, Stabilization-other, Water Yield, ...**3.0486**

MANAGEMENT FOR IMPROVEMENT OF WATER YIELD IN THE CONIFER ZONE OF CALIFORNIA ...Evapotranspiration, Forest Watersheds, Land Use, Precipitation-general, Snowmelt, Water Yield, ...**3.0032**

SEDIMENT YIELD IN RELATION TO CLIMATIC AND WATERSHED CHARACTERISTICS IN THE SOUTHERN BRANCH ...Agricultural Watersheds, Climate, Location, Sediment Transport-general, Sediment Yield, ...**2.0675**

SEDIMENT PRODUCTION, YIELD, & DELIVERY RATIO IN RELATION TO CLIMATIC, GEOLOGIC, & WATERSHED CHARACTERISTICS OF THE NORTHERN PLAINS ...Agricultural Watersheds, Climate, Location, Sediment Transport-general, Sediment Yield, ...**2.0230**

SOIL-MOISTURE-PLANT GROWTH RELATIONSHIPS ...Moisture Content, Moisture Retention, Moisture Tension, Root Absorption, Soil-water-plant Relationships, Translocation, ...**2.0438**

BIOLOGICAL (ENRICHMENT) CHAINS OF RADIONUCLIDES IN FINNISH LAKES ...Cesium, Eutrophication, Finland, Nutrients, Radioactive Fallout, ...**2.0309**

LEAD ISOTOPIC CHEMISTRY FOR POLLUTION RESEARCH ...Analysis and Detection, Lead, Other, Pollutants - Path of , Transport, ...**5.0150**

Tracers-general

THE HYDRAULICS OF GROUND WATER TESTS ...Aquifers-general, Dispersion -water, Groundwater Movement, Model Studies, ...**2.0288**

INVESTIGATION OF WATER LOSSES TO SINKHOLES IN THE PAHASAPA LIMESTONE, AND THEIR RELATION TO RESURGENT SPRINGS BLACK HILLS, SOUTH DAKOTA ...Groundwater, Karst Topography, Leekage, South Dakota, Springs, ...**2.0979**

TRACE AND TRACER ELEMENTS IN GROUND WATER ...Agricultural Chemicals-general, Arizona, Groundwater, Industrial Wastes, Trace Elements, ...**4.0010**

THE INTERFLOW PROCESS ON SLOPING WATERSHED AREAS ...Forecasting-prediction, Groundwater Movement, Mathematical Analysis, Physical Properties-general, Rain-general, ...**2.0961**

MIXING AND DISPERSION OF CONTAMINANTS IN RESERVOIRS ...Currents -water, Dispersion -water, Mixing, Reservoirs and Impoundments, Velocity -water, ...**5.1153**

TURBULENT DIFFUSION AND REAERATION IN NATURAL RIVERS ...Aeration, Flow of Gas in Liquid, Mixing, Model Studies, Turbulent Flow, ...**5.1136**

INFLUENCE OF VEGETATION IN SOIL MOISTURE FLOW ...Cover Crops, Groundwater Movement, Infiltration, Soil Environment, ...**2.0946**

ECOLOGICAL ENGINEERING PROJECT ...Atmosphere Radiation, Nutrients, Synthetic Hydrology-general, Temperature, Velocity -water, ...**6.0159**

Tracers-other

CHARACTERIZATION OF STREAM REAERATION CAPACITY ...Aeration, Industrial Wastes, Pollution - Effects of , Water Costs, ...**5.0303**

Training Grants, Fellowships

SUMMER RESEARCH AT THE UNIVERSITY OF OKLAHOMA BIOLOGICAL STATION ...Oklahoma, Personnel, Research Facilities, Water Resources - General, ...**9.0011**

WATER RESOURCES RESEARCH, MANPOWER AND TRAINING NEEDS FOR INDIANA ...Indiana, Management, Personnel, Requirement and Resources, ...**9.0007**

SUPPLY OF AND DEMAND FOR TRAINED WATER RESOURCES PERSONNEL - A PILOT STUDY ...Personnel, Requirement and Resources, Utilization, ...**9.0004**

CENTER FOR RESEARCH AND TRAINING IN HYDRAULIC AND HYDROLOGIC ASPECTS OF WATER POLLUTION CONTROL ...Document & Literature Info, Hydraulics-general, Water Quality Control-general, ...**5.1137**

EFFECT OF POLLUTION ON THE QUALITY OF SURFACE AND GROUND WATER RESOURCES ...Laboratory Analysis, Pollution - Effects of , Soil Environment, Water Quality Control-general, Water Reuse, ...**5.0703**

Transition Metal-general

A STUDY OF THE INTERACTIONS PRESENT IN AQUEOUS SALT SOLUTIONS BY NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY ...Conservation-general, Ionic, Nuclear Magnetic, Solution, Water Resources Development, ...**1.0074**

Translation Grants

TRANSLATION OF VOPROSY IKHTIOLOGII (PROBLEMS OF ICHTHYOLOGY) ...Commercial Fishing, Russia, ...**6.0122**

FIELD TECHNIQUES FOR CHEMICAL ANALYSIS OF WETLAND CRITERIA ...Chemical Analysis (water), Chromatography-other, Colorimetric, Wetlands, ...**1.0091**

Transportation Engineering

Bridges & Culverts

FLOOD FREQUENCY STUDY ...Culvert, Floods, New Mexico, Peak Flow, Rio Grande, ...**2.0772**

VERIFICATION OF HYDRAULIC COMPUTATION METHODS FOR BRIDGE SITES ...Construction Sites, Discharge-general, Location, ...**8.0207**

HYDRAULIC PERFORMANCE OF BRIDGES ...Culvert, Design Criteria, Dike, Drainage, Engineering Structures-general, ...**8.0158**

INVESTIGATION OF SCOUR AT BRIDGES IN ALASKA ...Alaska, Channel Geometry, Drainage, Erosion Control, Scouring, Suspension, ...**2.0285**

HYDROLOGY STUDY ...Culvert, Engineering Structures-general, Floods, Flow Characteristics -water, Small Watersheds, ...**2.0292**

INVESTIGATION AND ANALYSIS OF FLOOD HYDROGRAPHS FROM SMALL DRAINAGE BASINS IN SOUTH DAKOTA ...Culvert, Drainage, Floods, Hydrographs, Rain-general, Small Watersheds, ...**2.0294**

REDUCTION OF SCOUR AROUND BRIDGE PIERS ...Drainage, Erosion Control, Scouring, ...**2.0965**

ENGINEERING INVESTIGATION PERTAINING TO FLOOD PROTECTION OF BRIDGES AND CULVERTS ...Culvert, Design Criteria, Drag, Drainage, Erosion Control, Floods, ...**8.0145**

VERIFICATION OF HYDRAULIC DESIGN OF BRIDGES IN ALABAMA ...Alabama, Data Acquisition-general, Drainage, Engineering Structures-general, Floods, ...**8.0001**

SCOUR AT RELIEF BRIDGES ...Culvert, Drainage, Scouring, Sedimentation, Transition Sections, ...**8.0005**

SCOUR AT BRIDGE CROSSINGS IN ALASKA ...Discharge-other, Erosion Control, Scouring, Suspension, ...**2.0013**

Construction

PERFORMANCE OF CONSTRUCTION PLANT AND EQUIPMENT ...Concrete-general, Equipment, Machines, ...**8.0251**

RAPID SOILS EXCAVATION ...Excavation, Machines, Nuclear Excavation, Technique Development, ...**8.0082**

Design

Design-other

SMALL WATERSHED STUDY ...Drainage, Drainage Systems, Hydraulic Structures, ...**2.0297**

Location

VERIFICATION OF HYDRAULIC COMPUTATION METHODS FOR BRIDGE SITES ...Bridges & Culverts, Construction Sites, Discharge-general, ...**8.0207**

Standards & Criteria

PREVENTION AND CONTROL OF CULVERTS AND ROAD ICINGS ...Culvert, Heating, Snow and Ice Removal, ...**2.0025**

MODEL STUDY OF DISSIPATING STRUCTURES ...Energy Dissipators, Models, Safety, ...**8.0008**

DISPOSAL OF SURFACE WATER ...Drainage, Infiltration, Right-of-way, Runoff, Surface Water, ...**2.0150**

Structural

HYDROLOGY RESEARCH PROJECT ...Data Acquisition-general, Data Analysis - General, Drainage, Hydrology-general, Small Watersheds, ...**2.0281**

DEVELOPMENT OF HYDRAULIC DESIGN PROCEDURES FOR CONCRETE BOX CULVERTS WITH STANDARD, IMPROVED AND SIDE-TAPERED INLETS ...Culvert, Drainage, Economics-general, Engineering Structures-general, Transition Sections, ...**2.0304**

Drainage

HYDROLOGICAL STUDY ...Discharge-general, Gaging, Peak Flow, Rhode Island, Small Watersheds, ...**2.0943**

EROSION CONTROL CRITERIA FOR DRAINAGE STRUCTURES ...Drainage Systems, Erosion-general, ...**2.0681**

USE OF LARGE ROUGHNESS ELEMENTS FOR HYDRAULIC ENERGY DISSIPATION ...Channel Roughness, Culvert, Energy Dissipators, Models, Open Channel, ...**8.0295**

STUDY OF RUNOFF FROM SMALL DRAINAGE AREAS ...Runoff, ...**2.0520**

HYDRAULIC INVESTIGATION OF SOIL EROSION AND SEDIMENTATION IN HIGHWAY MEDIAN AND SIDE DITCHES ...Alabama, Flow Characteristics -water, Scouring, Sedimentation, Silting, ...**2.0004**

A STUDY OF STORM WATER INLET CAPACITIES ...Inlet, Louisiana, Model Studies, Storm Sewer Quantity-other, Storm Water, ...**8.0206**

FLOOD FREQUENCY OF SMALL STREAMS IN LOUISIANA ...Floods, Louisiana, ...**2.0541**

HIGHWAY DRAINAGE STUDY ...Maryland, ...**2.0579**

DRAINAGE AREA FLOW RESEARCH ...Discharge-general, Montana, Small Watersheds, ...**2.0270**

WATERSHED SHAPE-FACTOR ...Culvert, Design Criteria, Engineering Structures-general, North Dakota, Peak Flow, ...**2.0277**

STORM WATER INFLOW ...District of Columbia, Forecasting-prediction, Seepage, Storm Water, ...**2.0307**

FLOOD FREQUENCY SYNTHESIS FOR SMALL STREAMS IN ALABAMA ...Alabama, Forecasting-prediction, Gaging, Peak Flow, Runoff, Small Watersheds, ...**3.0172**

SMALL DRAINAGE AREA STUDY ...Arizona, Floods, Gaging, Peak Flow, Small Watersheds, ...**2.0289**

HYDRAULIC PERFORMANCE OF BRIDGES ...Bridges & Culverts, Culvert, Design Criteria, Dike, Engineering Structures-general, ...**8.0158**

ANALYSIS OF RUN-OFF FROM SMALL DRAINAGE AREAS ...Design Flow-flood, Floods, Massachusetts, Runoff, Small Watersheds, ...**2.0612**

INVESTIGATION OF SCOUR AT BRIDGES IN ALASKA ...Alaska, Bridges & Culverts, Channel Geometry, Erosion Control, Scouring, Suspension, ...**2.0285**

FLOOD FREQUENCY FOR SMALL DRAINAGE AREAS ...Discharge-general, Floods, Mississippi, Small Watersheds, ...**2.0291**

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REDUCTION OF SCOUR AROUND BRIDGE PIERS ...Bridges & Culverts, Erosion Control, Scouring, ...**2.0965**

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FLOOD PROFILES AND FLOOD-PLAIN INFORMATION, CEDAR RAPIDS, IOWA ...Floodplains, Floods, Iowa, Planning, Water Law-general, ...**2.0490**

CITY OF JACKSON, WATER RESOURCES STUDY, MISSISSIPPI ...Control and Protection, Floods, Groundwater, Mississippi, Water Supply-general, ...**4.0148**

FLOODING OF SMALL STREAMS IN NASHVILLE-DAVIDSON CO. AREA, TENN. ...Amount, Discharge-general, Floods, Gaging, Tennessee, ...**2.0994**

FLOOD INUNDATION MAPPING AND URBAN RUNOFF INV., DALLAS, TEXAS ...Floods, Land Use, Mapping, Runoff, Texas, ...**4.0232**

HYDROLOGIC INVESTIGATIONS OF URBAN AREAS - HOUSTON, TEXAS ...Amount, Discharge-general, Floods, Gaging, Texas, ...**4.0233**

URBAN HYDROLOGY STUDY - SAN ANTONIO, TEXAS ...Discharge-other, Floods, Runoff, Texas, ...**4.0234**

SEDIMENTATION AND HYDROLOGY-ROCK CREEK AND ANACOSTIA RIVER BASINS, MARYLAND ...Erosion-general, Groundwater, Land Use, Maryland, Sediment Yield, ...**4.0130**

REMOVAL OF NITROGEN COMPOUNDS FROM MUNICIPAL WASTEWATER ...Aeration, Denitrification, Microbial-bacterial, Nitrogen, ...**5.0855**

EMPIRICAL PREDICTION OF SAND FILTER PERFORMANCE ...Public Utilities, Public Works, Sand, Waste Water Treatment-general, ...**5.0403**

ORGANIC MATTER AND ITS ROLE IN WATER QUALITY ...Management, Organic Matter, Public Works, Reservoirs and Impoundments, Waste Water Treatment-general, ...**5.0122**

Urban Research

INTERRELATIONS BETWEEN RIVER BASIN DEVELOPMENTS AND DEVELOPMENT OF METROPOLITAN AREAS ...Planning, Redevelopment of Land, River Basins, Water Resources Development, ...**6.0165**

A METHOD FOR ASSESSING THE EXTENT OF POLLUTION FROM STORMWATER RUNOFF FROM AN URBAN AREA ...Combined Sewer, Construction-other, Runoff, Storm Water, Urban Environments, Waste Treatment-economics, ...**5.0090**

HYDRAULICS OF STORM SEWER JUNCTIONS ...Design Criteria, Drainage, Drainage Systems, Models, Storm Water, ...**5.0356**

TRACER STUDIES - URBAN RUNOFF ...Dyes, Peak Flow, Runoff, Urban Environments, Velocity -water, ...**4.0101**

Architecture and Design

INTERACTIONS OF URBAN ACTIVITY AND THE HYDROLOGICAL CYCLE ...Benefit-cost Analysis, Land Use, Value, Land Planning, Pollution Abatement, Recreation Sites, Urban Environments, ...**4.0135**

Beautification

BACTERIOLOGICAL AND ESTHETIC OF PLEASURE BOAT WASTE DISCHARGE ON SMALL HARBORS ...Analysis and Detection, Bacterial Pollutant Sources, Boat Discharges, Harbors, Marinas, ...**5.1267**

Demography

URBANIZATION AND ITS EFFECT ON WATER RESOURCES ...Industry and Industrialization, Land Use, Value, Land Planning, River Basins, Urbanization, Water Resources Development, Water Utilization -domestic, ...**6.0351**

Housing

Location Choice

EFFECT OF WATER QUALITY ON RESIDENTIAL LOCATION DECISIONS ...Economic Impact, New Jersey, Pollution - Effects of , Water Costs, ...**6.0348**

Industry and Industrialization

URBANIZATION AND ITS EFFECT ON WATER RESOURCES ...Demography , Land Use, Value, Land Planning, River Basins, Urbanization, Water Resources Development, Water Utilization - domestic, ...**6.0351**

Land Use, Value, Land Planning

URBANIZATION AND ITS EFFECT ON WATER RESOURCES ...Demography , Industry and Industrialization, River Basins, Urbanization, Water Resources Development, Water Utilization - domestic, ...**6.0351**

INTERACTIONS OF URBAN ACTIVITY AND THE HYDROLOGICAL CYCLE ...Architecture and Design, Benefit-cost Analysis, Pollution Abatement, Recreation Sites, Urban Environments ...**4.0135**

Planning

CASE STUDY OF REMEDIAL FLOOD MANAGEMENT IN AN URBAN AREA-PHASE I ...Alternative Planning, Floodplains, Floods, Management, Urban Environments, ...**6.0166**

Politics

URBAN WATER POLITICS AND DECISION MAKING IN THE DETROIT METROPOLITAN REGION ...Decision Theory, Model Studies, Optimization Technique, Urban Environments, ...**6.0298**

THE MUNICIPALITY AS A WATER POLICY DETERMINING ENTITY ...Social Aspects, State-local Government, Urban Environments, Water Supply-general, ...**6.0061**

Public-works

THE ECOMONIC IMPLICATIONS OF THE INTERCONNECTION OF URBAN WATER SYSTEMS ...Policy Making, Production & Processing, Risk & Uncertainty, Urban Environments, Water Demand, Water Transfer, ...**6.0466**

COMPREHENISVE PLANNING FOR WATER RESOURCES MANAGEMENT IN METROPOLITAN ENVIRONMENTS ...Administrative Structures, District of Columbia, Planning, Policy Making, Survey Studies, ...**6.0123**

Services

Recreation

SCORP UNIVERSITY OUTDOOR RECREATION RESEARCH STUDY SERVICE SPECIAL PROBLEMS ...Demand Analysis, Georgia, Recreation Sites, Urban Environments, ...**6.0160**

Social Environment of The City

SOCIO-ECONOMIC FACTORS RELATED TO THE INCIDENCE OF A WATER-BORNE DISEASE ...Economic Impact, Intestine, Pollution-water, Puerto Rico, Social Aspects, ...**5.1048**

Urbanization

URBANIZATION AND ITS EFFECT ON WATER RESOURCES ...Demography, Industry and Industrialization, Land Use, Value, Land Planning, River Basins, Water Resources Development, Water Utilization -domestic, ...**6.0351**

Urea

STUDY OF EXCRETORY PATTERNS IN CRAYFISHES ...Crayfish, All, Metabolism, Nitrogen, Osmoregulation, Stress, ...**6.0376**

Use of Impaired Water

A COST-EFFECTIVENESS STUDY OF PRETREATMENT METHODS SUITABLE FOR INTEGRATION TO MEMBRANE DESALTING PLANTS ...Brackish Water, Desalination, Economic Efficiency, Waste Treatment-economics, Waste Water Pre-treatment, ...**5.0746**

DEVELOPMENT OF ECONOMICAL METHODS OF BORON REMOVAL FROM IRRIGATION RETURN WATERS ...Boron, Desalination, Reverse Osmosis, Waste Treatment-economics, Waste Water Pre-treatment, ...**5.0093**

COMPARISON OF VARIOUS FORAGES FOR AGRICULTURAL WASTE WATER DISPOSAL ...Infiltration, Organic Fertility - other, Sprinkler Irrigation, Waste Disposal -underground, ...**5.0494**

EFFECTS OF MARGINAL QUALITY IRRIGATION WATER ON THE ACCUMULATION OF SALTS AND ALKALI IN SOUTH DAKOTA SOILS ...Irrigation-general, Saline and Alkaline Soils, Saline Soils, Soil pH , South Dakota, ...**3.0434**

THE ENGINEERING AND ECONOMIC ASPECTS OF USING SEWAGE EFFLUENT FOR IRRIGATION ...Irrigation-general, Louisiana, Sewage, Water Costs, ...**5.0463**

DESIGN OF WASTEWATER TREATMENT SYSTEMS TO SATISFY EFFLUENT QUALITY REQUIREMENTS BASED ON INTENDED USE ...Effluent-standards, Process Design, Waste Water Treatment-general, Water Quality Control-general, Water Reuse, ...**5.0769**

ANTELOPE VALLEY WASTE WATER RECLAMATION FACILITY ...Chemical Treatment, Effluent-standards, Filter-other, Flocculation, Pond, ...**5.0108**

IMPURITIES OF IRRIGATION WATERS AFFECTING SOIL PROPERTIES ...Irrigation-general, Saline and Alkaline Soils, Saline Soils, Soil Environment, Water Quality-general, ...**3.0043**

MANAGEMENT OF SALINE WATER FOR CROP PRODUCTION ...Arizona, Brackish Water, Management, Saline and Alkaline Soils, Water Quality-general, ...**3.0014**

A UNIFIED APPROACH TO WATER, FOOD AND POWER IN A COASTAL DESERT COMMUNITY ...Arid and Desert, Desalination, Deserts, Diesel, Distilling Units, Electric Power Plants, Greenhouse, ...**3.0015**

THE FEASIBILITY OF REUSE OF CHLORINATED SEWAGE EFFLUENT FOR FERTILIZATION AND IRRIGATION IN IDAHO (ABBREV) ...Chlorination, Irrigation-general, Sewage, Stream Rehabilitation, Water Reuse, ...**5.0327**

OPTIMIZATION IN THE USE OF VARIABLE QUALITY DESALTED WATER AND AN ARTIFICAL UNDERGROUND RESERVOIR TO SUPPLY PEAK MUNICIPAL WATER DEMANDS ...Computers-general, Conjunctive Use, Desalination, Optimization, Other Computers, Urban Environments, ...**3.0470**

VALUE OF DESALTED WATER FOR IRRIGATION ...Augmentation-general, Benefit-cost Analysis, Desalination, Irrigation-general, Planning, ...**3.0122**

Utah

PHYSIOGRAPHIC STUDY OF PART OF THE HENRY MOUTAINS REGION, UTAH ...Erosion, Henry Mountains, Physical Features-general, Physiography-general, Processes, ...**2.0563**

UTAH ATMOSPHERIC WATER RESOURCES (THE WASATCH WEATHER MODIFICATION PROJECT) ...Automatic Stations, Clouds-precipitation, Data Networks, Gages, Patterns, ...**2.1074**

EFFECTS OF WATER TEMPERATURE UPON RESPIRATORY METABOLISM OF CUTTHROAT TROUT, SALMO CLARKI ...Cutthroat Trout, Environmental Physiology, Respiration, Temperature, Water Temperature-non-specific, ...**5.1192**

EVALUATION OF FIVE METHODS FOR SAMPLING DESERT AND WETLAND VEGETATION ...Arid and Desert, Colorado, Deserts, Plant Ecology (non-specific), Wetlands, ...**3.0471**

WATERFOWL UTILIZATION OF SAGO PONDWEED (POTAMOGETON PECTINATUS) ON A SELECTED MARSH IN NORTHERN UTAH ...Food Supply, Mallard, Potamogeton, Ruppia, Zostera.., Storage, Swamps-marshes, ...**6.0588**

FRAIL LANDS STUDIES NEAR CISCO, UTAH (ABBREV) ...Erosion-general, Land, Sediment Yield, Soil Environment, Tillage, Cropping Systems, ...**4.0255**

THE EFFECT OF LIVESTOCK UTILIZATION ON WATERFOWL HABITAT AND PRODUCTION ...Cattle, Habitat Studies, Vasc. plant & Vert. -other, Water Fowl, N.s. , Wetlands, ...**6.0595**

THE VALUE OF WATER IN COMPLEMENTARY INDUSTRY COMPLEXES ...Agriculture Industry, Augmentation-general, Economic Impact, Social Aspects, ...**6.0576**

EUTROPHICATION OF SHELTERED BAYS IN A LARGE LAKE ...Bays, Chemical-general, Currents -water, Eutrophication, Freshwater Ecology, ...**5.1188**

RECREATION VALUE OF WATER FOR THE PRODUCTION OF WATERFOWL ...Benefit-cost Analysis, Recreation Sites, Water Fowl, N.s. , Wetlands, ...**6.0593**

THE DEVELOPMENT OF A SIMULATION MODEL FOR THE BEAR RIVER BASIN ...Analog Computers, Development of Models, Model Studies, Planning, River Basins, ...**6.0586**

APPLICATION OF OPERATIONS RESEARCH TECHNIQUES FOR ALLOCATION OF COLORADO RIVER WATERS IN UTAH ...Colorado River, Operations Research, Optimization, Water Allocation, ...**6.0575**

CALCULATION OF TEMPERATURE AND PRECIPITATION VALUES ...Air Temperature -non-specific, Distributions, Forecasting, Patterns, Temperature, ...**2.1058**

DATA REDUCTION METHODS FOR STREAMFLOW FROM SMALL, WILDLAND WATERSHEDS ...Computers-general, Data Analysis - General, Discharge-general, Gaging, Integration, Quadrature, Small Watersheds, ...**2.1068**

WATER QUANTITY AND QUALITY REQUIREMENTS ON WESTERN SALINE MARSHLANDS ...Habitat Studies, Swamps-marshes, Water Allocation, Water Fowl, N.s. , Water Quality-general, ...**6.0582**

THE EFFECTIVENESS OF WATERFOWL IN CARRYING PATHOGENIC MICRO-ORGANISMS ...Sewage, Swamps-marshes, Vertebrates, Water Fowl, N.s. , ...**5.1193**

FACTORS LIMITING WATERFOWL PRODUCTION ON THE SPRING-FED SALT MARSHES WEST OF THE GREAT SALT LAKE ...Mallard, Nutrition -other, Productivity (agricultural), Swamps-marshes, Viremia, ...**5.1194**

THE IMPROVED USE OF WET AND SALTED SOILS FOR FORAGE PRODUCTION ...Cultivation Methods, Ns, Excessive Moisture, Management, Saline and Alkaline Soils, Saline Soils, ...**3.0474**

FARM ADJUSTMENT TO LIMITED IRRIGATION WATER WITH REFERENCE TO CENTRAL UTAH PROJECT ...Economic Impact, Irrigation-general, Water Supply-general, ...**6.0589**

THE POTENTIAL DEMAND FOR WATER AND LAND IN SELECTED AREAS OF UTAH ...Agriculture, Economic Impact, Income, Industry, Water Demand, ...**6.0578**

DRAINAGE FARM SERVICE ...Agriculture Industry, Drainage Engineering, Land Use, Research Facilities, ...**4.0254**

STATE WATER PLAN INVESTIGATIONS ...Land Use, Management, River Basins, Water Supply-general, Water Utilization - general, ...**6.0579**

UNDESIRABLE SHRUB AND TREE CONTROL ...Evaluation, Forest Watersheds, in Forests, of Trees and Shrubs, Relations - Forage - Timber, ...**3.0475**

VEGETATION AND SOIL RESPONSE TO SOIL SURFACE TREATMENTS ...Economic Efficiency, Erosion-general, Management and Fertility, Tillage, Cropping Systems, Vigor, ...**3.0476**

CHARACTERISTICS OF UTAH STREAMS ...Discharge-general, Flow Characteristics -water, Gaging, Streams, ...**2.1060**

A STUDY OF THE INTEGRATION OF THE WATER RESOURCES OF THE BEAR, WEBER, AND JORDAN RIVERS IN NORTHERN UTAH ...Analog Computers, Analog Computers Math, Model Studies, Planning, Water Transfer, ...**6.0587**

SPRINGS OF UTAH ...Chemical-general, Potential of Deposit, Springs, Variation in Time, Water Properties-general, ...**2.1081**

Vacuum

VACUUM FILTRATION OF SEWAGE SLUDGE ...Filter-other, Filtration, Sludge-other, ...**5.0175**

Varietal Evaluation

MOISTURE USE CHARACTERISTICS OF CERTAIN CROP PLANTS ...Climate-general, Moisture Levels, Plant Water Use-other, Soil Fertility, Yield, ...**2.0991**

GUAVA VARIETIES. SELECTION & PROPAGATION OF GUAVA VARIETIES & INVESTIG. OF COMMERCIAL & INDUST. POSSIBILITIES OF THE FRUIT (ABBREV) ...Irrigation, Myrtaceae, Puerto Rico, Selection & Breeding, Trees, ...**5.1047**

RICE CULTURE ...Concentration Within Fertilize, Management, Maturity & Growth Stages, Methods of Application, Other, Rates Or Levels of Application, Rice, Yield, ...**2.0570**

VARIETAL EVALUATIONS AND IMPROVED AGRONOMIC PRACTICES FOR SUGARBEETS ...Breeding and Genetics, Irrigation, Management, Sugar Beets, ...**3.0262**

Velocity -water

GUIDING JUVENILE AND ADULT MIGRANT SALMONIDS BY NON-ELECTRICAL MEANS ...Behavioral Ecology, Migration, Salmon & Trout - Non-specific, Water Light Quality & Quantity, ...**8.0311**

THE EFFECTS OF VELOCITY ON THE PASSIVATION OF ALLOYS IN BRACKISH WATER ...Brackish Water, Desalination, Electrolytes, Metallic Alloys, Passivation, ...**3.0136**

RECLAMATION AND MANAGEMENT OF SOILS ON IRRIGABLE LAND (MONTANA) ...Internal Water Movement, Irrigation, Management, Saline and Alkaline Soils, Saline Soils, ...**4.0159**

INFLUENCE OF ACCUMULATED SEDIMENTS UPON WATER VELOCITY OF MICROHABITATS OCCUPIED BY TROUTS ...Colorado, Habitat Studies, Rio Grande River, Salmon & Trout - Non-specific, Sediments, ...**4.0068**

WATER VELOCITY AND SPATIAL CO-ACTIONS OF HATCHERY TROUT AND WILD BROWN TROUT ...Behavioral Ecology, Brown Trout, Colorado, Flume Studies, Rainbow Trout, Steelhead Trout, ...**5.0198**

INVESTIGATION OF THE CIRCULATION OF LAKE SUPERIOR ...Circulation -water, Model Studies, Stratified Flow, Temperature, ...**2.1161**

APPLICATION OF MAGNETOHYDRODYNAMICS TO MEASUREMENT OF LIQUID VELOCITY AND TURBULENCE ...Analog Computers, Analog Computers Math, Technique Development, Turbulent, Turbulent Flow, Velocity, ...**2.1166**

MICROSCOPIC INVESTIGATION OF TRACTIVE FORCE DISTRIBUTION IN OPEN CHANNEL ...Open Channel Flow, Suspension, Traction, Turbulent, Turbulent Flow, ...**8.0183**

BOUNDARY EFFECTS ON JET FLOW PATTERNS RELATED TO WATER QUALITY AND POLLUTION PROBLEMS ...Flow Characteristics -water, Jet Flow-other, Reservoirs and Impoundments, Velocity, Water Quality Control-general, ...**8.0180**

EXPERIMENTAL AND THEORETICAL STUDY OF THE HYDRODYNAMICS OF DISPERSION IN RIVERS AND ESTUARIES ...Dispersion -water, Estuaries, Flow Characteristics -water, Model Studies, Streams, ...**2.0584**

EFFECTS OF RIVER CURVATURE ON RESISTANCE TO FLOW ...Channels, Flow Characteristics -water, Flume Studies, Roughness, Unsteady Flow, ...**8.0198**

MIXING AND DISPERSION OF CONTAMINANTS IN RESERVOIRS ...Currents -water, Dispersion -water, Mixing, Reservoirs and Impoundments, Tracers-general, ...**5.1153**

COMPUTE SIMULATION OF DIFFUSION STUDIES ...Dispersion -water, Monte Carlo Methods, Simulation Theory, Turbulent Flow, ...**5.0785**

FEASIBILITY OF RATING CURRENT METERS IN A VELOCITY FIELD ...Currents -water, Gaging, Mass, Model Studies, ...**7.0107**

SPECIFIC YIELD RESEARCH AND PERMEABILITY RESEARCH ...Aquifers-general, California, Permeability, Storage of Water, Water Yield, ...**7.0013**

TRACER STUDIES - URBAN RUNOFF ...Dyes, Peak Flow, Runoff, Urban Environments, Urban Research, ...**4.0101**

TIME OF TRAVEL - PRINCIPAL MARYLAND STREAMS ...Dyes, Maryland, Pollutants - Path of , Streams, ...**2.0565**

WATER POLLUTION FROM ERODED SEDIMENTS ...Flow Characteristics -water, Other Transport Effects, Rain-general, Sediments, Suspension, ...**2.1042**

GROUNDWATER FLOW ...Flow Characteristics -water, Groundwater Movement, Permeability, Radioisotopes, Tritium, ...**2.0947**

GENERAL COASTAL INLET STUDIES ...Coastal Engineering-other, Coastlines-shorelines, Discharge-other, Model Studies, Synthetic Hydrology-general, Tides, ...**2.0689**

GREAT LAKES RESEARCH - EFFECTS OF STRUCTURES ON COASTAL SEDIMENTATION ...Beach, Bed Load, Coastal Engineering-other, Energy-dynamics, Engineering Structures-general, Great Lakes-general, ...**2.0650**

EVALUATION OF VARIABLES IN ALLUVIAL CHANNEL FLOW ...Bed Load, Channels, Flow Characteristics -water, Model Studies, Morphology-general, ...**2.0237**

ECOLOGICAL ENGINEERING PROJECT ...Atmosphere Radiation, Nutrients, Synthetic Hydrology-general, Temperature, Tracers-general, ...**6.0159**

MECHANICS OF SEDIMENT ENTRAINMENT, TRANSPORTATION AND DEPOSITION IN CHANNELS OF THE SOUTHERN BRANCH AND AT THE USDA SEDIMENTATION LABORATO ...Channels, Flume Studies, Sediment Transport-general, Sedimentation, Waves, ...**2.0677**

Venezuela

TIDAL, SALINITY AND SEDIMENTATION PROBLEMS IN LAKE MARACAIBO CHANNEL, VENEZUELA ...Bed Load, Erosion-general, Rate of Deposition, Salinity, Tides, ...**2.0618**

Venom

MARINE BIOTOXINS ...Animal Pollutant Sources, Bioindicators, Contamination, Pollution-water, Eutrophication, Gonyaulax, ...**5.1072**

Vermont

AN EVALUATION OF THE LAMPREY IN LAKE CHAMPLAIN ...Lakes, Lampreys, Maturity & Growth Stages, Predation, Spawn Or Nesting Sites, ...**6.0598**

BOTTOM SEDIMENTS OF LAKE CHAMPLAIN ...Chemical, Clays, General, Lakes, Size, ...**2.1087**

GLACIAL GEOLOGY OF THE CHAMPLAIN VALLEY ...Clays, Glacial History, Mapping, New York, Till, ...**2.1089**

CHEMICAL CHARACTERISTICS OF PRECIPITATION FALLING IN CHAMPLAIN VALLEY ...Chemical Analysis, Rain-general, Snow-general, Storms-general, Water Quality-general, ...**2.1086**

PARAMETERIZATION OF THE OBSERVED HYDROGRAPH AS A MEANS OF UNDERSTANDING RUNOFF PHENOMENA FROM SMALL WATERSHEDS ...Forecasting-prediction, Hydrographs, Model Studies, Runoff, Small Watersheds, ...**2.1085**

AUTECOLOGICAL STUDIES ON SOME DOMINANT PHYTOPLANKTON SPECIES OF LAKE CHAMPLAIN ...Algae-Diatoms, Aphanizomenon, Cyanophyta (non-specific & Ot), Eutrophication, Freshwater Ecology, ...**2.1084**

LIMNOLOGICAL STUDIES OF LAKE CHAMPLAIN ...Biological-general, Chemical-general, Lakes, Physical-general, Pollution - Effects of , Temperature, ...**5.1203**

Vertebrate Toxins & Poisons

Animal Origin

THE INVESTIGATION AND ANALYSIS OF BIOCHEMICAL PROCESSES OF AQUATIC ORGANISMS UNDER STRESS ...Aquatic Ecology, Fish -non-specific, Metabolism -animal, Other, Stress, ...**5.0585**

MARINE TOXINS OF THE TROPICAL PACIFIC ...Algal Metab.(non-specific &ot), Fish -non-specific, Other, Polynesia, Toxicology, ...**5.0315**

Mineral Origin

TOXIC ACTION OF WATER SOLUBLE POLLUTANTS ON FRESHWATER FISH ...Contamination - Water, Pollution Effects, Rainbow Trout, Steelhead Trout, Stress, ...**5.0565**

EFFECTS OF POSSIBLE POLLUTANTS ON ENERGY PRODUCTION BY BLUEGILL LIVER MITOCHONDRIA ...Bluegills, Bream, Metallic Ions, Mineral, Respiration, ...**5.0348**

CHRONIC EFFECTS OF HEAVY METALS ON FISH ...Computer Matching-code, Contamination - Water, Industrial Wastes, Mineral, Radioisotopes, ...**5.0584**

EFFECT OF METAL POISONING ON VARIOUS ENZYMES IN FISH ...Atpase, Chemical Effect-other, Inhibitors, Killifishs - Cyprinodon, Metals Ns, ...**5.1091**

HEMATOLOGICAL CHANGES IN F. HETEROCLITUS UPON EXPOSURE TO TOXIC METALS ...Blood Cells, Blood Plasma and Serum, Cadmium, Killifishs - Cyprinodon, Lead, ...**5.1092**

COMPARATIVE TOXICITIES OF METALS TO ESTUARINE FISHES ...Bioassays, Estuaries, Industrial Wastes, Killifishs - Cyprinodon, Solid Waste, ...**5.1084**

Toxins and Poisons -other

A STUDY OF A WATER TOXICITY PROBLEM ...Bioassays, Bioindicators, Growth Rate, Management, Potable Water, ...**5.0197**

WATER QUALITY REQUIREMENTS FOR AQUATIC LIFE ...Contamination - Water, Fish -non-specific, Pollution - Effects of , Water Quality-general, ...**5.0844**

Vegetable Origin

BLUE-GREEN ALGAE POISONING ...Algal Pollutant Sources, Algal Toxins, Arizona, Cyanophyta (non-specific & Ot), Range Or Territorial Distr. , ...**5.0041**

LABORATORY STUDIES OF TOXIC DINOFLAGELLATES ...Algal Culture, Algal Toxins, Gonyaulax, Gulf of Mexico, Gymnodinium, ...**5.1161**

Viral Studies

Assay

DETECTION AND ENUMERATION OF VIRUS IN NATURAL WATERS ...Bioindicators, Detection, Enteroviruses of Animals, Technique Development, Viral Pollutant Sources, ...**5.0713**

PLAQUING AND FLUORESCENT ANTIBODY METHODS FOR DETECTION AND IDENTIFICATION OF ENTEROVIRUSES ...Cell Cloning, Detection & Diagnosis, Enteroviruses of Animals, Pollutants-general, Waste Water Treatment-other, ...**5.0046**

AN ATTEMPT TO DETECT HIGHLY DILUTED VIRUSES IN WATERS BY FLOCCULATION ...Biochemical Oxygen Demand, Flocculation, Precipitation & Sedimentation, Sewage, Viral Pollutant Sources, ...**4.0139**

THE GAUZE PAD METHOD FOR THE ISOLATION OF VIRUSES FROM INLAND AND ESTUARINE WATERS ...Isolation, Precipitation & Sedimentation, Shoreline - Coastline, Viral Pollutant Sources, ...**5.1060**

Concentration

DEVELOPMENT OF METHODOLOGY FOR ISOLATION OF VIRUSES FROM SEA WATER ...Animal Viruses (non-specific), Marine Biology (non-specific), Physical Parameters, Viral Pollutant Sources, ...**5.1228**

Precipitation & Sedimentation

AN ATTEMPT TO DETECT HIGHLY DILUTED VIRUSES IN WATERS BY FLOCCULATION ...Assay, Biochemical Oxygen Demand, Flocculation, Sewage, Viral Pollutant Sources, ...**4.0139**

THE GAUZE PAD METHOD FOR THE ISOLATION OF VIRUSES FROM INLAND AND ESTUARINE WATERS ...Assay, Isolation, Shoreline - Coastline, Viral Pollutant Sources, ...**5.1060**

Control of Viruses

ADSORPTION OF VIRUSES ON MINERAL SURFACES ...Adsorption, Adsorption Capacity, Escherichia Coli, Mineralogy, Viral Pollutant Sources, ...**5.0474**

Inactivation

EFFECTS OF CHEMICAL IONS ON VIRUS INACTIVATION ...Animal Viruses (non-specific), Concentration, Ion Exchange-other, Ionic Effect, Virus, ...**5.0475**

DESTRUCTION OF INFECTIOUS VIRAL NUCLEIC ACID BY IODINE ...Enteroviruses of Humans, Iodine, RNA , ...**5.0843**

ISOLATION OF VIRUS FROM SEWAGE & DRINKING WATER ...Activated, Chlorination, Enteroviruses of Humans, Hepatitis, N.s. , Isolation, Potable, ...**5.0569**

Detection & Diagnosis

PLAQUING AND FLUORESCENT ANTIBODY METHODS FOR DETECTION AND IDENTIFICATION OF ENTEROVIRUSES ...Assay, Cell Cloning, Enteroviruses of Animals, Pollutants-general, Waste Water Treatment-other, ...**5.0046**

ENTEROCOCCI, COLIFORM BACTERIA AND BACTERIOPHAGES IN LAKE WATER ...Bacterial Pollutant Sources, Bacteriophages (non-spec & Ot), Streptococcus Fecalis, ...**5.1315**

Isolation

THE GAUZE PAD METHOD FOR THE ISOLATION OF VIRUSES FROM INLAND AND ESTUARINE WATERS ...Assay, Precipitation & Sedimentation, Shoreline - Coastline, Viral Pollutant Sources, ...**5.1060**

APPLICATION OF BACTERIOPHAGES TO ELIMINATE MINE ACIDS ...Acidity, Bacterial Pollutant Sources, Bacteriophages (non-spec & Ot), Mining Industry, ...**5.0995**

PHYCOVIRUSES - THEIR NATURE, OCCURRENCE, AND APPLICATION ...Algal Pollutant Sources, Algal Virus, Biocontrol, Eutrophication, Pathological Physiology, ...**5.0859**

BIOLOGICAL METHODS RESEARCH ...Chemical Identification, Crustacea -non-specific, Enteroviruses of Humans, Sewage, Viral Pollutant Sources, ...**5.0017**

ISOLATION OF VIRUS FROM SEWAGE & DRINKING WATER ...Activated, Chlorination, Enteroviruses of Humans, Hepatitis, N.s. , Inactivation, Potable, ...**5.0569**

Virginia

POROSITY AND PERMEABILITY OF VIRGINIA AGGREGATES ...Aggregrates - Crushed Rock, Nitrogen, Permeability, Porosity, ...**2.1111**

HYDROLOGIC STUDIES ...Data Acquisition-general, Floods, Small Watersheds, ...**2.0299**

QUANTITATIVE AND QUALITATIVE MEASUREMENT OF AQUATIC VEGETATION-CURRITUCK SOUND ...Aquatic Plants (non-specific), Mapping, North Carolina, Pollution - Effects of , Saline Water Intrusion, ...**5.0816**

SIMULATION OF THE HYDROLOGIC CYCLE ON SMALL AGRICULTURAL WATERSHEDS BY DIGITAL TECHNIQUES ...Agricultural Watersheds, Algorithms, Digital Computers, Other Models, Water Cycle, ...**2.1109**

BIOLOGICAL AND CHEMICAL STUDY OF VIRGINIAS ESTUARIES ...Estuaries, Nitrogen, Phosphorus, Phytoplankton, Population Dynamics, Primary Productivity, ...**2.1112**

WATER YIELDS FROM SMALL WATERSHEDS ...Climate, Runoff, Shape, Small Watersheds, Water Yield, ...**4.0265**

DRAINAGE REQUIREMENTS AND PRACTICES FOR CROP PRODUCTION ...Drainage, ...**4.0266**

Viruses (animal)

Animal Viruses (non-specific)

EFFECTS OF CHEMICAL IONS ON VIRUS INACTIVATION ...Concentration, Inactivation, Ion Exchange-other, Ionic Effect, Virus, ...**5.0475**

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USE OF MODIFIED ACTIVATED SLUDGE TREAT TO ACHIEVE NUTRIENT REMOVAL & TO PROVIDE CONSISTENT FEED TO TERTIARY TREATMENT SYSTEM ...Activated, Aeration, Pilot Plant, Tertiary Treatment, Waste Treatment-economics, ...**5.0245**

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SELECTIVE NITRATE AND PHOSPHATE REMOVAL ...Denitrification, Ion Exchange-other, Ion Selective, Nitrate, Nitrite, Phosphate, Phosphite, Waste Treatment-economics, ...**5.0532**

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ALUMINA COLUMNS FOR THE SELECTIVE REMOVAL OF PHOSPHORUS FROM WASTEWATERS AND THE ULTIMATE DISPOSAL OF PHOSPHORUS AS CALCIUM PHOSPHATE ...Aluminum, Material Recovery Wastes, Phosphate, Phosphite, Process Design, Regeneration-other, ...**5.1243**

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RELATIONSHIP OF ACTIVATED SLUDGE BULKING TO ORGANIC LOADING, OXYGEN AVAILABILITY, AND HYDRAULIC CHARACTERISTICS OF THE AERATION TANK ...Aeration, Model Studies, Organics, Process Design, ...**5.0879**

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KINETICS AND MECHANISM IN ACTIVATED SLUDGE PROCESSES ...Kinetics-other, Process Design, ...**5.0927**

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USE OF MODIFIED ACTIVATED SLUDGE TREAT TO ACHIEVE NUTRIENT REMOVAL & TO PROVIDE CONSISTENT FEED TO TERTIARY TREATMENT SYSTEM ...Aeration, Pilot Plant, Pollutant-other, Tertiary Treatment, Waste Treatment-economics, ...**5.0245**

REMOVAL OF ORGANICS AND NUTRIENTS FROM CITRUS PROCESSING PLANT WASTES ...Aeration, Citrus, Food Processing Industry, Organics, Pond, Waste Water Treatment-general, ...**5.0266**

PHOSPHATE REMOVAL BY BIOLOGICAL PROCESS ...Drying-dewatering, Phosphate, Phosphite, Process Design, ...**5.0582**

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SEWAGE PHOSPHORUS REMOVAL BY AN ACTIVATED SLUDGE PLANT ...Aerobic, Digestive Tanks, Phosphorus, Sewage Testing, ...**5.1321**

A COMPLETE RECYCLE WASTE WATER TREATMENT PLANT ...Biological Treatment-other, Coagulation, Sedimentation, Trickling, Water Reuse, ...**5.1165**

OPTIMAL DESIGN OF WASTE TREATMENT SYSTEMS ...Biological Treatment-other, Electrodialysis, Optimization, Oxidation-general, Process Design, ...**8.0202**

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PHOSPHORUS REMOVAL BY ADDITION OF ALUMINUM TO THE ACTIVATED SLUDGE PROCESS ...Aluminum, Phosphate, Phosphite, Waste Treatment-economics, ...**5.0109**

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PHOSPHORUS REMOVAL IN THE ACTIVATED SLUDGE PLANT ...Aeration, Aluminum, Phosphate, Phosphite, Precipitation, Sewage - Domestic, ...**5.0788**

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IMPROVED CAPABILITIES OF BIOLOGICAL SYSTEMS TO ASSIMILATE OIL ...Biological, Organics, Waste Water Pre-treatment, ...**5.0780**

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ECONOMIC ANALYSIS OF ALTERNATIVE WATER USE TECHNIQUES IN PRODUCTION OF COTTON, GRAIN SORGHUM & RELATED CROPS - SOUTHERN HIGH PLAINS OF TEXAS ...Conjunctive Use, Conservation-general, Economic Efficiency, Irrigation-general, Water Costs, ...**6.0571**

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ECONOMIC ANALYSIS OF WATER USE IN IRRIGATION IN THE NORTHERN PLAINS ...Benefit-cost Analysis, Costs, Great Plains Province, Irrigation-general, Production & Processing, Rates Or Levels of Application, ...**4.0077**

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MAXIMIZING PRODUCTIVITY OF WATER USED FOR IRRIGATION OF AGRICULTURAL LANDS ...Irrigation-general, Model Studies, Optimization, Water - Alternative Uses, ...**6.0610**

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A COMPARATIVE STUDY OF THE USE TAX AS A MEANS OF ALLOCATION OF WATER RESOURCES IN A CONJUNCTIVE USE SYSTEM ...Benefit-cost Analysis, Conjunctive Use, Fiscal, Groundwater, Welfare Economics, ...**6.0056**

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PROCEDURES FOR ESTIMATING CROP WATER REQUIREMENTS FOR USE IN WATER ALLOCATIONS AND FOR IMPROVEMENT OF IRRIGATION EFFICIENCY ...Evapotranspiration, General Synoptic Observations, Irrigation-general, Lysimeters, Requirements for Water, ...**3.0047**

WATER QUANTITY AND QUALITY REQUIREMENTS ON WESTERN SALINE MARSHLANDS ...Habitat Studies, Swamps-marshes, Utah, Water Fowl, N.s. , Water Quality-general, ...**6.0582**

NATURAL RESOURCE MANAGEMENT AND CONSERVATION IN THE SOVIET UNION ...Conservation-general, Multiple-purpose Projects, Russia, Survey Studies, Water Quality-general, ...**3.0485**

ECONOMIC GROWTH AND OPTIMUM WATER RESOURCE DEVELOPMENT ...Alternative Planning, Economics-general, Optimization, Water Demand, Water Resources Development, ...**6.0043**

IRRIGATION IN RELATION TO CROPPING SYSTEMS ...Irrigation-general, Model Studies, Water Costs, Water Sources -general, Water Yield, ...**6.0053**

CALIFORNIA-ARIZONA ECONOMIC INTERDEPENDENCE AND THE COLORADO RIVER CONFLICT WITH PARTICULAR REFERENCE TO AGRICULTURE ...Agriculture, Agriculture Industry, Colorado River, Economic Impact, Income, Input - Output Analysis, ...**6.0050**

A STUDY OF THE SOCIAL MECHANISM OF RURAL-URBAN WATER TRANSFERS WITH SPECIAL REFERENCE TO EXTERNAL EFFECTS ...Administrative Structures, Agriculture, Base Studies, Economic Efficiency, Fiscal, Model Studies, Social Aspects, Water Transfer, Welfare Economics, ...**6.0105**

AQUIFER STUDIES IN MARYLAND - SEDIMENTARY ROCKS IN THE COASTAL PLAIN ...Aquifers-general, Geologic Sections, Hydrology-general, Management, Specific Rock Unit, Subsurface, ...**2.0561**

WATER RIGHTS AND WATER LAW ...Alternative Planning, Eminent Domain, Riparian Rights, Water Resources Development, Water Utilization -general, ...**6.0386**

SIMULATION AS A MEANS OF STUDYING RESOURCE ALLOCATIONS ...Alternative Planning, Economics-general, Model Studies, River Basins, Simulation Theory, ...**6.0456**

METHODOLOGY FOR DETERMINING VALUATIONS OF WATER FOR ALTERNATIVE USES ...Economic Efficiency, Input - Output Analysis, Model Studies, Water - Alternative Uses, Water Costs, ...**6.0592**

ECONOMICS OF WATER MANAGEMENT TECHNIQUES IN SOUTH DAKOTA ...Economic Impact, Impact, Input - Output Analysis, Irrigation-general, Management, Optimization, Production & Processing, South Dakota, ...**6.0136**

ECONOMICS OF WATER MANAGEMENT ON THE TEXAS HIGH PLAINS ...Aquifers-general, Economic Impact, Groundwater, Production & Processing, Texas, Water Yield, Welfare Economics, ...**6.0137**

ECONOMICS OF WESTERN STREAMFLOW ACCRETIONS ...Benefit-cost Analysis, Irrigation-general, Missouri River, Water Rights-general, Water Transfer, ...**6.0100**

VALUE OF IRRIGATION WATER FOR THE PRODUCTION OF SUGAR CANE ...Economic Feasibility, Irrigation, Irrigation-general, Sugar Cane, Water Costs, ...**6.0174**

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HYDRAULIC OPERATING CHARACTERISTICS OF LOW GRADIENT BORDER SYSTEMS PHASE II ...Border Irrigation, Infiltration, Irrigation, Irrigation Engineering, ...**3.0139**

WATER REQUIREMENTS FOR SALINITY CONTROL IN UNSATURATED SOILS ...Irrigation-general, Saline Properties, Saturated-unsaturated, Soil and Rock Leaching, ...**5.0751**

EFFECTS OF WATER APPLICATION ON CROP PLANTS ...Evaporation, Growth Rate, Requirements for Water, Water Balance-budget, ...**2.0652**

HYDRAULICS OF SURFACE IRRIGATION ...Irrigation Engineering, Math Models, Model Studies, Surface Flow, Surface Irrigation -general, ...**4.0252**

SOIL MANAGEMENT INVESTIGATIONS ON IRRIGATED LAND ...Irrigation, Management, Rotations, Soil Analysis, Soil Comparison, Tillage, Cropping Systems, ...**4.0114**

SUBIRRIGATION ...Irrigation Engineering, Orifice, Subsurface Irrigation, ...**4.0121**

A STUDY OF TECHNIQUES FOR INCREASING EFFICIENCY OF IRRIGATION WATER APPLIED TO POTATOES ...Irrigation, Moisture Tension, Potatoes, ...**2.0798**

THE ADAPTATION OF SPRINKLER IRRIGATION TO SOILS OF LOW INTAKE RATE ...Absorption, Fixation, Exchange, Irrigation, Moisture Content, Sprinkler Irrigation, ...**3.0402**

WATER NEEDS FOR IRRIGATION IN OREGON ...Agricultural Watersheds, Irrigation-general, Requirements for Water, Soil Conditions, Water Demand, ...**6.0462**

DESIGN FACTORS IN SURFACE IRRIGATION ...Furrow Irrigation, Infiltration, Irrigation Engineering, ...**3.0477**

EFFECT OF VARIOUS IRRIGATION TECHNIQUES ON SOIL AERATION, SOIL STRUCTURE, AND CROP RESPONSE ...Irrigation, Soil Aeration, Soil Structure, ...**2.1070**

WATER APPLICATION AND USE ON A RANGE WATER-SPREADER ...Irrigation, Irrigation Engineering, Management and Fertility, Soil Environment, Surface Irrigation -general, ...**4.0056**

IRRIGATION SYSTEMS FOR EFFICIENT WATER USE ...Evapotranspiration, Infiltration, Irrigation-general, Model Studies, Water Loss Control, ...**8.0003**

IRRIGATION REQUIREMENTS, PRACTICES AND METHODS OF APPLICATION FOR EFFICIENT PRODUCTION OF CROPS IN THE SOUTHEAST ...Irrigation, Soil-water-plant Relationships, ...**3.0191**

IRRIGATION PRACTICES, REQUIREMENTS AND DESIGN CRITERIA FOR EFFICIENT USE OF WATER AND SUSTAINED CROP PRODUCTION IN THE NORTHERN PLAINS ...Irrigation, Irrigation Engineering, ...**3.0142**

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HEAT BUDGET AND EVAPOTRANSPIRATION OF FRUIT TREES ...Energy Budgets, Evapotranspiration, Temperature Or Heat Budgets, Transpiration and Evap, Trees, ...**2.0311**

DETERMINATION OF EVAPOTRANSPIRATION FOR SHORT INTERVALS ON A BENCHMARK BASIN ...Evapotranspiration, Heat Budget, Israel, Karst Topography, Moisture Content, ...**2.0493**

HYDROLOGIC ANALYSIS OF LAKE SYSTEMS AND OF GLACIERS ...Climate, Glaciology-general, Infrared Radiation, Lakes, Snowpack, ...**6.0142**

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EFFECTS OF PINYON-JUNIPER CONVERSION ON WATERSHED VALUES IN UTAH ...Cover Crops, Forest Watersheds, Juniperus, Moisture Budgets, Pines, ...**2.1067**

HYDROLOGY OF WATER YIELD PREDICTION ...Amount, Forecasting-prediction, Forest Watersheds, Moisture Retention, Water Yield, ...**2.0892**

PHYSICAL, METEOROLOGICAL, AND HYDROLOGIC ASPECTS OF EVAPOTRANSPIRATION ...Evapotranspiration, Meteorological Studies-general, Soil-water-plant Relationships, Translocation, Water Yield, ...**2.0951**

AVAILABILITY, DISTRIBUTION, QUANTITY AND QUALITY OF WATER RESOURCES IN CARBONATE KARST TERRAIN ...Available Water, Carbonate Aquifers, Groundwater, Karst Topography, Runoff, Water Quality-general, ...**4.0155**

WATER BALANCE IN SEWAGE STABILIZATION LAGOONS ...Industrial Wastes, Organic Matter, Seepage, Sewage Lagoons, Water Quality-general, ...**5.0833**

THE GROUND-WATER FLOW SYSTEM IN THE DELMARVA PENINSULA ...Aquifers-general, Delaware, Flow Characteristics - water, Groundwater, Model Studies, ...**2.0254**

WATER TRANSFER FROM SOIL TO THE ATMOSPHERE AS RELATED TO CLIMATE AND SOIL PROPERTIES ...Evaporation, Humidity, Moisture Content, Physical Climatology, Radiation-general, Water Transfer, ...**2.1046**

AN ATMOSPHERIC ENERGY BUDGET STUDY ...Great Basin, Heat Exchange, Storms-general, ...**2.0738**

ATMOSPHERIC WATER BALANCE AND THE FORECAST OF ANNUAL RUNOFF FROM THE UPPER COLORADO RIVER BASIN ...Colorado River, Evaporation, Forecasting-prediction, Runoff, ...**2.0222**

HYDROLOGIC RELATIONSHIPS IN A CONIFEROUS FOREST ...Amount, Evapotranspiration, Forest Watersheds, Groundwater, Storage of Water, ...**2.0552**

AERATION OF LAGOONS IN RIGOROUS CLIMATE AREAS ...Aeration, Climate, Degradation-other, Lagoon, Pollution Abatement, Pond, Wyoming, ...**5.1325**

WATER BALANCE AND ALKALINE EXCHANGE RELATIONSHIPS AS INFLUENCED BY WATER MANAGEMENT PRACTICES IN RICE ...Arkansas, Microclimate-general, Rice, Salt, Water Depth, Water Levels, ...**2.0071**

SOIL-WATER-VEGETATION RELATIONS IN THE DOUGLAS FIR ZONE ...Flow Characteristics -water, Forest Watersheds, Moisture Content, Patterns, Runoff, Water Cycle, ...**3.0027**

EFFECTS OF WATER APPLICATION ON CROP PLANTS ...Evaporation, Growth Rate, Requirements for Water, Water Application Methods, ...**2.0652**

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EFFECT OF METABOLIC ANTITRANSPIRANTS ON INTERNAL WATER BALANCE, GROWTH AND SURVIVAL OF OUTPLANTED TREES ...Antitranspirants, ...**2.1158**

COMPUTER SIMULATION AND EVALUATION OF CLIMATOLOGICAL MODELS ...Computers-general, Model Studies, Patterns, Statistics-general, ...**7.0044**

EVALUATION OF CONSUMPTIVE WATER USE, SOIL-WATER STORAGE, AND THE INTERRELATION OF THREE COMPONENTS OF THE WATER BUDGET ...Agricultural Watersheds, Climate, Consumptive Use, Evapotranspiration, Groundwater, Moisture Retention, ...**4.0080**

A PHYSICAL AND ECONOMIC ANALYSIS OF ALTERNATIVE IRRIGATION METHODS IN A SUB-HUMID CLIMATE ...Applied Climatology, Evapotranspiration, Irrigation-general, Model Studies, Sub - Humid, ...**3.0384**

THE IMPACT OF SUBURBAN DEVELOPMENT ON THE WATER RESOURCES OF NEW JERSEY. ...Agricultural Watersheds, Flow Characteristics -water, Gaging, Measurement, Surburban Areas, Water Table Fluctuation, ...**6.0352**

THE ROLE OF VEGETATION AND SOIL IN WATERSHED YIELD ...Cover Crops, Dendroclimatology, Soil Properties - General, Soil-water-plant Relationships, Water Yield, Watersheds-general, ...**4.0256**

WATERSHED WATER BUDGET ...Agricultural Watersheds, Evapotranspiration, Mathematical Analysis, Moisture Content, Runoff, ...**2.1157**

EVAPORATION FROM LAKES AND RESERVOIRS ...Evaporation, Evapotranspiration, Heat Budget, Lakes, Reservoirs and Impoundments, ...**2.0187**

HYDROLOGY OF PRAIRIE POTHOLES ...Management -other, North Dakota, Potholes, Seepage, Water Fowl, N.s. , Water Utilization -animal, ...**2.0170**

GILA RIVER PHREATOPHYTE PROJECT ...Arizona, Energy Budgets, Evapotranspiration, Phreatophytes, Water Loss Control, ...**2.0042**

QUANTITATIVE WATER-BUDGET ANALYSIS OF WESTERN LONG ISLAND, NEW YORK ...Alternative Planning, Groundwater Basins, Management, New York, Water Resources Development, ...**2.0809**

EVAPORATION LOSSES FROM LAKES IN INDIANA ...Evaporation, Indiana, Lakes, Reservoirs and Impoundments, ...**2.0454**

EFFECT OF IRRIGATION ON STREAMFLOW IN CENTRAL SAND PLAINS OF WISCONSIN ...Drainage, Groundwater, Irrigation-general, Morphology-general, Wisconsin, ...**4.0279**

BASIC INVESTIGATION OF HEAT AND MOISTURE TRANSFER ACROSS THE AIR-WATER INTERFACE ...Boundary Layer Studies, Evaporation, Heat Exchange, Interface, Water Loss Control, ...**3.0124**

HYDROLOGY OF HUNGRY HORSE RESERVOIR MONTANA ...Inflow, Low Flow, Montana, Reservoirs and Impoundments, ...**2.0124**

FLOOD RUNOFF & WATER YIELD FROM GLACIATED MOUNTAINS ...Floods, Forest Watersheds, Glacial Environment, Heat Budget, Runoff, Water Yield, ...**3.0372**

THE ENERGY BUDGET AT THE EARTHS SURFACE ...Energy Budgets, Heat Exchange, Humidity, Moisture Content, Transpiration and Evap, Wind Tunnels, ...**2.0808**

IRRIGATION SYSTEMS FOR EFFICIENT WATER USE IN THE GREAT BASIN ...Arid and Desert, Evapotranspiration, Great Basin, Lysimeters, Sprinkler Irrigation, ...**3.0314**

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GEOCHEMICAL STUDIES OF CONTINENTAL WATERS ...Authigenesis, Location, Pore Fluids, Radioisotopes, ...**1.0081**

DISSOLVED ORGANIC PHOSPHORUS IN NATURAL WATERS ...Organic-general, Precipitation, Radiochemical Techniques, Removal--inorganics, Saturated Hydrocarbons, ...**1.0088**

(U) DETERMINATION OF FREE BROMINE IN WATER (US 14) ...Amines, Bromine, Chlorine, Colorimetric, ...**5.0372**

STABLE CARBON AND OXYGEN ISOTOPE RATIO VARIATIONS IN THE FLOW TO CARBON AND OXYGEN THROUGH NORMAL AND POLLUTED AQUATIC SYSTEMS ...Carbon, Element Ratios, Organic-general, Oxygen, Pollutants - Path of , Sewerage Systems-other, ...**5.1183**

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CONTROL OF EVAPORATION AND TRANSPIRATION THROUGH SOIL, PLANT AND AIR - WATER INTERFACE MODIFICATIONS ...Anti-transpirants, Evaporation, Modified Water Use, Transpiration, Transpiration and Evap, ...**2.1040**

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WATER SALVAGE STUDY ...Colorado, Modified Water Use, Phreatophytes, Transpiration, ...**6.0096**

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WATER YIELD IMPROVEMENT, AND SNOW AND AVALANCHE PREDICTION AND PREVENTION, IN THE ALPINE REGIONS OF THE CENTRAL ROCKY MOUNTAINS ...Alpine, Colorado, Snowslide-avalanche, Water Yield, ...**3.0146**

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GROWTH OF THE BROWN BULLHEAD, ICTALURUS NEBULOSUS (LESUEUR), IN MINE ACID POLLUTED WATER ...Bullheads, Contamination - Water, Growth Rate, Mining Activities, Ph, Acidity -water, Pollution Effects, ...5.1278

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APPLICATION OF BACTERIOPHAGES TO ELIMINATE MINE ACIDS ...Bacterial Pollutant Sources, Bacteriophages (non-spec & Ot), Isolation, Mining Industry, ...5.0995

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ESTIMATING ACID MINE DRAINAGE POTENTIAL FROM COAL BEDS BY USE OF THE SOXHLET EXTRACTOR ...Acid Mine Wastes, Coal-general, Extraction, Iron, Sulfate, Sulfite, ...5.0993

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AN ECOLOGICAL STUDY OF AN ALKALINE STREAM WITH HEAVY IRON DEPOSITS ORIGINATING FROM TREATMENT OF MINE ACID WATER ...Lake Trout, Brook Trout, Mineral Content -water, Mining Activities, Productivity - Food Chain, Susquehanna River, Water Alkalinity, ...5.1025

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EFFECT OF COPPER SULFATE ON AQUATIC WEEDS ...Canals, Copper, Copper Sulfate, Irrigation-general, of Aquatic Plants, ...**3.0108**

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WATER QUALITY, STUDIES AND AERIAL MEASUREMENTS ...Aircraft, Chemical-general, Lasers-masers, Pollutants-general, Remote Sensing-general, ...**6.0145**

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A STUDY OF THE BIOLOGICAL, CHEMICAL AND PHYSICAL NATURE OF WATER QUALITY FACTORS UNDER UTAH CONDITIONS ...Chemical-general, Model Studies, Mountains-alpine, Physical-general, Pollutants - Path of , ...**5.1195**

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A LIMNOLOGICAL STUDY OF SPIRITWOOD, NORTH DAKOTA - WATER QUALITY AND SEASONAL CYCLES ...Chemical-general, Lakes, North Dakota, Physical-general, Recreation Sites, ...**2.0833**

CHEMICAL, PHYSICAL, AND BIOLOGICAL DYNAMICS OF NORTHERN PRAIRIE LAKES ...Chemical-general, Lakes, Land Use, Physical-general, Water Quality-general, ...**5.1114**

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INVESTIGATION OF THE INFLUENCE OF VALENCE STATES OF IRON AND MANGANESE UPON THE BIOTA OF THE HYPOLIMNION ...Chemical-general, Electron Spin, Ions and Gases, Model Studies, Reservoirs and Impoundments, ...**5.0298**

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EFFECT OF CHLORINATION ON CILIATE PROTOZOA AND THEIR ROLE AS A BARRIER TO STREAM POLLUTION ...Chlorination, Illinois, Population Dynamics, Protozoa -other, Streams, ...**5.0379**

EXPERIMENTAL REVERSAL OF THE LAKE EUTROPHICATION PROCESS ...Circulation -water, Eutrophication, Nutrients, Temperature, Wisconsin, ...**5.1308**

EFFECTS OF DOMESTIC POLLUTION ABATEMENT ON A EUTROPHIC LAKE ...Chemical-general, Eutrophication, Physical-general, Pollution Abatement, Self-purification, ...**6.0220**

RENOVATION OF A DYSTROPHIC LAKE INTO A EUTROPHIC LAKE ...Aeration, Eutrophication, Lakes, Nutrients, Organic Matter, ...**5.0761**

TUSCON WASTEWATER RECLAMATION PROJECT ...Chemical-general, Filter-other, Fish -non-specific, Productivity (agricultural), Stream Rehabilitation, Water Standards, ...**5.0043**

LIMNOLOGICAL STUDIES OF LAKE CHAMPLAIN ...Chemical-general, Lakes, Physical-general, Pollution - Effects of , Temperature, Vermont, ...**5.1203**

EFFECT OF HEATED WATER DISCHARGE FROM IPALCO'S PETERSBURG PLANT ON THE WATERS OF WHITE RIVER, INDIANA ...Chemical-general, Electric Power Plants, Physical-general, Pollution - Effects of , Thermal Pollution, White River, ...**5.0383**

LAKE ERIE ENVIRONMENTAL STUDIES PROGRAM ...Biological, Chemical, Chemical-general, Deltas, Eutrophication, Lake Erie, Meteorological Studies-general, Monitoring (long Term Studies), Physical-general, Sedimentology-general, ...**2.0783**

INTERRELATIONSHIP OF FACTORS AFFECTING QUALITY OF IMPOUNDED WATERS ...Chemical Analysis (water), Chemical-general, Lakes, Physical-general, Water Quality-general, ...**2.0413**

LIMNOLOGICAL STUDY OF PEORIA LAKE ...Chemical-general, Illinois River, Turbidity, ...**5.0354**

RESEARCH IN LIMNOLOGY - INTERRELATIONS OF HYDROLOGY AND AQUATIC ECOLOGY ...Chemical-general, Destratification, Hydrology-general, Organic Matter, Physical-general, ...**2.0128**

AUKE LAKE STUDIES ...Chemical-general, Gulf of Alaska, Lakes, Physical-general, Spawn Or Nesting Sites, ...**6.0006**

PHYSIOLOGY AND BEHAVIOR ...Aquatic Ecology, Environmental Physiology, Productivity - Food Chain, ...**6.0290**

MONITORING FISH STOCKS AND ENVIRONMENTAL CONDITIONS ...Aquatic Ecology, Environmental Effects-geologic, Population Dynamics, Water Properties-general, ...**6.0635**

PREDICTION OF ENVIRONMENT ...Columbia River, Environmental Ecology, Low Temp. -but Above 32f, Physical-general, Reservoirs and Impoundments, Salmon & Trout - Non-specific, Snake River, Temperature, Thermal Pollution, ...**6.0617**

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ASYMMETRIC BUBBLE COLLAPSE STUDIES 6310 ...Cavity Flow, Coaxial, Photography-general, Pressure Gradient, ...**1.0067**

THE ORGANIC CONCENTRATION GRADIENT IN AN AERATION COLUMN ...Aeration, Foam, Organic Matter, Surfactants, Waste Water Treatment-general, ...**5.0734**

EXPERIMENTAL STUDY OF MOTION OF CAVITATION BUBBLES ...Close Channel, Growth, Inception, Turbulent, ...**8.0270**

ANALYSIS OF MIXING PHENOMENA ASSOCIATED WITH THE RISE OF GASEOUS BUBBLES THRU A STRATIFIELD LIQUID ...Destratification, Mixing, Model Studies, Salinity, Stratification, ...**1.0072**

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WATER QUALITY, STUDIES AND AERIAL MEASUREMENTS ...Aircraft, Biological-general, Lasers-masers, Pollutants-general, Remote Sensing-general, ...**6.0145**

CHEMICAL STUDIES ON THE WATERS AND SOILS OF LAKES AND WETLANDS, WITH SPECIAL REFERENCE TO MINOR ELEMENTS ...Chemical, Lakes, Minnesota, Trace Element Analysis, Wetlands, ...**2.0660**

LIMNOLOGY OF ROSS ISLAND, ANTARCTICA ...Antarctica, Benthic Organisms (non-specif), Lakes, Plankton (non-specific), Pubilications -other, ...**2.0087**

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STUDY OF RED SALMON IN THE NUSHAGAK DISTRICT ...Alaska, Physical-general, Salmon -coho,chinook,sockeye.., Spawn Or Nesting Sites, ...**6.0622**

EVALUATION OF METHODS DESIGNED TO PREVENT WINTER-KILL ...Aeration, Circulation -water, Lakes, Mortality Rates, North Dakota, ...**5.0828**

PLANKTON STUDIES ...Lakes, Number, Plankton (non-specific), Water Level Fluctuation, ...**4.0125**

DOCUMENT LOGGING DAMAGE ...Biological-general, Fish - non-specific, Forest Debris, Logging, Transport, Equipment, Physical-general, Pollution - Effects of , Population Dynamics, ...**5.0145**

PHYSICAL AND CHEMICAL CHANGES OF RECIRCULATED HATCHERY WATER SUPPLIES ...Captive Rearing, Chemical Measurements -water, Physical Measurements -water, Physical-general, Water Reuse, ...**5.0708**

IMPACT OF WINTER DRAWDOWN ON A SLOW-GROWING PANFISH POPULATION AND ASSOCIATED SPECIES ...Aquatic Ecology, Depth,water Level, Fluctuation, Drawdown, Population Dynamics, ...**4.0276**

EFFECTS OF CHANGES IN WATER QUALITY ON FRY AND FINGERLINGS ...Aquatic Ecology, Basses -sea,white, White

Perch, Environmental Ecology, Louisiana, Water Quality-general, ...5.0454

MARSH HABITAT STUDY ...Centrarchidae -other, Florida, Habitat Studies, Life History Studies, Swamps-marshes, ...6.0157

STABILIZATION STUDY OF FALCON RESERVOIR ...Biological-general, Fish -non-specific, Physical-general, Population Dynamics, Reservoirs and Impoundments, ...4.0229

LIMESTONE DRUM PRODUCTIVITY STUDY JOB NUMBER 3 - ECONOMIC EVALUATION ...Acidity, Benefit-cost Analysis, Biological-general, Limestone - General, ...5.1274

LIMESTONE DRUM PRODUCTIVITY STUDY JOB NUMBER 1 - LIMNOLOGICAL STUDY ...Acidity, Aquatic Ecology, Biological-general, Limestone - General, Stream Rehabilitation, ...5.1275

LIMESTONE DRUM PRODUCTIVITY STUDY ...Aquatic Ecology, Limestone - General, Ph, Acidity -water, Population Dynamics, Productivity (agricultural), ...5.1273

CHEMICAL AND PHYSICAL ANALYSES OF WATER AND SOILS ...Bottom Sampling, Lakes, Physical-general, Soil Chemical Properties, Water Level Fluctuation, ...2.0548

PHYSICAL AND CHEMICAL PROPERTIES OF ALABAMA WATERS LIKELY TO SUPPORT STRIPED BASS, ROCCUS SAXATILIS ...Aquatic Ecology, Basses -sea,white, White Perch, Chemical Measurements -water, Physical Measurements -water, Physical-general, ...6.0003

A STUDY OF THE BIOLOGICAL, CHEMICAL AND PHYSICAL NATURE OF WATER QUALITY FACTORS UNDER UTAH CONDITIONS ...Biological-general, Model Studies, Mountains-alpine, Physical-general, Pollutants - Path of , ...5.1195

LIMNOLOGY OF LAKE CHAMPLAIN ...Biological-general, Physical-general, Phytoplankton, Pollution - Effects of , Sediments, Zooplankton, ...2.1088

GEOCHEMISTRY AND ORIGIN OF SULFO-SALINE GROUND WATER, SALINE COUNTY, MISSOURI ...Atlases-maps, Geochemical Analysis, Groundwater, Permeability, Salinity, Sulfide, ...4.0152

A LIMNOLOGICAL STUDY OF SPIRITWOOD, NORTH DAKOTA - WATER QUALITY AND SEASONAL CYCLES ...Biological-general, Lakes, North Dakota, Physical-general, Recreation Sites, ...2.0833

PHOSPHORUS BUDGETS OF LAKES SIDNEY, LANIER AND HARTWELL ...Georgia, Nutrients, Phosphorus, Pollutants - Path of , Reservoirs and Impoundments, ...5.0293

PRIMARY PRODUCTIVITY OF MINNESOTA LAKES ...Lakes, Plankton (non-specific), Primary Productivity, Trace Element Analysis, Water Sampling, ...5.0607

IDENTIFICATION OF IRRIGATION RETURN WATER IN THE SUBSURFACE ...Hawaii, Irrigation-general, Physical-general, Springs, Tritium, ...5.0314

CHEMICAL, PHYSICAL, AND BIOLOGICAL DYNAMICS OF NORTHERN PRAIRIE LAKES ...Biological-general, Lakes, Land Use, Physical-general, Water Quality-general, ...5.1114

LIMNOLOGICAL INVESTIGATIONS OF TEXAS IMPOUNDMENTS FOR WATER QUALITY MANAGEMENT PURPOSES ...Management, Nutrients, Reservoirs and Impoundments, Texas, Water Quality Control-general, ...5.1148

EUTROPHICATION OF SHELTERED BAYS IN A LARGE LAKE ...Bays, Currents -water, Eutrophication, Freshwater Ecology, Utah, ...5.1188

BROOD PRODUCTION AND POND PREFERENCE OF DIVING DUCKS IN THE TURTLE MOUNTAINS OF NORTH DAKOTA ...Aquatic Plants (non-specific), Habitat Studies, Land Use, Water Fowl, N.s. , Water Utilization -animal, ...6.0410

RELATIONSHIPS BETWEEN PHOSPHATE AND OTHER CHEMICALS AT THE WATERSUBSTRATE INTERFACE IN WESTERN LAKE ERIE ...Aquatic Soils, Chemical, Phosphate, Phosphite, Sediments, ...5.0874

A STUDY OF BIOLOGICAL SYSTEMS IN THE SCIOTO RIVER AS INDICES TO WATER QUALITY ...Bioindicators, Ohio, Physical-general, Systems Analysis, Water Sampling, ...5.0875

GEOCHEMICAL INVESTIGATION OF THE GROUNDWATER SYSTEM IN THE LANSING, MICHIGAN, AREA ...Aquifers-general, Groundwater, Ions and Gases, Michigan, Water Quality-general, ...1.0069

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A CONCEPTUAL STUDY OF THE DISTRICT OF COLUMBIA BIOLOGICAL TREATMENT PILOT PLANT ...Biological Treatment-other, Disposal, Drying-dewatering, Process Design, Waste Treatment-economics, ...**5.1007**

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PRIMARY TREATMENT OF STORM WATER OVERFLOW FROM COMBINED SEWERS BY HIGH RATE FINE MESH SCREENS ...Combined Sewer, Industrial Waste-other, Primary Treatment, Screening, Storm Water, ...**5.0931**

AEROBIC BIOLOGICAL TREATMENT, SLUDGE DEWATERING AND DISPOSAL AND EFFLUENT REUSE FOR A SIDE LEATHER TANNERY ...Aerobic, Disposal, Drying-dewatering, Lagoon, Tannery Wastes, ...**5.0608**

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COMBINED SEWER STUDY FOR WASHINGTON, D.C. ...Combined Sewer, District of Columbia, Effluent-standards, Storage-retention-facilities, Water Quality-general, ...**5.1005**

APPLICATION OF HYPERFILTRATION WITH DYNAMICALLY-FORMED MEMBRANES TO TREATMENT OF MUNICIPAL SEWAGE EFFLUENTS ...Membranes-other, Polyelectrolytes, Secondary Treatment, Sludge-general, Tertiary Treatment, ...**5.1143**

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VACUUM FILTRATION OF SEWAGE SLUDGE ...Filter-other, Sludge-other, Vacuum, ...**5.0175**

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EFFECT OF REACTOR EFFLUENT ON QUALITY OF COLUMBIA RIVER WATER ...Atomic Plants, Columbia River, Digital Computers, Pollution - Effects of , Radioactivity-general, ...**5.1246**

CW-BW WATER DECONTAMINATION SET ...Chlorination, Coagulation, Potable Water, ...**5.1214**

INDIVIDUAL WATER FILTRATION DEVICE ...Porous Media - Flow Through, Pump-other, Sediments, Technique Development, Waste Water Treatment-general, ...**3.0252**

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TRANSPORT MECHANISMS IN WATER FILTRATION ...Development of Models, Flow of Dispersed Solids, Model Studies, Ordinary, Transport, ...5.0811

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THE OPTIMUM RELEASE POLICY FOR A MULTIPURPOSE RESERVOIR USING STOCHASTIC HYDROLOGY ...Multiple-purpose Projects, Reservoirs and Impoundments, Stochastic Models, Stochastic Processes, Synthetic Hydrology-general, ...6.0337

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MOVEMENT AND MIXING OF WATER INJECTED INTO AQUIFERS ...Aquifers-general, Artificial Recharge, Dispersion - water, Exchange Capacity, Fluid Mixing, Groundwater Movement, Water Wells, ...5.0527

A MODEL FOR QUANTIFYING FLOW AUGMENTATION BENEFITS ...Flood Control, Model Studies, Other Methods, River Basins, Systems Analysis, Water Distribution Systems, ...6.0152

WATER RIGHTS RELATED TO WATER QUALITY STORAGE ...Alternative Planning, Conflicts, Reservoirs and Impoundments, Riparian Rights, Storage of Water, ...6.0606

SYSTEM ANALYSIS OF EUTROPHICATION CONTROL BY FLUSHING ...Eutrophication, Lakes, Systems Analysis, Water Quality Control-general, ...5.1266

AN EVALUATION OF THE REJUVENATION OF THE BUFFALO RIVER ...Chemical-general, New York, Sediments, Streams, Turbidity, ...4.0181

SMALL IMPOUNDMENTS ...Computers-general, Destratification, Reservoirs and Impoundments, Water Quality-general, ...5.0189

EUTROPHICATION - EFFECT OF FLOW AUGMENTATION ...Chemical Analysis (water), Chemical-general, Eutrophication, Physical-general, Pollution Abatement, ...5.0969

Fluoridation

BIBLIOGRAPHY ON FLUORIDATION OF PUBLIC WATER SUPPLIES ...Abstracts, Bibliography, Potable Water, ...7.0088

Mine Drainage Control

NEUTRALIZATION OF ACID STRIP-MINE LAKES ...Acidity, Lakes, Mining Activities, Neutralization, Stocking of Fish & Shellfish, ...5.0626

FISH ECOLOGY AND PHYSIOLOGY IN RELATION TO ACID MINE DRAINAGE ...Acidity, Aquatic Ecology, Fish -non-specific, Pollution - Effects of , Pollution Effects, ...5.1277

GEOCHEMICAL BEHAVIOR OF IRON AND MANGANESE IN A RESERVOIR (LAKE LYNN, WEST VIRGINIA) FED BY STREAMS CONTAINING ACID MINE DRAINAGE ...Acidity, Geochemical Analysis, Iron, Manganese, West Virginia, ...2.1139

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CHEMICAL CHARACTERISTICS OF WATERS IN FLOODED BITUMINOUS-COAL MINESHAFTS ...Acidity, Bituminous, Geochemical Analysis, Mine Hydrology, Pyrite Group, ...5.1279

METABOLIC ROLE OF SULFATES AND SULFIDES PRODUCING BACTERIA IN THE POLLUTION OF WATERS ...Autotrophic, Bacterial Pollutant Sources, Budgets -other, Respiration, Sulfur Bacteria, ...5.0438

USE OF LATEX AS A SOIL SEALANT TO CONTROL ACID MINE WASTE DRAINAGE ...Acidity, Elastomers Rubber, Linings-pavings, Sealant Materials, Seepage, ...5.0996

HYDROLOGY STUDY IN U. S. GYPSUM MINE, SHOALS, INDIANA ...Artesian Flow, Carbonate Aquifers, Hydrated Acid and Norm, Indiana, Mine Hydrology, ...5.0386

FACTORS AFFECTING MINE DRAINAGE AND THE GROUND WATER INTERACTIONS IN SELECTED AREAS OF WESTERN PENNSYLVANIA (PART 1) ...Acidity, Groundwater Movement, Iron Bacteria, Pyrite Group, Soil and Rock Leaching, ...1.0107

FACTORS AFFECTING MINE DRAINAGE AND THE GROUND WATER INTERACTIONS IN SELECTED AREAS OF WESTERN PENNSYLVANIA (PART 2) ...Acidity, Baseflow, Groundwater Movement, Pyrite Group, Stratified Flow, ...5.1044

WATER CONTROL - CONTROL TECHNIQUES FIELD TESTING AND EVALUATION ...Acidity, Chemical Analysis (water), Coal-general, Mining Activities, Pollution Abatement, ...5.1018

MINING-POLLUTION CONTROL TECHNOLOGY - OIL PRODUCTION GROUND-WATER RECLAMATION BY SELECTIVE PUMPING ...Brines, Groundwater, Petroleum Industry, Pumping, Saline Water Intrusion, Secondary Recovery, ...5.0913

Neutralization

NEUTRALIZATION OF ACID STRIP-MINE LAKES ...Acidity, Lakes, Mine Drainage Control, Mining Activities, Stocking of Fish & Shellfish, ...5.0626

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Pollution Abatement

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DETERMINATION, EVALUATION, AND ABATEMENT OF COLOR IN TEXTILE PLANT EFFLUENTS ...Effluents-waste Water, Textile Industry, Water Sampling, ...5.0296

IMPROVEMENT OF QUALITY OF WATER RESOURCES BY A THREE-FOLD ATTACK - ADSORPTION, SEDIMENTATION AND MIXING ...Adsorption, Adsorption Capacity, Aquatic Ecology, Flocculation, Sedimentation, ...5.0502

ALTERNATE METHODS OF MOSQUITO CONTROL TO REDUCE CHEMICAL POLLUTION OF WATERS FOR RECHARGE OF THE OGALALLA FORMATION ...Alternative Planning, Aquifers-general, Chlorinated Hydrocarbons, Insecticides -non-specific, Mosquitoes -non-specific, Playas, ...5.1180

PUBLIC INVESTMENT CRITERIA FOR WATER-ORIENTED RECREATION IN THE LAKE ERIE BASIN ...Alternative Planning, Costs, Finance, Fiscal, Projected Demand, Recreation Sites, ...6.0428

THE IMPACT OF IMPOSING A WATER QUALITY STANDARD ON A LIVE STREAM ...Flow Augmentation, Low Flow, Multiple-purpose Projects, Reservoirs and Impoundments, Water Standards, ...6.0494

CONSERVATION OF FRESH-WATER RESOURCES BY DEEP-WELL DISPOSAL OF LIQUID WASTES ...Borehole Geophysics, Core Analysis, Lithology, Permeability, Underground Waste Disposal, ...5.0025

INTERACTIONS OF URBAN ACTIVITY AND THE HYDROLOGICAL CYCLE ...Architecture and Design, Benefit-cost Analysis, Land Use, Value, Land Planning, Recreation Sites, Urban Environments, ...4.0135

LAW AFFECTING INSTITUTIONAL DESIGN FOR WATER QUALITY MANAGEMENT ...Administrative Structures, Legal Review, Riparian Rights, State Government, Water Quality Control-general, ...6.0642

THE ECONOMICS OF WATER SUPPLY AND QUALITY ...Benefit-cost Analysis, Delaware River, Flow Augmentation, Model Studies, Urban Environments, Water Allocation, ...6.0286

AERATION OF LAGOONS IN RIGOROUS CLIMATE AREAS ...Aeration, Climate, Degradation-other, Lagoon, Pond, Water Balance-budget, Wyoming, ...5.1325

OXYGEN REGENERATION OF POLLUTED RIVERS ...Aeration, Delaware River, Economic Efficiency, Instrumentation-general, Oxygen, Streams, ...5.0740

EFFECTS OF DOMESTIC POLLUTION ABATEMENT ON A EUTROPHIC LAKE ...Biological-general, Chemical-general, Eutrophication, Physical-general, Self-purification, ...6.0220

DELAWARE ESTUARY AND BAY WATER QUALITY SAMPLING AND MATHEMATICAL MODELING PROJECT ...Data Analysis - General, Delaware Bay, Mathematical Analysis, Model Studies, Technique Development, ...5.0749

PHOSPHATE EXCHANGE WITH SEDIMENTS ...Chemical-general, Eutrophication, Phosphate, Phosphite, Pollution - Effects of , Water Quality Control-general, ...**5.0525**

FLUSHING OF SMALL SHALLOW LAKES ...Circulation -water, Discharge-other, Lakes, Mixing, Self-purification, ...**5.1242**

THE SPREADING OF OIL FILMS ...Forecasting-prediction, Ocean Currents, Oil, Tides, Waves, ...**5.0787**

AN ENGINEERING INVESTIGATION OF STORM AND COMBINED SEWER PROBLEMS ...Combined Sewer, Land Use, Nonstructural Alternative, Runoff, Storm Water, ...**5.0229**

SYSTEM STUDY, DESIGN, AND EVALUATION OF THE LOCAL STORAGE, TREATMENT, AND REUSE OF STORM WATER - DEPARTMENT OF INTERIOR ...Storage of Water, Storm Water, Urban Environments, Water Quality Control-general, Water Reuse, ...**5.0503**

A PILOT-SCALE STUDY OF ACID MINE DRAINAGE ...Acidity, Data Acquisition-general, Mining Industry, Systems Analysis, ...**5.0881**

CATAWISSA CREEK MINE DRAINAGE POLLUTION ABATEMENT PROJECT ...Acidity, Mine Hydrology, Mining Industry, Pennsylvania, ...**5.0998**

PHOTOLYSIS MECHANISMS FOR POLLUTION ABATEMENT ...Chemical Treatment, Organics, Oxidants, Photolysis, Sunshine, ...**5.0335**

EVALUATION OF POLLUTION ABATEMENT PROCEDURES IN THE MORAINE STATE PARK, BULTER COUNTY, PENNSYLVANIA ...Pennsylvania, Systems Analysis, Water Quality-general, Water Quantity-general, ...**5.1002**

ANTI-POLLUTION AND SEWAGE DISPOSAL FOR FLORIDA COMMUNITIES ...Lagoon, Organics, Sand, Sewage - Domestic, Sub - Tropic, ...**5.0255**

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STUDIES ON AQUATIC MYXOBACTERIA ...Applied Ecology, Bacterial Pollutant Sources, Fresh Water, Myxobacteria, Range Or Territorial Distr. , ...**5.0954**

STUDY OF METHODS FOR CONTROLLING AQUATIC GROWTH AT PYMATUNING RESERVOIR AND CONNEAUT LAKE, PENNSYLVANIA ...Lakes, of Aquatic Plants, Pennsylvania, Plant Pollutants, Reservoirs and Impoundments, ...**6.0470**

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IRON ORE FLOTATION ...Beneficiation, Flotation, Industrial Processes-other, Mining Industry, Ores, Recovery, Scrap and Wastes, ...**5.0616**

WATER CONTROL - CONTROL TECHNIQUES FIELD TESTING AND EVALUATION ...Acidity, Chemical Analysis (water), Coal-general, Mine Drainage Control, Mining Activities, ...**5.1018**

EUTROPHICATION - EFFECT OF FLOW AUGMENTATION ...Chemical Analysis (water), Chemical-general, Eutrophication, Flow Augmentation, Physical-general, ...**5.0969**

THE ECONOMIC ANALYSIS OF WATER POLLUTION BY PESTICIDES AND OTHER AGRICULTURAL WASTES ...Agricultural Watersheds, Benefit-cost Analysis, Economic Impact, Model Studies, Pesticides -non-specific, Pollution, ...**5.0238**

Self-purification

COLUMBIA RIVER SEDIMENT STUDIES ...Columbia River, Geochemical Analysis, Radioactivity-general, Radiochemical Techniques, Sediments, ...**5.1249**

SIMULATION MODELING OF THERMAL EFFECTS ON SELECTED RIVER SYSTEMS ...Atomic Plants, Digital Computers, Forecasting-prediction, Model Studies, Thermal Pollution, ...**4.0270**

REOXYGENATION OF IOWA STREAMS ...Aeration, Iowa, Photosynthesis, Streams, ...**5.0417**

THE ECOLOGY OF STREAM BIOTA IN WASTE ASSIMILATION ...Degradation, Organic Matter, Periphyton, Streams, Water Bacteria, ...**5.0675**

POLLUTION TAXES AND THE COSTS OF WATER QUALITY MANAGEMENT ...Benefit-cost Analysis, Economic Efficiency, Management, Water Costs, Water Quality Control-general, ...**6.0423**

PHOTOSYNTHETIC REAERATION IN THE UPPER PASSAIC RIVER ...Aeration, Chemical Oxygen Demand, New Jersey, Photosynthesis, Streams, ...**5.0733**

RECOVERY FROM ACID POLLUTION IN FOUR STRIP-MINE LAKES ...Acidity, Iron, Lakes, Mining Industry, Stratification, ...**5.0669**

OXYGEN RELATIONSHIPS IN SMALL STREAMS ...Aeration, Ions and Gases, Oxygen, Streams, ...**5.0357**

EFFECTS OF DOMESTIC POLLUTION ABATEMENT ON A EUTROPHIC LAKE ...Biological-general, Chemical-general, Eutrophication, Physical-general, Pollution Abatement, ...**6.0220**

BACTERIAL ADSORPTION ON SOILS ...Bacterial Pollutant Sources, Pollutants - Path of , Recharge -general, Soil Chemical Properties, Temperature, ...**5.1190**

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ENTERIC BACTERIAL DEGRADATION OF STREAM DETRITUS ...Bacterial Pollutant Sources, Intestinal Bacteria, Model Studies, Organic-general, Sanitation, ...**5.0291**

WATER POLLUTION ...Bacterial Pollutant Sources, Cell. env.(non-specific & Ot.), Identification, Septic Tanks, Streams, ...**5.0730**

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ILLINOIS RIVER STUDY ...Illinois River, Ions and Gases, Low Flow, Streams & Rivers, Waste Water Treatment-general, ...**5.0351**

EFFECTS OF CHEMICAL AND BIOLOGICALLY MODIFIED PULPING EFFLUENTS ON THE PRODUCTION OF FISH ...Effluents-waste Water, Fish -non-specific, Industrial Wastes, Pulp, Paper , and Logging, Tox & Allergenic Effects, Willamette River, ...**5.0936**

WASTE DISPOSAL FROM FOOD PROCESSING PLANTS IN SOUTH CAROLINA ...Disposal Wastes, Food Processing Industry, Percolation, Soil Environment, ...**5.1104**

STUDY OF ASSIMILATIVE CAPACITY OF ARCTIC AND SUBARCTIC STREAMS ...Environmental Effects-geologic, Polar, Pollution - Effects of , Streams, ...**5.0029**

Stream Rehabilitation

REPOPULATION OF EXPERIMENTALLY DECIMATED AREAS BY STREAM FISHES ...Aquatic Ecology, Control of Nuisance Species, Fish -non-specific, Louisiana, Population Dynamics, Streams, ...**5.0460**

SPORT FISHERY POTENTIAL IN RECLAIMED WASTEWATER ...Channel Catfish, Growth Rate, Other, Salmon & Trout - Non-specific, Tilapia, Cichlids, ...**5.0050**

WATERSHED EVALUATION ...Chemical Analysis (water), Population Dynamics, Streams, Temperature, Watersheds-general, ...**4.0226**

STREAM RESTORATION AND CONTROLLED FLOWS ...Dams-other, Lake Trout, Brook Trout, Logging, Transport, Equipment, Maine, Salmon & Trout - Non-specific, ...**4.0129**

LIMESTONE DRUM PRODUCTIVITY STUDY JOB NUMBER 1 - LIMNOLOGICAL STUDY ...Acidity, Aquatic Ecology, Biological-general, Chemical-general, Limestone - General, ...**5.1275**

RESTORATION AND REHABILITATION OF EARTHQUAKE DAMAGED PINK AND CHUM SALMON STUDIES IN PRINCE WILLIAM SOUND ...Alaska, Aquatic Ecology, Data Acquisition-general, Earthquakes, Flow Characteristics -water, Salmon -coho,chinook,sockeye.., Spawn Or Nesting Sites, Tectonics-general, ...**2.0026**

REDUCTION OF RIVER HEAT POLLUTION BY TURBULENCE STIMULATION ...Destratification, Electric Power Plants, Engineering Structures-general, Roughness, Thermal Pollution, Turbulent Flow, ...**5.0214**

TUSCON WASTEWATER RECLAMATION PROJECT ...Biological-general, Chemical-general, Filter-other, Fish -non-specific, Productivity (agricultural), Water Standards, ...**5.0043**

NUTRIENT CONTROL PROJECT - DETROIT LAKES, MINNESOTA ...Eutrophication, Lakes, Nutrients, of Aquatic Plants, Secondary Treatment, ...**5.0583**

THE FEASIBILITY OF REUSE OF CHLORINATED SEWAGE EFFLUENT FOR FERTILIZATION AND IRRIGATION IN IDAHO (ABBREV) ...Chlorination, Irrigation-general, Sewage, Use of Impaired Water, Water Reuse, ...**5.0327**

COAL STRIP MINE WATERSHED STUDY ...Aquatic Ecology, Coal-general, Mining Activities, Pollution - Effects of , Soil Management -non-specific, Strip Mines, ...**2.0980**

REDUCTION OF FLOOD RUNOFF, SEDIMENTATION AND STREAMFLOW IMPROVEMENT IN UNGLACIATED AREAS ...Erosion-general, Forest Watersheds, Mississippi River, Runoff, Slope - Degree of , Water Loss Control, ...**4.0275**

Waste Water Pre-treatment

A COST-EFFECTIVENESS STUDY OF PRETREATMENT METHODS SUITABLE FOR INTEGRATION TO MEMBRANE DESALTING PLANTS ...Brackish Water, Desalination, Economic Efficiency, Use of Impaired Water, Waste Treatment-economics, ...**5.0746**

LIME MAGNESIUM CARBONATE PROCESS - SEA WATER SOFTENING PLANT ...Brines, Evaporation, High Temperature - 1000-3000 , Precipitation , Removal--inorganics, ...**3.0105**

DEVELOPMENT OF ECONOMICAL METHODS OF BORON REMOVAL FROM IRRIGATION RETURN WATERS ...Boron, Desalination, Reverse Osmosis, Use of Impaired Water, Waste Treatment-economics, ...**5.0093**

DEVELOPMENT OF ECONOMICAL METHODS OF BORON REMOVAL FROM IRRIGATION RETURN WATERS ...Material Recovery Wastes, Pollutant-other, Recycle, Reverse Osmosis, Waste Treatment-economics, ...**3.0480**

IMPROVEMENT OF ECONOMICS OF ELECTRODIALYSIS SYSTEMS BY SELECTIVE PRETREATMENT ...Brackish Water, Cost Analysis, Desalination, Electrodialysis, Ion Selective, Other, ...**3.0407**

WATER UTILIZATION AND WASTE CONTROL IN THE TEXTILE INDUSTRY ...Alternative Planning, Material Recovery Wastes, Recycle, Textile Wastes, ...**3.0377**

FLOC STRENGTH AND FILTERABILITY OF PRE-TREATED WATER ...Coagulation, Filtration, Flocculation, Pilot Plant, Sand, ...**5.0061**

WASTEWATER TREATMENT PILOT PLANT INVESTIGATION, MIXED CHROME TANNERY WASTEWATER ...Disposal, Drying-dewatering, Pollutant-other, Tannery Wastes, Waste Treatment-economics, ...**5.0536**

TREATMENT OF MUNICIPAL SECONDARY EFFLUENT BY REVERSE OSMOSIS ...Carbon, Fiber, Filament, Whisker, Glass, Membranes-other, Pollutant-fouling, Reverse Osmosis, ...**5.0131**

COMPLETE TREATMENT OF TANNERY INDUSTRIAL WASTE FOR CHROME TANNING, ALUM TANNING AND VEGETABLE TANNING ...Aerobic, Anaerobic, Neutralization, Process Design, Tannery Wastes, ...**5.0436**

IN-PLANT TREATMENT OF DILUTE WASTES OF THE PULPING INDUSTRY ...Biological Treatment-other, Pulp and Paper Wastes, Pulp, Pulping & Composite, Reverse Osmosis, Water Reuse, ...**5.1288**

IMPROVED CAPABILITIES OF BIOLOGICAL SYSTEMS TO ASSIMILATE OIL ...Activated, Biological, Organics, ...**5.0780**

RECLAMATION OF BIOLOGICALLY, MECHANICALLY & CHEMICALLY TREATED WASTEWATER FOR POTABLE WATER SUPPLY USES (ABBREV) ...Activated Carbon, Chlorination, Electrodialysis, Ion Exchange-other, Risk & Uncertainty, ...**5.0159**

DEMINERALIZATION OF WASTEWATER BY THE TRANSPORT-DEPLETION PROCESS ...Demineralization, Electrodialysis, Process Design, Sewage Treatment Plant, Waste Treatment-economics, ...**5.0015**

Waste Water Treatment-general

COALESCING MARINE OIL-WATER SEPARATOR ...Boat Discharges, Fluid-device-other, Technique Development, Two-phase-other, ...**5.0747**

EVALUATION OF EARTHY MATERIALS FOR USE IN DECONTAMINATION OF WATER ...Clay, Removal of Residues, ...**5.0002**

EXCHANGE OF PHOSPHORUS SPECIES BETWEEN LIVING AND NONLIVING SYSTEMS IN FRESH WATER ENVIRONMENTS ...Algae- General, Bioindicators, Biological Treatment-general, Nutrients, ...**5.0812**

FLUIDIZED EXCHANGE SYSTEMS FOR REMOVAL OF NITROGEN AND PHOSPHOROUS FROM WASTEWATER ...Fluidized Bed, Ion Exchange-other, Nitrate, Nitrite, Nutrients, Phosphate, Phosphite, ...**5.0556**

AN EVALUATION OF RECENT APPROACHES FOR THE DESIGN OF BIOLOGICAL WASTES TREATMENT ...Biological Treatment-general, Data Analysis - General, Pilot Plant, Process Design, ...**5.0928**

TREATMENT OF LIQUID WASTE FROM FOOD PROCESSING PLANTS ...Disposal Wastes, Food Processing Industry, Recycle, Salting Out, Water Reuse, ...**5.0497**

FEASABILITY OF FISH PRODUCTION IN TERTIARY WASTE TREATMENT PONDS ...Aquaculture & Fish-farming, Sewage Lagoons, Tertiary Treatment, ...**5.0401**

ECONOMIC ANALYSIS OF ALTERNATIVE WATER POLLUTION CONTROL MEASURES ...Alternative Planning, Economics-general, Model Studies, Water Quality Control-general, ...**6.0231**

PHOSPHATE UPTAKE, STORAGE, AND RELEASE BY MICROORGANISMS IN WASTEWATER TREATMENT ...Chemostat, Microorganisms (non-specific), Nutrition, Phosphate, Phosphite, Storage, ...**5.1282**

REMOVAL OF TRACE ORGANICS FROM WATER BY ADSORPTION ON COAL ...Activated Carbon, Adsorption, Coal-general, Isotherm, Organic, ...**5.1209**

PRECIPITATION OF PHOSPHATES FROM WATER WITH FERROUS SALTS ...Biochemical Oxygen Demand, Chemical Treatment, Iron, Phosphate, Phosphite, Precipitation, ...**5.0882**

EFFECTS OF AUDIO VIBRATIONS ON AERATED BIOLOGICAL SYSTEMS ...Activated, Aeration, Bubble, Sewage Bacteria, Sonic, ...**5.0673**

THE ORGANIC CONCENTRATION GRADIENT IN AN AERATION COLUMN ...Aeration, Bubbles, Foam, Organic Matter, Surfactants, ...**5.0734**

TEXTILE WASTE TREATMENT PRACTICE ...Loading, Textile Wastes, Waste Treatment-economics, Water Costs, ...**5.0005**

KINETIC STUDIES OF THE OXIDATIVE DEGRADATION OF DETERGENT, AND RELATED CHEMICAL SPECIES IN AQUEOUS SOLUTION ...Biodegradation, Biological, Chemical Degradation, Kinetic-general, Physical Degradation, Surfactants, ...**5.0495**

MASS TRANSFER AND CHEMICAL REACTION IN TWO PHASE FLOW ...Close Channel, Mass Transfer, Mathematical Analysis, Model Studies, Phase Relationship, ...**5.0225**

ELECTROPHORETIC CLARIFICATION OF WATER ...Bacterial Pollutant Sources, Colloidal Phenomena, Desalination, Other, Pesticides -non-specific, Tertiary Treatment, ...**5.1157**

DESIGN OF WASTEWATER TREATMENT SYSTEMS TO SATISFY EFFLUENT QUALITY REQUIREMENTS BASED ON INTENDED USE ...Effluent-standards, Process Design, Use of Impaired Water, Water Quality Control-general, Water Reuse, ...**5.0769**

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CONFERENCE ON SANITARY ENGINEERING EDUCATION ...Air Pollution Control, Atmpopheric Pollution-general, Education and Training, Management, Meetings, ...**5.1152**

COOPERATIVE STUDIES WITH FEDERAL AND STATE AGENCIES ...Bioassays, Crustacea -non-specific, Mollusks -non-specific & Other, Public Health Ecology, Survey Studies, ...**7.0111**

GENERAL TECHNICAL ASSISTANCE ...Committee-support, Crustacea -non-specific, Mollusks -non-specific & Other, Shellfish Depuration, ...**5.1075**

Water Quantity Studies

Available Water

EFFECTS OF WEATHER ON CROPS ...Evapotranspiration, Meteorological Studies-general, Moisture Tension, Projections and Estimations, Soil Moisture -non-specific, ...**2.0482**

A WATER SUPPLY-DEMAND ANALYSIS IN CLINTON COUNTY, PENNSYLVANIA - A STUDY IN ECONOMIC HYDROLOGY ...Economic Impact, Model Studies, Water Demand, Water Quality-general, Water Utilization -general, ...**6.0477**

AVAILABILITY, DISTRIBUTION, QUANTITY AND QUALITY OF WATER RESOURCES IN CARBONATE KARST TERRAIN ...Carbonate Aquifers, Groundwater, Karst Topography, Runoff, Water Balance-budget, Water Quality-general, ...**4.0155**

ECONOMIC EVALUATION OF WATER - A DYNAMIC INTERREGIONAL IMPUT-OUTPUT PROGRAMMING MODEL OF CALIFORNIA AND THE WESTERN STATES WATER ECONOMY ...California, Economics-general, Other Models, ...**6.0044**

ENGINEERING PHASES OF LAND SHAPING FOR SOIL AND WATER CONSERVATION ...Conservation & Management Eng, Nebraska, Runoff, Soil Environment, Water Loss Control, ...**3.0312**

THE DEVELOPMENT OF GEOCHEMICAL AND GEOPHYSICAL TECHNIQUES AS AN AID TO DETERMINING AVAILABILITY OF GROUND WATER IN LIMESTONE TERRANES ...Geochemical Analysis, Geophysical Analysis, Groundwater, Karst Topography, Water Sources -general, ...**2.0009**

THE INFLUENCE OF WETLANDS ON QUANTITY AND QUALITY OF STREAM FLOW ...Evapotranspiration, Hydrology-general, Low Flow, Streams, Wetlands, ...**4.0170**

GROUNDWATER - SURFACE WATER INTEGRATION STUDY IN THE GRAND PRAIRIE REGION OF ARKANSAS ...Arkansas, Conjunctive Use, Groundwater, Recharge -general, Water Demand, ...**4.0020**

EFFECT OF WATER AVAILABILITY ON PHOTOSYNTHESIS OF PLANTS ...Corn, Drought, Irrigation-general, Moisture Content -plants, Photosynthesis, Soybean, ...**2.0426**

A GENERALIZED, PROBABILISTIC APPROACH TO REGIONAL WATER SUPPLY ASSESSMENT ...Confidence Intervals, Model Studies, Patterns, Regional Areas, Runoff, ...**6.0059**

THE EFFECT OF WATER RESOURCES ON ECONOMIC GROWTH IN THE TENNESSEE VALEY ...Correlation, Economic Impact, Location, Tennessee River, Water Resources Development, ...**6.0537**

WATER CONTROL FOR FOREST PRODUCTION ...Cultural Control, Palms, Pines, Timber Stand Improvement, Water Loss Control, ...**3.0175**

GROWTH AND DEVELOPMENT OF NATIVE HARDWOODS AND PINE ...Growth, Pines, Soil Environment, Soil Types, Soils and Fertilizer, ...**2.0430**

ECONOMICS OF WATER SUPPLY-PORTALES VALLEY, NEW MEXICO ...Alternative Planning, Economic Impact, Projections and Estimations, Water Costs, Water Transfer, ...**6.0363**

THE RELOCATION OF INDUSTRY AND THE LOCATION OF NEW INDUSTRY AS AFFECTED BY THE AVAILABILITY OF WATER SITES ...Industrial-general, Mississippi River, ...**4.0090**

MOISTURE RETENTION, MOVEMENT, MEASUREMENT, AND AVAILABILITY TO PLANTS IN FLORIDA SOILS ...Internal Water Movement, Moisture Content, Moisture Retention, Natural Variation of Water USE, Soil Tests, Soil-water-plant Relationships, ...**2.0313**

GROUND-WATER GEOLOGY OF OGLE COUNTY, ILLINOIS ...Aerial, Groundwater, Joints-fractures, Observation Wells, Unconsolidated Aquifers, ...**7.0034**

WATER RESOURCE DEVELOPMENT AND MANAGEMENT MODEL ...Alternative Planning, Model Studies, State-local Government, Systems Analysis, Water Resources Development, ...**6.0201**

EVALUATION OF MAGOTHY AQUIFER - ANNAPOLIS AREA ...Atlases-maps, Clastic Aquifers, Maryland, Model Studies, Saline Water Intrusion, ...**2.0564**

WATER RESOURCES OF COPIAH COUNTY ...Aquifers-general, Chemical Analysis (water), Groundwater, Surface Water, Water Quality-general, ...**4.0147**

SOIL MOISTURE STORAGE AND UTILIZATION. ...Modified Water Use, Moisture Levels, Soil Environment, Soil-water-plant Relationships, Storage of Water, ...**2.1037**

LOW-FLOW STUDIES OF IOWA STREAMS ...Iowa, Low Flow, Water Law-general, Water Quality Control-general, Water Standards, ...**2.0489**

WATER AVAILABILITY OF MUSCATINE ISLAND, IOWA ...Aquifers-general, Chemical-general, Iowa, Prediction Models, Water Resources Development, ...**2.0488**

HYDROGEOLOGY OF GLACIAL OUTWASH NEAR SIOUX FALLS, SOUTH DAKOTA ...Analog Computers, Outwash Plains, Prediction Models, Projections and Estimations, South Dakota, ...**2.0975**

WATER RESOURCES OF SOUTHEASTERN WISCONSIN - FOX RIVER BASIN ...Groundwater Movement, Mans Activities, Projections and Estimations, Surface Water, Wisconsin, ...**4.0277**

WATER RESOURCES OF THE LOWER WISCONSIN RIVER VALLEY, WISCONSIN ...Hydrology-general, Projections and Estimations, Water Quality-general, Water Supply-general, Wisconsin, ...**2.1149**

RESERVOIR AND RIVER OPERATION PROCEDURES ...Management, Model Studies, Optimization, Reservoirs and Impoundments, River Basins, ...**6.0095**

DEVELOPMENT OF WATER SUPPLIES FOR IRRIGATION IN THE SOUTH ...Carbonate Aquifers, Clastic Aquifers, Irrigation Engineering, Irrigation-general, Water Resources Development, Water Sources -general, ...**2.0332**

Total Volume

GROUNDWATER SUPPLIES ...Aquifers-general, Atlases-maps, Groundwater, Natural Recharge, Water Table Fluctuation, ...**2.0058**

HYDROLOGY OF LOWER COLORADO RIVER BASIN ...Colorado River, Groundwater, Groundwater Movement, Water Loss-general, Water Quality-general, ...**2.0066**

HYDROLOGY OF HUNGRY HORSE RESERVOIR, MONTANA ...Flow Characteristics -water, Forecasting-prediction, Hydrology-general, Multiple-purpose Projects, Reservoirs and Impoundments, ...**2.0705**

FLUVIAL SEDIMENTATION IN STONY BROOK WATERSHED ...Gaging, Peak Flow, Runoff, Sedimentology-general, Small Watersheds, ...2.0766

WATER RESOURCES STUDY, DUVAL COUNTY, FLORIDA ...Carbonate Aquifers, Florida, Hydrology-general, Surface Water, Water Quality-general, ...2.0330

Variation in Time

RECESSION CHARACTERISTICS OF IOWA STREAMS ...Iowa, Low Flow, Mathematical Analysis, Streams, ...5.0413

URBAN HYDROLOGIC RELATIONSHIPS ...Drainage, Forecasting-prediction, Hydrographs, Runoff, Urban Environments, ...2.0554

SPRINGS OF UTAH ...Chemical-general, Potential of Deposit, Springs, Utah, Water Properties-general, ...2.1081

LOW FLOW CHARACTERISTICS OF TENNESSEE STREAMS ...Annual, Gaging, Low Flow, Tennessee, ...2.0997

Water Quantity-general

RELATION OF BEDROCK FRACTURE SYSTEMS TO UNDERGROUND WATER IN STAFFORD SPRINGS, SOUTH COVENTRY, SPRING HILL & WESTFORD QUADS ...Groundwater Movement, Joints-fractures, Local Structure, Rocks - Bedrock, Subsurface Flow, ...2.0243

ON-FARM IRRIGATION WATER SUPPLIES AND COSTS IN RELATION TO CROPPING SYSTEMS AND PRODUCTION ADJUSTMENTS IN THE SACRAMENTO VALLEY ...California, Economic Efficiency, Irrigation-general, Water - Alternative Uses, Water Costs, ...6.0051

APPLICATION OF SPECIALIZED OPTIM TECH IN WATER QUANTITY & QUALITY MANAGEMENT WITH RESPECT TO PLANNING FOR THE TRINITY RIVER BASIN ...Optimization, Planning, River Basins, Texas, Water Quality-general, ...6.0551

RESEARCH ON DATA AND ANALYTICAL SYSTEMS FOR PREPARING NATIONAL WATER ASSESSMENTS ...Data & Statistics Info Storage, Data Acquisition-general, Model Studies, Statistics-general, Water Quality-general, ...6.0397

EVALUATION OF POLLUTION ABATEMENT PROCEDURES IN THE MORAINE STATE PARK, BULTER COUNTY, PENNSYLVANIA ...Pennsylvania, Pollution Abatement, Systems Analysis, Water Quality-general, ...5.1002

EFFECTS OF IMPOUNDMENT ON WATER QUALITY ...Flow Characteristics -water, Management, Reservoirs and Impoundments, Water Quality Control-general, Water Quality-general, ...5.1122

GEOHYDROLOGY OF THE ANCHORAGE AREA, ALASKA ...Alaska, Groundwater, Surface Water, Urban Environments, Water Resources Development, ...2.0011

WATER MEASUREMENT ...Discharge-general, Dyes and Coloring, Fluids, Measurement, Technique Development, ...8.0128

ATMOSPHERIC WATER RESOURCES PROGRAM ...Augmentation-general, Clouds-precipitation, Modification, Reservoirs and Impoundments, Technique Development, ...2.0163

Water Yield

WATERSHED IMPROVEMENT--SOIL AND MOISTURE CONSERVATION PROGRAM ...Gaging, Modified Water Use, Moisture Content, Snowmelt, Watersheds-general, ...8.0143

REYNOLDS CREEK WATERSHED STUDY ...Idaho, Management and Fertility, Runoff, Sediment Yield, Watersheds-general, ...2.0571

SAN LUIS WATERSHED STUDY ...Conservation-general, Management, New Mexico, Sediment Yield, Small Watersheds, ...2.0234

EFFECTS OF WATERSHED MANIPULATION ON DEER AND ELK USE ...Cover Crops, Habitat Studies, Management, Population Dynamics, Watersheds-general, ...4.0003

DEER FOODS ON WATERSHEDS TREATED FOR INCREASED WATER YIELD ...Arizona, Deer Ns, Food Supply, Forages, N. s. , ...4.0004

CORRELATION OF SOIL SURFACE AND RAINFALL-RUNOFF-MOISTURE RELATIONSHIPS ON AGRICULTURAL WATERSHEDS ON COASTAL PLAINS SOILS (ABBREV) ...Antecedent Moisture, Recharge -general, Runoff, Small Watersheds, Soil Environment, ...2.0002

RUNOFF STUDIES ON SMALL WATERSHEDS ...Hydrographs, Runoff, Small Watersheds, Subsurface Flow, Surface Water, ...2.1138

FACTORS AFFECTING WATER YIELD FROM SMALL WATERSHEDS IN TENNESSEE ...Correlation, Cover Crops, General Synoptic Observations, Small Watersheds, Tennessee, ...4.0224

HYDROLOGY OF WATER YIELD PREDICTION ...Amount, Forecasting-prediction, Forest Watersheds, Moisture Retention, Water Balance-budget, ...2.0892

CHARACTERISTICS OF STREAM FLOW OF SMALL WATERSHEDS IN PENNSYLVANIA AND INFLUENCING FACTORS ...Climate, Flow Characteristics -water, Land Use, Model Studies, Morphology-general, Small Watersheds, ...2.0929

CHARACTERISTICS OF MAJOR FOREST AND RANGE WATERSHED TYPES IN IDAHO ...Erosion-general, Forest Watersheds, Idaho, Land Use, Runoff, ...6.0176

PHYSICAL, METEOROLOGICAL, AND HYDROLOGIC ASPECTS OF EVAPOTRANSPIRATION ...Evapotranspiration, Meteorological Studies-general, Soil-water-plant Relationships, Translocation, Water Balance-budget, ...2.0951

USE OF WATER BY LOWLAND VEGATATION IN NEW JERSEY COASTAL PINE REGION ...Consumptive Use, Evapotranspiration, New Jersey, Plant Water Use-other, Transpiration and Evap, ...2.0759

OPTIMUM UTILIZATION AND MANAGEMENT OF WATER IN FORMATIONS HYDROLOGICALLY-CONNECTED TO A STRETCH OF THE CONNECTICUT RIVER ...Aquifers-general, Artificial Recharge, Baseflow, Connecticut River, Massachusetts, ...4.0134

EVALUATION OF GROUNDWATER RESOURCES, LIVERMORE VALLEY, CALIFORNIA ...Data Acquisition-general, Groundwater Basins, Management, Model Studies, Subsurface Flow, ...4.0025

MORPHOLOGY AND HYDROLOGY OF PLEISTOCENE DEPOSITS, DELAWARE ...Geophysical Analysis, Groundwater Movement, Morphology-general, Permeability, Quaternary Period, Unconsolidated Aquifers, ...2.0253

APPLICATION OF AERIAL PHOTOGRAPHS FOR THE INVESTIGATION OF THE DISCHARGE PROPERTIES OF DRAINAGE BASINS ...Aerial, Data Acquisition-general, Discharge-general, Photogrammetry, River Basins, ...2.0792

GLACIAL MELT WATER PREDICTION ...Energy, Forecasting-prediction, Glaciers, Water, ...2.0010

HYDROLOGIC CHARACTERIZATION OF FORESTED WATERSHEDS IN ARIZONA ...Dendrochronology, Forecasting-prediction, Forest Watersheds, Management, Runoff, Snowpack, ...2.0051

METAMORPHOSIS OF SNOWPACK PROFILES AND CHANGES IN WATER STORAGE FOLLOWING STRIP CUTTING IN PINE FORESTS IN MICHIGAN ...Cutting Operations, Michigan, Natural Recharge, Nuclear Moisture Meters, Snowmelt, ...2.0655

OCCURRENCE AND CHARACTERISTICS OF FRACTURES IN CRYSTALLINE ROCKS OF SOUTHEASTERN NEW HAMPSHIRE AND THEIR RELATIONSHIP TO THE YIELD OF DRIL ...Groundwater Mining, Joints-fractures, Mapping, New Hampshire, Water Wells, ...2.0744

EFFECTS OF FOREST COVER MANIPULATION ON WATER YIELD AS STUDIED BY AN ELECTRIC ANALOG ...Analog Computers, Development of Models, Forest Watersheds, Soils and Fertilizer, Washington, ...3.0484

PARTIAL AREA CONTRIBUTION TO STREAM FLOW ...Digital Computers, Flow Characteristics -water, Model Studies, Runoff, Watersheds-general, ...2.0581

ANALOG MODELING TO DETERMINE FRESH WATER AVAILABILITY ON THE OUTER BANKS OF NORTH CAROLINA ...Analog Computers, Groundwater, Groundwater Movement, Model Studies, North Carolina, ...3.0375

WATER MOVEMENT CONTROL AND CULTURAL PRACTICES IN COTTON PRODUCTION ...Conservation & Management Eng, Cotton, Management, Soil Tillage Methods -other, Sub - Humid, Tillage, Cropping Systems, ...2.0003

MANIPULATION AND MANAGEMENT OF SECOND GROWTH PONDEROSA PINE FOR OPTIMUM YIELDS OF WATER AND/OR WOOD AND FORAGE ...Forest Watersheds, Other, Relations - Forage - Timber, Soil-water-plant Relationships, Soils and Fertilizer, ...3.0021

FACTORS AFFECTING WATER YIELDS FROM SMALL WATERSHEDS IN GEORGIA ...Baseflow, Georgia, Runoff, Small Watersheds, Statistics-general, ...4.0083

THE INTERRELATIONSHIP BETWEEN WATERSHED FACTORS THAT AFFECT RUNOFF RATES AND VOLUME YIELDS IN THE SOUTHERN COASTAL PLAINS ...Agricultural Watersheds, Georgia, Hydrology-general, Morphology-general, Runoff, ...3.0193

COMPUTER SIMULATION OF EFFECTS OF LAND MANAGEMENT AND WEATHER MODIFICATION ON WATERSHED ECOSYSTEMS ...Land Use, Multivariate Analysis, Plant Ecosystems(non-specific), Simulation Theory, Weather Modification-general, ...**6.0297**

SMALL WATERSHED YIELDS ...Amount, Aquifers-general, Land Use, Runoff, Small Watersheds, ...**4.0149**

DISTRIBUTION, APPLICATION AND USE OF WATER ...Furrow Irrigation, Irrigation Engineering, Model Studies, Moisture Content, Soil-water-plant Relationships, ...**3.0304**

WATER YIELDS FROM SHALLOW GROUND AQUIFERS ...Aquifers-general, Irrigation-general, Permeability, Recharge - general, ...**4.0214**

HYDROLOGY OF PIEDMONT AGRICULTURAL WATERSHEDS ...Agricultural Watersheds, Cover Crops, General Synoptic Observations, Groundwater, Management, Piedmont Province, Soil-water-plant Relationships, ...**2.0958**

FACTORS AFFECTING WATER YIELDS FROM SMALL WATERSHEDS IN TENNESSEE ...Conservation & Management Eng, Instrumentation-general, Runoff, Small Watersheds, Soil Conditions, Water Harvesting, ...**4.0225**

DEVELOPING COMPUTER PROGRAMS FOR SOLUTION OF HYDROLOGIC PROBLEMS RELATED TO SMALL WATERSHEDS ...Climate-general, Forecasting-prediction, Hydrographs, Physiography-general, Small Watersheds, ...**7.0102**

MANIPULATION OF TREMBLING ASPEN AND GAMBEL OAK FOR INCREASED WATER YIELD ...Cutting Operations, Nuclear Moisture Meters, Oaks, Poplars, Aspens, Cottonwoods, Snowmelt, Water Loss Control, ...**4.0259**

WATER YIELDS FROM SMALL WATERSHEDS ...Climate, Runoff, Shape, Small Watersheds, Virginia, ...**4.0265**

FACTORS AFFECTING WATER YIELDS FROM SMALL WATERSHEDS AND SHALLOW GROUND AQUIFERS ...Amount, Applied Climatology, Aquifers-general, Runoff, Small Watersheds, Soil Types-general, ...**4.0207**

DIFFERENCE IN EFFECTS OF FOREST AND OTHER VEGETATIVE COVERS ON WATER YIELD ...Cover Crops, Evapotranspiration, Israel, Moisture Tension, Precipitation -non-specific, ...**3.0235**

SEISMIC EVALUATION OF PERMEABILITY OF FRACTURE ZONES IN ROCK ...Aquifers-general, Joints-fractures, Permeability, Southwest, Structure Location, Tunnels, ...**3.0017**

INFILTRATION CAPACITIES UNDER VARIOUS VEGETATION TYPES AS INFLUENCED BY WATERSHED MANAGEMENT PRACTICES ...Cover Crops, Environment, Infiltration, Management, Watersheds-general, ...**4.0013**

INCREASING CHAPARRAL WATERSHED YIELD THROUGH IMPROVED USE OF PHENOXY-TYPE HERBICIDES ...Environmental Effects, Herbicides -non-specific, Moisture Tension, Temperature, Translocation, Watersheds-other, ...**3.0089**

RESEARCH ON GEOHYDROLOGY OF THE EASTERN SLOPE OF WEST MAUI ...Aquifers-general, Hawaii, Mountains-alpine, Patterns, Projections and Estimations, Slopes, ...**6.0170**

FACTORS AFFECTING WATER YIELDS FROM SMALL WATERSHEDS AND SHALLOW GROUND AQUIFERS ...Atlases-maps, Moisture Content, Patterns, Puerto Rico, Runoff, ...**4.0208**

GEOLOGY AND HYDROLOGY OF THE PRESIDIO BOLSON, TEXAS AND ADJACENT MEXICO ...Bolsons, Groundwater, Hydrology-general, Local Stratigraphy, Sedimentary Basins, ...**2.1011**

GEOLOGY OF THE PALUXY AND BRAZOS VALLEYS IN HOOD, SOMERVELL, AND ERATH COUNTIES, TEXAS ...Clastic Aquifers, Groundwater, Texas, Water Table Fluctuation, Water Utilization -general, ...**4.0235**

GENERALIZED ANALYSIS OF SMALL WATERSHED RESPONSES ...Mathematical Analysis, Rain-general, Sequences - Series, Small Watersheds, ...**2.0085**

IRRIGATION IN RELATION TO CROPPING SYSTEMS ...Irrigation-general, Model Studies, Water Allocation, Water Costs, Water Sources -general, ...**6.0053**

SPECIFIC YIELD RESEARCH AND PERMEABILITY RESEARCH ...Aquifers-general, California, Permeability, Storage of Water, Velocity -water, ...**7.0013**

STUDY OF IRRIGATION SYSTEM DESIGN CRITERIA FOR HAWAIIAN VEGETABLE CROPS ...Economics-general, Hawaii, Irrigation, Irrigation-general, Soil-water-plant Relationships, ...**2.0380**

WATER SUPPLY FROM AGRICULTURAL WATERSHEDS AND UTILIZATION IN IRRIGATION ...Agricultural Watersheds, Forecasting-prediction, Irrigation-general, Moisture Content, Patterns, Runoff, ...**4.0187**

IMPROVING IRRIGATION WATER SUPPLY FORECASTS AND THEIR USE ...Forecasting-prediction, Frost and Permafrost, Irrigation-general, Moisture Content, Moisture Meters, Runoff, ...**3.0401**

HYDROGEOLOGY OF PUBLIC GROUND WATER SUPPLIES IN PENNSYLVANIA ...Chemical-general, Groundwater, Management, Pennsylvania, Pollution Abatement, ...**2.0907**

PHYSICAL, METEOROLOGICAL, AND HYDROLOGIC ASPECTS OF EVAPOTRANSPIRATION ...Biophysics & Molec. biology, Evapotranspiration, Forest Watersheds, Southeast, Transpiration and Evap, ...**2.0953**

WATER YIELD AND GROUNDWATER MOVEMENT IN THE EDWARDS PLATEAU AS AFFECTED BY GEOLOGY, CHANNEL AND VALLEY MATERIALS, AND FLOOD STRUCTURES ...Engineering Structures-general, Groundwater Movement, Karst Topography, Rain, Texas, Water Table Fluctuation, ...**2.1031**

RUNOFF AND WATER YIELD AS AFFECTED BY CLIMATIC AND WATERSHED CONDITIONS IN THE BLACKLANDS OF TEXAS ...Agricultural Watersheds, Amount, Floods, Runoff, Texas, ...**2.1021**

THE ROLE OF VEGETATION AND SOIL IN WATERSHED YIELD ...Cover Crops, Dendroclimatology, Soil Properties - General, Soil-water-plant Relationships, Water Balance-budget, Watersheds-general, ...**4.0256**

MISCELLANEOUS FIELD RESEARCH IN CLIMATOLOGY ...Amount, Physical Climatology, Precipitation-general, Water Resources Development, Weather Modification-general, ...**2.0606**

PRECIPITATION ...Amount, Forecasting-prediction, Gages, Runoff, Snowpack, ...**2.0601**

SNOW METAMORPHOSIS AND SNOWMELT ...Forecasting-prediction, Snowmelt, Snowpack, Streams, Technique Development, ...**2.0602**

EVAPORATION ...Atmosphere Radiation, Evaporation, Forecasting-prediction, Lakes, Radiation-general, ...**2.0603**

WHITE HOLLOW WATERSHED RESEARCH ...Forest Watersheds, Other, Seasonal, Sediment Yield, Tennessee, ...**4.0221**

HYDROLOGIC EFFECT OF VEGETATION MODIFICATION ...Hydrology-general, Model Studies, Modified Water Use, Water Development, Water Movement, Velocity, ...**3.0009**

PERMEABILITY DISTRIBUTION AND SEDIMENTATIONAL FEATURES ...Big Horn, Clastic Aquifers, Permeability, Petrography, Sedimentary Structures-other, ...**2.0271**

SPECIFIC YIELD INVESTIGATION ...Aquifers-general, California, Groundwater Basins, Moisture Content, Projections and Estimations, ...**2.0182**

HYDROLOGY OF THE CRYSTALLINE ROCK SYSTEM IN SOUTHEASTERN STATES ...Crystalline, Groundwater, Groundwater Movement, Hydrology-general, Water Quality-general, Water Wells, ...**2.0825**

SPRINGFIELD AREA INFILTRATION STUDY, OHIO ...Artificial Recharge, Clastic Aquifers, Flow Characteristics -water, Induced Infiltration, Ohio, ...**4.0196**

VEGETATION MANIPULATION EFFECTS ON RUNOFF - SYCAMORE CREEK, ARIZ ...Conservation-general, Cover Crops, Runoff, Sediment Yield, Watersheds-general, ...**3.0008**

FLOOD FLOWS AND SEDIMENT YIELD OF COLMA CREEK BASIN, CALIFORNIA ...California, Construction, Floods, Projections and Estimations, Sediment Yield, Urban Environments, ...**4.0038**

HYDROLOGIC STUDIES OF SMALL RURAL TEXAS WATERSHEDS ...Water Loss Control, ...**2.1005**

WATER RESOURCES OF BRANCH-BLACKSTONE RIVER BASIN, RHODE ISLAND ...Gaging, Groundwater Basins, Permeability, Rhode Island, Runoff, ...**2.0614**

WATER YIELD IMPROVEMENT, EROSION CONTROL, AND SEDIMENT REDUCTION IN FORESTS ...Erosion-general, Forest Watersheds, Land Use, Moisture Content, Radioisotopes, Stabilization-other, ...**3.0486**

MANAGEMENT FOR IMPROVEMENT OF WATER YIELD IN THE CONIFER ZONE OF CALIFORNIA ...Evapotranspiration, Forest Watersheds, Land Use, Precipitation-general, Radioisotopes, Snowmelt, ...**3.0032**

WATER YIELD IMPROVEMENT IN THE BRUSHLANDS OF THE SOUTHWEST ...Consumptive Use, Internal Water Movement, Soil-water-plant Relationships, Southwest, Unsaturated Flow, ...**3.0062**

STREAMFLOW REGULATION AND SEDIMENT CONTROL IN NORTHERN ROCKY MOUNTAIN FORESTS ...Flow Characteristics -water, Forest Watersheds, Infiltration, Peak Flow, Snowmelt, ...**5.0321**

WATER YIELD IMPROVEMENT, AND SNOW AND AVALANCHE PREDICTION AND PREVENTION, IN THE ALPINE REGIONS OF THE CENTRAL ROCKY MOUNTAINS ...Alpine, Colorado, Snowslide-avalanche, Water Loss Control, ...**3.0146**

WATER YIELD IMPROVEMENT IN THE SNOWPACK TIMBER ZONE, RUNOFF FROM RANGELANDS ...Erosion-general, Gully Or Channel Erosion, Mountains-alpine, Radiation-general, Snowmelt, ...**3.0143**

IMPROVEMENT OF WATER YIELDS AND SOIL STABILIZATION IN RIVER BASINS ...Artemisia, Cover Crops, Erosion-general, Forest Watersheds, Management, Soil-water-plant Relationships, ...**3.0495**

MANAGEMENT OF STORM RUNOFF AND THE IMPROVEMENT OF WATER YIELD ON FOREST LAND ...Forest Watersheds, Infiltration, Runoff, Storm Water, Subsurface Flow, ...**2.0863**

FLOOD RUNOFF & WATER YIELD FROM GLACIATED MOUNTAINS ...Floods, Forest Watersheds, Glacial Environment, Heat Budget, Runoff, Water Balance-budget, ...**3.0372**

FLOOD RUNOFF REDUCTION AND WATER YIELD IMPROVEMENT ...Appalachian Highlands-other, Cutting Operations, Forest Watersheds, Management, Runoff, ...**5.1287**

WATERSHED CORRELATION AND SYNTHESIS ...Eastern, Flow Characteristics -water, Forest Watersheds, Land Use, Management, ...**3.0420**

EFFECTS OF DIFFERENT FOREST TYPES AND CONDITIONS ON STREAM REGIMEN AND WATER YIELDS ...Climatic Effects, Environment, Flow Characteristics -water, Forest Watersheds, Land Use, Radiation-general, ...**5.0794**

QUANTITY, QUALITY, AND TIMING OF WATER YIELDS IN THE SOUTHERN APPALACHIANS-PIEDMONT ...Appalachia, Evapotranspiration, Forest Watersheds, Heat Budget, Piedmont Province, ...**3.0374**

FLOOD REDUCTION AND IMPROVEMENT IN TIMING OF WATER YIELD IN THE OZARKOUACHITA UPLANDS ...Erosion-general, Floods, Infiltration, Land Use, Water Cycle, ...**5.0054**

WATER YIELD IMPROVEMENT FROM SOIL TREATMENTS AND PLANT-COVER ALTERATIONS (ABBREV) ...Cover Crops, Precipitation -non-specific, Soil Management -other, Soil-water-plant Relationships, Watersheds-general, ...**4.0249**

IMPROVEMENT OF WATER YIELDS AND SOIL STABILIZATION IN THE BLACK HILLS ...Erosion-general, Flow Characteristics -water, Forest Watersheds, Management, Sedimentology-general, Stabilization-other, ...**3.0436**

BOG AND SWAMP HYDROLOGY ...Forest Watersheds, High Organic Soils, Management, North Central, Soils and Fertilizer, ...**3.0294**

IMPROVEMENT OF WATER YIELDS BY MODIFICATION OF RADIANT ENERGY OVER LAND SURFACES (ABBREV) ...Energy Budgets, Evapotranspiration, Interception, Radiation-general, Snowmelt, ...**2.0235**

WATER YIELD IN RELATION TO CLIMATIC & WATERSHED CHARACTERISTICS OF LAND ...Agricultural Watersheds, Climate, Morphology-general, Patterns, Subsurface Flow, ...**3.0419**

STORM RUNOFF AND FLOOD FLOWS IN RELATION TO CLIMATIC AND WATERSHED CHARACTERISTICS ...Channels, Hydrographs, Watersheds-general, ...**4.0206**

ANALYTICAL HYDROGRAPHY IN WATERSHED ENGINEERING ...Agricultural Watersheds, Conservation & Management Eng, Conservation-general, Hydrology-general, ...**4.0131**

RELATION OF CLIMATIC AND WATERSHED FACTORS TO RUNOFF RATES AND VOLUME YIELDS ...Agricultural Watersheds, Climate, Flow Characteristics -water, Geomorphology-quantitative, Morphology-general, Storms-general, ...**2.0333**

RELATION OF CLIMATIC AND WATERSHED PHYSIOGRAPHIC AND CULTURAL FACTORS TO WATER YIELD ...Agricultural Watersheds, Climate-general, Groundwater, Land Use, Shape, ...**3.0393**

AQUIFER AND SUBSURFACE RELATIONSHIPS IN THE HYDROLOGY OF UPSTREAM AGRICULTURAL WATERSHEDS ...Aquifers-general, Baseflow, Forecasting-prediction, Groundwater Movement, Natural Recharge, Streams, Technique Development, ...**3.0394**

WATER YIELD AS RELATED TO CLIMATIC WATERSHED CHARACTERISTICS IN THE NORTHERN PLAINS ...Agricultural Watersheds, Climate, Groundwater Movement, Morphology-general, Patterns, ...**3.0145**

RELATION OF CLIMATIC AND WATERSHED PHYSIOGRAPHIC AND CULTURAL FACTORS TO WATER YIELD ...Agricultural Watersheds, Conservation-general, Flow Characteristics -water, Land Use, Physiography-general, ...**3.0462**

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CITY OF JACKSON, WATER RESOURCES STUDY, MISSISSIPPI ...Control and Protection, Floods, Groundwater, Mississippi, Urban Environments, ...**4.0148**

WATER REOURCES OF SOUTHEASTERN WISCONSIN - RACINE AND KENOSHA COUNTIES ...Groundwater, Hydrographs, Stratigraphy-general, Water Quality-general, Wisconsin, ...**2.1151**

WATER RESOURCES OF THE LOWER WISCONSIN RIVER VALLEY, WISCONSIN ...Available Water, Hydrology-general, Projections and Estimations, Water Quality-general, Wisconsin, ...**2.1149**

WATER RESOURCES OF SOUTHEASTERN WISCONSIN - MILWAUKEE RIVER BASIN ...Discharge-general, River Basins, Water Quality-general, Water Table Fluctuation, ...**2.1152**

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HYDROLOGIC ANALYSIS OF THE NORTH FORK OF ELK CREEK ...Automatic Data Aquisition, Discharge-general, Montana, Observation Wells, ...**2.0714**

FOREST SITE AMELIORATION IN THE COASTAL FLATWOODS OF MISSISSIPPI - ECONOMIC AND BIOLOGICAL CONSIDERATIONS ...Mississippi, Moisture Tension, Pines, Site Index and Site Quality, Water Table - Depth of , ...**2.0682**

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COMPUTER SIMULATION OF AQUIFERS OF COASTAL PLAIN OF NORTH CAROLINA ...Carbonate Aquifers, Computers-general, Mining Industry, North Carolina, Saline Water Intrusion, ...**2.0821**

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GROUND WATER RESERVOIR RESPONSE TO EARTH TIDES ...Aquifers-general, Earth Tides, Geophysical Analysis, Porosity, Storage of Water, ...**2.1108**

REDUCTION OF GROUND WATER INFILTRATION INTO SEWERS BY ZONE PUMPING ...Lining, Pump, Pumping, Sewerage Systems-general, Water Wells, ...**5.0320**

MANAGEMENT OF FLATWOOD SOILS ...Depth, Sand, Tillage, Cropping Systems, Water Table - Depth of , ...**6.0153**

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SEASONAL VARIABLITY OF SOIL MOISTURE AND LEVELS OF GROUNDWATER TABLE ON LOWLAND AREAS ...Moisture Levels, Poland, Seasonal, Soils and Fertilizer, Wetlands, ...**3.0422**

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...Clastic Aquifers, Groundwater, Texas, Water Utilization - general, Water Yield, ...**4.0235**

GROUNDWATER SUPPLIES ...Aquifers-general, Atlases-maps, Groundwater, Natural Recharge, Total Volume, ...**2.0058**

IMPROVEMENT OF IRRIGATION MANAGEMENT AND SALINITY CONTROL IN THE IMPERIAL VALLEY. ...Drainage, Drainage Engineering, Management, Saline and Alkaline Soils, Sprinkler Irrigation, ...**3.0048**

GENESIS AND MORPHOLOGY OF PYGMY FOREST-BLACKLOCK SOIL ECOSYSTEM ...California, Douglas Fir, Sequoia, Soil Ecology, Wave-built Terrace, ...**6.0041**

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WATER CONTROL FOR FOREST PRODUCTION ...Drainage, Forests, Irrigation-general, Moisture Content, Palms, ...**2.0314**

WATER RELATIONS WITH CITRUS ON THE FLATWOODS AND MARSHES OF THE EAST COAST ...Citrus, Drainage, Saline Soils, Sprinkler Irrigation, Swamps-marshes, ...**2.0310**

GROUND-WATER STUDIES - DEEP SANDSTONE AQUIFER IN CHICAGO REGION ...Clastic Aquifers, Groundwater Movement, Permeability, Pumping, Sandstones, ...**2.0419**

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RECHARGE OF GROUND WATER IN RIVER VALLEYS OF EASTERN AND CENTRAL KANSAS, AND THE HIGH PLAINS ...Artificial Recharge, Augmentation-general, Great Plains Province, Groundwater, Groundwater Mining, Natural Recharge, ...**4.0116**

EFFECTS OF TUTTLE CREEK RESERVOIR ON GROUND WATER LEVELS BELOW THE DAM ...Observation Wells, Project Post-evaluation, Pumping, Water Level Fluctuation, Water Wells, ...**4.0117**

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CHARACTERIZATION OF WATER TABLES IN OREGON SOILS WITH REFERENCE TO TRAFFICABILITY ...Dynamic, Moisture Content, Rain-general, Static Load-general, Trafficability, ...**2.0887**

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DRAINAGE OF SUGARCANE LANDS IN THE HUMID SECTIONS OF PUERTO RICO ...Drainage, Humid, Puerto Rico, Sugar Cane, Water Table - Depth of , Yield, ...**2.0936**

CROP RESPONSE TO STATIC AND FLUCTUATING WATER TABLES ...Saline Soils, Soil Aeration, Soil-water-plant Relationships, Texas, Water Table - Depth of , ...**3.0446**

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THE ECONOMICS OF IRRIGATED CROP PRODUCTION BY LOW CAPACITY WELLS AND BY SPRINKLER SYSTEMS ON TEXAS FARMS ...Economics-general, Irrigation-general, Management, Optimization, Texas, ...**3.0452**

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CHARACTERIZATION OF THE PHYSICAL PROPERTIES OF THE SOILS OF VIRGINIA ...Moisture Content, Permeability, Soil Environment, Soil Genesis, Underground Waste Disposal, ...**2.1106**

GROUNDWATER RECHARGE ...Applied Climatology, Forecasting-prediction, Groundwater, Natural Recharge, Observation Wells, ...**3.0430**

STATISTICAL INFERENCE AND MODELS ...Aquifers-general, Dendrochronology, Distributions, Statistical Models, Stochastic Processes, ...**7.0108**

PERIODIC PLANT GROWTH PHENOMENA AND HYDROLOGY ...Dendrochronology, Moisture Levels, Natural Variation of Water USE, Precipitation -non-specific, Soil-water-plant Relationships, ...**2.1098**

MECHANICS OF GROUND-WATER FLOW ...Aquifers-general, Artificial Recharge, Earthquakes, Groundwater Basins, Groundwater Movement, ...**2.1093**

HYDROLOGY OF UPPER BUFFALO RIVER BASIN ...Discharge-general, Groundwater, River Basins, Surface Water, Tennessee, ...**2.0996**

GROUND-WATER HYDROLOGY AND DEVELOPMENT IN EAST-CENTRAL WASHINGTON ...Drawdown, Groundwater Basins, Groundwater Mining, Subsurface Flow, Washington, ...**2.1135**

WATER RESOURCES OF THE GREATER JUNEAU BOROUGH, ALASKA ...Alaska, Observation Wells, Unconsolidated Aquifers, Urban Environments, Water Resources Development, ...**2.0014**

WATER RESOURCES APPRAISAL OF THE TUCSON BASIN, ARIZONA ...Arizona, Groundwater Movement, River Basins, Storage of Water, Surface Water, ...**2.0043**

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GROUNDWATER ANALYSIS BY DIGITAL COMPUTER APPLICATION DEVELOPMENT ...Aquifers-general, Digital Computers, Forecasting-prediction, ...**4.0059**

RELATION OF NITROGEN LEVEL, HIGH WATER TABLE AND SOIL SALINITY TO GROWTH, YIELD AND FRUIT QUALITY OF DATES ...Rates Or Levels of Application, Saline Soils, Trees, Water Table - Depth of , ...**3.0185**

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APPRAISAL OF WATER MANAGEMENT INSTITUTIONS-SURVEY OF OREGON WATER LAW ...Administrative Structures, Legal Review, Management, Water Rights-general, Water Standards, ...**6.0455**

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ANALYSIS OF SMALL WATER MANAGEMENT STRUCTURES ...Administrative Structures, Hydraulic Structures, Management, Water Control Works-general, Water Distribution Systems, ...**4.0260**

ECONOMIC CONSEQUENCES OF INTERBASIN WATER TRANSFERS ...Benefit-cost Analysis, Economic Impact, Irrigation-general, River Basins, ...**6.0451**

SURFACE AND GROUND WATER POTENTIALITIES OF THE MULLICA RIVER BASIN ...Aqueducts, Conjunctive Use, Economic Impact, Systems Analysis, Water Quality-general, ...**4.0172**

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THE ECONOMICS OF WATER TRANSFER - AN APPRAISAL OF INSTITUTIONS ...Administrative Structures, Alternative Planning, Economic Efficiency, Legal Review, Model Studies, Welfare Economics, ...**4.0169**

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A STUDY OF THE SOCIAL MECHANISM OF RURAL-URBAN WATER TRANSFERS WITH SPECIAL REFERENCE TO EXTERNAL EFFECTS ...Administrative Structures, Agriculture, Base Studies, Economic Efficiency, Fiscal, Model Studies, Social Aspects, Water Allocation, Welfare Economics, ...**6.0105**

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A STUDY OF THE INTEGRATION OF THE WATER RESOURCES OF THE BEAR, WEBER, AND JORDAN RIVERS IN NORTHERN UTAH ...Analog Computers, Analog Computers Math, Model Studies, Planning, Utah, ...**6.0587**

THE ECONOMICS OF WATER RESOURCE DEVELOPMENT ...Administrative Structures, Economic Efficiency, Water Law-general, Water Resources Development, ...**6.0651**

HYDROLOGY OF ARKANSAS RIVER VALLEY, CANON CITY TO STATE LINE ...Arkansas River, Flow Characteristics -water, Groundwater, Hydrology-general, Irrigation-general, Management, ...**2.0202**

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EFFECTS OF EARLY WATER ON WATERFOWL PRODUCTION ...Benefit-cost Analysis, Irrigation-general, Spawn Or Nesting Sites, Water Fowl, N.s. , Water Supply-general, ...**2.0214**

EFFECTS OF RESTORATION AND MANAGEMENT OF THE SAN SIMON MARSH ON ITS UTILIZATION BY MEXICAN DUCKS ...Food Supply, Management, Mexican Duck, Spawn Or Nesting Sites, Swamps-marshes, ...**6.0364**

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SOME EFFECTS OF WATER IMPOUNDMENTS ON WATERFOWL POPULATIONS AND REPRODUCTION ON THE SNAKE RIVER, WASHINGTON ...Other, Pre-impoundment Sites, Reservoirs and Impoundments, Snake River, Washington, ...**6.0609**

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ECOLOGY OF SOME WADING BIRD POPULATIONS AFFECTED BY THE INVASION OF THE CATTLE EGRET INTO ALABAMA ...Aquatic Ecology, Behavioral Ecology, Ciconiiformes - Wading Birds, Mark, Tag Or Capture -other, Migration, ...**6.0001**

EFFECT OF RANGE AND WATER ON MULE DEER POPULATION ...New Mexico, Odocoileus, Population Dynamics, Range Or Territorial Distr. , Relations - Forage - Timber, ...**3.0338**

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METHODS OF ANALYSIS AND DETERMINATION OF EFFECTS OF ALTERNATIVE USES OF FORESTED LANDS ON STREAMFLOW ...Alternative Planning, Land Use, Other, River Basins, Washington, ...**4.0272**

HYDROLOGIC CHARACTERIZATION OF FORESTED WATERSHEDS IN ARIZONA ...Dendrochronology, Forecasting-prediction, Management, Runoff, Snowpack, Water Yield, ...**2.0051**

EFFECTS OF FOREST COVER MANIPULATION ON WATER YIELD AS STUDIED BY AN ELECTRIC ANALOG ...Analog Computers, Development of Models, Soils and Fertilizer, Washington, Water Yield, ...**3.0484**

HYDROLOGIC RELATIONSHIPS IN A CONIFEROUS FOREST ...Amount, Evapotranspiration, Groundwater, Storage of Water, Water Balance-budget, ...**2.0552**

SEASONAL SHALLOW STORAGE AND DEEP SEEPAGE COMPONENTS FOR THE HYDROLOGIC BUDGET OF A SMALL FORESTED OZARK WATERSHED ...Amount, Groundwater Movement, Missouri, Seismic Surveys, Storage of Water, ...**2.0700**

STUDIES ON EFFECTS OF WATERSHED PRACTICES ON STREAMS ...Chemical-general, Discharge-general, Organic Matter, Periphyton, Physical-general, Primary Productivity, ...**5.0948**

MANIPULATION AND MANAGEMENT OF SECOND GROWTH PONDEROSA PINE FOR OPTIMUM YIELDS OF WATER AND/OR WOOD AND FORAGE ...Other, Relations - Forage - Timber, Soil-water-plant Relationships, Soils and Fertilizer, Water Yield, ...**3.0021**

SNOW HYDROLOGY ...Arizona, Energy Budgets, Mathematical Analysis, Snow, Snowmelt, ...**2.0064**

SOIL-WATER-VEGETATION RELATIONS IN THE DOUGLAS FIR ZONE ...Flow Characteristics -water, Moisture Content, Patterns, Runoff, Water Balance-budget, Water Cycle, ...**3.0027**

EFFECTS OF FIRE ON HYDROLOGY AND EROSION ...Erosion-general, Fire Damage, Recovery, Hydrology-general, Middle Rocky Mts, ...**2.0226**

AN EVALUATION OF THE INSECTICIDE SEVIN AS A WATERSHED POLLUTANT ...Persistance of Residues, Pollution - Effects of , Sevin, ...**5.1206**

FOREST COVER ...Cover Crops, Forests, Interception, Missouri, Soils and Fertilizer, ...**4.0156**

EVAPOTRANSPIRATION PATTERNS OF FOREST AND BRUSH VEGETATION ON THE EAST SLOPE OF THE SIERRA NEVADA ...Evapotranspiration, Moisture Levels, Mountains-alpine, Sierra Nevada, Slope - Direction of , ...**4.0167**

INFLUENCE OF FOREST COVER AND TIMBER HARVESTING METHODS ON STREAMFLOW ...Canopy & Overstory, Logging, Transport, Equipment, Pennsylvania, Streams, ...**2.0930**

EVAPOTRANSPIRATION LOSSES AS RELATED TO SITE AND VEGETATION DIFFERENCES ...Cover Crops, Evapotranspiration, Interception, Rhode Island, Soil Environment, ...**2.0939**

DEVELOPMENT OF MULTIPLE-USE PRODUCTION/OUTPUT INFORMATION FOR OWNERS OF SMALL WOODLANDS IN THE CENTRAL HARDWOOD REGION ...Control and Protection, Erosion-general, General Information Services, Input - Output Analysis, Multiple-purpose Projects, ...**7.0027**

COOPERATIVE WATERSHED MANAGEMENT IN SNOWLANDS AND LOWER CONIFER ZONES OF CALIFORNIA ...California, Coniferous Forests, Management, Moisture Tension, Snowmelt, ...**4.0022**

TRACING STORM AND BASE FLOW TO VARIABLE SOURCE AREAS ON FORESTED HEADWATERS ...Baseflow, Flow Characteristics -water, Georgia, Physical Properties -other, Sediment Yield, ...**2.0341**

WATERSHED VALUES AS AFFECTED BY FOREST MANAGEMENT ...Cover Crops, Erosion-general, Forests, Moisture Content, Runoff, Swamps-marshes, ...**4.0142**

INTERRELATION OF MOISTURE REGIME & NUTRIENT LEVELS OF SELECTED MISSISSIPPI SOILS & THEIR RELATION TO THE SITE INDEX OF LOBLOLLY PINE ...Mississippi, Moisture Tension, Pines, Site Index and Site Quality, Soils and Fertilizer, ...**2.0683**

SEASONAL WATER USE BY FOREST VEGETATION ...Conservation-general, Environment, Seasonal, Transpiration and Evap, Water Quality Control-general, ...**2.0893**

PHYSICAL, METEOROLOGICAL, AND HYDROLOGIC ASPECTS OF EVAPOTRANSPIRATION ...Biophysics & Molec. biology, Evapotranspiration, Southeast, Transpiration and Evap, Water Yield, ...**2.0953**

UNDESIRABLE SHRUB AND TREE CONTROL ...Evaluation, in Forests, of Trees and Shrubs, Relations - Forage - Timber, Utah, ...**3.0475**

MOLLUSK STUDIES ...Agricultural Watersheds, Mollusca - General Studies, Paleohydrology, Percolation, Strontium, ...**1.0114**

FOREST INFLUENCES STUDIES ...Erosion-general, Infiltration, Land Use, Runoff, Stabilization-general, Water Quality-general, ...**2.0986**

NORTH FORK CITICO CREEK WATERSHED RESEARCH ...Construction, Hydrology-general, Land Use, Multiple-purpose Projects, ...**4.0220**

WHITE HOLLOW WATERSHED RESEARCH ...Other, Seasonal, Sediment Yield, Tennessee, Water Yield, ...**4.0221**

PINE TREE BRANCH WATERSHED RESEARCH ...Cutting Operations, Erosion-general, Land Use, Other, Sediment Yield, Tennessee, ...**6.0536**

BEECH RIVER WATERSHED PROJECT ...Design Flow-flood, Land Use, Reservoirs and Impoundments, Sediment Yield, Tennessee, ...**4.0222**

SEDIMENTATION IN SMALL FORESTED DRAINAGE BASINS ...Logging, Transport, Equipment, Oregon, Runoff, Soil Erosion - non-specific, ...**2.0901**

SKYWATER--PARK RANGE FOREST HYDROLOGY ...Colorado, Model Studies, Mountains-alpine, Topographic Influences, Weather Modification-general, ...**2.0172**

EFFECTS OF LARGE SCALE FOREST FIRES ON WATER QUALITY IN THE INT. AK ...Alaska, Fire Damage, Recovery, Soil Analysis, Soils and Fertilizer, Water Quality-general, ...**5.0030**

CONTROL OF EROSION AND SEDIMENTATION ASSOCIATED BUILDING AND LOGGING ...Conservation, Erosion-general, Logging, Transport, Equipment, Sediment Yield, Streams, ...**2.0027**

WATER YIELD IMPROVEMENT, EROSION CONTROL, AND SEDIMENT REDUCTION IN FORESTS ...Erosion-general, Land Use, Moisture Content, Radioisotopes, Stabilization-other, Water Yield, ...**3.0486**

SOIL STABILIZATION AND RUNOFF REGULATION IN CONIFER WATERSHEDS ...Channels, Erosion-general, Internal Water Movement, Land Use, Runoff, Stabilization-other, ...**5.0967**

MANAGEMENT FOR IMPROVEMENT OF WATER YIELD IN THE CONIFER ZONE OF CALIFORNIA ...Evapotranspiration, Land Use, Precipitation-general, Radioisotopes, Snowmelt, Water Yield, ...**3.0032**

HYDROLOGIC ANALYSIS METHODS ...Floods, Land Use, Reservoirs and Impoundments, Sediment Yield, Snowmelt, ...**2.0077**

STREAMFLOW REGULATION AND SEDIMENT CONTROL IN NORTHERN ROCKY MOUNTAIN FORESTS ...Flow Characteristics -water, Infiltration, Peak Flow, Snowmelt, Water Yield, ...**5.0321**

WATERSHED PROTECTION & REHABILITATION TO REDUCE WATER RUNOFF ...Erosion-general, Floods, Infiltration, Land Use, Runoff, ...**4.0250**

IMPROVEMENT OF WATER YIELDS AND SOIL STABILIZATION IN RIVER BASINS ...Artemisia, Cover Crops, Erosion-general, Management, Soil-water-plant Relationships, Water Yield, ...**3.0495**

REDUCTION IN DAMAGES TO FORESTS BY IMPROVING MINING AND REHABILITATION PROCEDURES ...Coal-general, Conservation & Management Eng, Mining Industry, Site Index and Site Quality, Soils and Fertilizer, ...**4.0120**

MANAGEMENT OF STORM RUNOFF AND THE IMPROVEMENT OF WATER YIELD ON FOREST LAND ...Infiltration, Runoff, Storm Water, Subsurface Flow, Water Yield, ...**2.0863**

FLOOD RUNOFF & WATER YIELD FROM GLACIATED MOUNTAINS ...Floods, Glacial Environment, Heat Budget, Runoff, Water Balance-budget, Water Yield, ...**3.0372**

FLOOD RUNOFF REDUCTION AND WATER YIELD IMPROVEMENT ...Appalachian Highlands-other, Cutting Operations, Management, Runoff, Water Yield, ...**5.1287**

WATERSHED CORRELATION AND SYNTHESIS ...Eastern, Flow Characteristics -water, Land Use, Management, Water Yield, ...**3.0420**

EFFECTS OF DIFFERENT FOREST TYPES AND CONDITIONS ON STREAM REGIMEN AND WATER YIELDS ...Climatic Effects, Environment, Flow Characteristics -water, Land Use, Radiation-general, Water Yield, ...**5.0794**

QUANTITY, QUALITY, AND TIMING OF WATER YIELDS IN THE SOUTHERN APPALACHIANS-PIEDMONT ...Appalachia, Evapotranspiration, Heat Budget, Piedmont Province, Water Yield, ...**3.0374**

EFFECT OF FOREST TYPES AND CONDITIONS ON WATER MOVEMENT AND GROUND WATER RECHARGE ...Groundwater Movement, Infiltration, Land Use, Natural Recharge, Runoff, Water Cycle, ...**3.0301**

SILVICULTURE OF COASTAL PLAIN TIMBER TYPES ...Environment, Pines, Taxodioideae, Timber Stand Improvement, Wetlands, ...**4.0212**

IMPROVEMENT OF WATER YIELDS AND SOIL STABILIZATION IN THE BLACK HILLS ...Erosion-general, Flow Characteristics -water, Management, Sedimentology-general, Stabilization-other, Water Yield, ...**3.0436**

EFFECTS OF VARIOUS FOREST TYPES AND STAND TREATMENTS ON GROUNDWATER RECHARGE AND STREAMBANK EROSION IN AREAS OF DEEP GLACIAL DRIFT ...Erosion Control, Erosion-general, Natural Recharge, Open Channel, Stream Banks, ...**5.0573**

REDUCTION OF FLOOD RUNOFF, SEDIMENTATION AND STREAMFLOW IMPROVEMENT IN UNGLACIATED AREAS ...Erosion-general, Mississippi River, Runoff, Slope - Degree of , Stream Rehabilitation, Water Loss Control, ...**4.0275**

BOG AND SWAMP HYDROLOGY ...High Organic Soils, Management, North Central, Soils and Fertilizer, Water Yield, ...**3.0294**

Morphology

Area

HYDROLOGIC CHARACTERIZATION OF SMALL WATERSHEDS ...Aerial, Illinois, Mathematical Analysis, Slopes, Small Watersheds, ...**6.0206**

Morphology-general

PREDICTION OF THE MAGNITUDES AND FREQUENCIES OF FLOODS IN MICHIGAN ...Drainage, Floods, Forecasting-prediction, Michigan, Rain-general, ...**2.0635**

SAN ISIDRO WASH STUDY FLOW LOSSES IN AN EPHEMERAL STREAM CHANNEL ...Ephemeral, Evapotranspiration, Gaging, Infiltration, New Mexico, ...**2.0177**

CHARACTERISTICS OF STREAM FLOW OF SMALL WATERSHEDS IN PENNSYLVANIA AND INFLUENCING FACTORS ...Climate, Flow Characteristics -water, Land Use, Model Studies, Small Watersheds, Water Yield, ...**2.0929**

INFLUENCE OF GEOHYDROLOGY ON LANDSCAPE AND SOIL FORMATION ...Hydrology-general, Physiography-general, Soil Genesis, Weathering-general, ...**5.0409**

A METHOD OF DETERMINING AND MAPPING THE HYDROLOGIC RESPONSE OF UNGAGED WATERSHEDS IN THE SOUTHEAST ...Atlases-maps, Hydrology-general, Land Use, Small Watersheds, Southeast, ...**7.0025**

RAINWASH AND SOIL CREEP IN WESTERN NORTH DAKOTA ...Creep, Environmental Effects-geologic, Erosion-general, North Dakota, Slopes, ...**2.0848**

ANOMALOUS FLOOD RESPONSE IN REGIONS OF SIMILAR GEOMORPHIC CHARACTERISTICS ...Computers-general, Floods, Flow Characteristics -water, Pennsylvania, ...**2.0927**

THE INTERRELATIONSHIP BETWEEN WATERSHED FACTORS THAT AFFECT RUNOFF RATES AND VOLUME YIELDS IN THE SOUTHERN COASTAL PLAINS ...Agricultural Watersheds, Georgia, Hydrology-general, Runoff, Water Yield, ...**3.0193**

LONG TERM CHANNEL CHANGES ...Channels, Cross-section, Gaging, Soil Erosion -non-specific, ...**2.0284**

GEOMORPHIC STUDIES IN THE SIERRA NEVADA, CALIFORNIA ...Glaciers, Regimen, Sediment Relationship, Sierra Nevada, Streams, ...**2.0119**

LAKE HYDROLOGY STUDIES ...Evaporation, Florida, Inflow, Lakes, Water Level Fluctuation, ...**2.0328**

FLOOD-FREQUENCY AND BASIN PARAMETER RELATIONSHIPS IN SMALL DRAINAGE AREAS ...Amount, Discharge-general, Floods, Peak Flow, Small Watersheds, ...**2.0280**

EFFECT OF IRRIGATION ON STREAMFLOW IN CENTRAL SAND PLAINS OF WISCONSIN ...Drainage, Groundwater, Irrigation-general, Water Balance-budget, Wisconsin, ...**4.0279**

WATER YIELD IN RELATION TO CLIMATIC & WATERSHED CHARACTERISTICS OF LAND ...Agricultural Watersheds, Climate, Patterns, Subsurface Flow, Water Yield, ...**3.0419**

RELATION OF CLIMATIC AND WATERSHED FACTORS TO RUNOFF RATES AND VOLUME YIELDS ...Agricultural Watersheds, Climate, Flow Characteristics -water, Geomorphology-quantitative, Storms-general, Water Yield, ...**2.0333**

WATER YIELD AS RELATED TO CLIMATIC WATERSHED CHARACTERISTICS IN THE NORTHERN PLAINS ...Agricultural Watersheds, Climate, Groundwater Movement, Patterns, Water Yield, ...**3.0145**

STORM RUNOFF AND FLOODS AS RELATED TO INTEGRATED CLIMATIC AND WATERSHED CHARACTERISTICS ...Climate, Floods, Land Use, Runoff, Storm Water, ...**4.0071**

LABORATORY CATCHMENT INVESTIGATIONS RELATING TO HYDROLOGIC SYSTEMS ANALYSIS ...Gaging, Hydrology-general, Model Studies, Systems Analysis, ...**6.0574**

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A STUDY OF SUBSURFACE FLOW INTO MOUNTAIN STREAMS AS RELATED TO TOPOGRAPHY AND PARTIAL SOURCE AREAS ...Baseflow, Georgia, Japan, Mountains-alpine, ...**2.0340**

THE RELATION OF DRAINAGE NETWORKS AND BASIN DEVELOPMENT TO ROCK TYPE AND CLIMATE ...Climate, Drainage Density-texture, River Basins, Rock Type, Slopes, ...**2.0179**

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INFLOW HYDROGRAPH STUDY ...Floods, Hydrographs, Inflow, Small Watersheds, Wyoming, ...**2.0302**

STREAM VALLEY ASYMMETRY IN AN ARCTIC ENVIRONMENT-CONDITIONS GOVERNING GEOMORPHIC PROCESSES 7360 ...Arctic, Environmental Effects-geologic, Microclimate-general, Slopes, Valleys and Canyons, ...**2.0255**

STOCHASTIC TREATMENT OF RIVER GEOMETRY ...Channel Geometry, Meanders, Morphology-general, Open Channel, Stochastic Processes, ...**2.0443**

WATER YIELDS FROM SMALL WATERSHEDS ...Climate, Runoff, Small Watersheds, Virginia, Water Yield, ...**4.0265**

RELATION OF CLIMATIC AND WATERSHED PHYSIOGRAPHIC AND CULTURAL FACTORS TO WATER YIELD ...Agricultural Watersheds, Climate-general, Groundwater, Land Use, Water Yield, ...**3.0393**

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STREAM VALLEY ASYMMETRY IN AN ARCTIC ENVIRONMENT-CONDITIONS GOVERNING GEOMORPHIC PROCESSES 7360 ...Arctic, Environmental Effects-geologic, Microclimate-general, Shape, Valleys and Canyons, ...**2.0255**

SOURCES, MOVEMENT, AND DISTRIBUTION OF SEDIMENT IN A SMALL WATERSHED ...Energy-dynamics, Erosion, Sediment Transport-general, Small Watersheds, ...**2.0567**

INTERAGENCY FRAIL LANDS STUDY - MONTANA IV. WATER QUANTITY MANAGEMENT ...Conservation, Erosion-general, Montana, Runoff, Soil Erosion -non-specific, ...**4.0161**

THE EFFECT OF A PERMEABLE BED ON SEDIMENT MOTION ...Channels, Permeability, Sediment Transport-general, Seepage, ...**2.0353**

RAINWASH AND SOIL CREEP IN WESTERN NORTH DAKOTA ...Creep, Environmental Effects-geologic, Erosion-general, Morphology-general, North Dakota, ...**2.0848**

HYDROLOGIC CHARACTERIZATION OF SMALL WATERSHEDS ...Aerial, Area, Illinois, Mathematical Analysis, Small Watersheds, ...**6.0206**

HYDROLOGIC CHARACTERIZATION OF SMALL WATERSHEDS ...Drainage, Gravitational Movement -water, Internal Water Movement, Moisture Content, Small Watersheds, ...**2.0434**

DEVELOPMENT OF LAND USE EQUATIONS FOR THE SLOPING SOILS OF INDIANA ...Development of Models, Erosion-general, Indiana, Land Use, Tillage, Cropping Systems, ...**2.0464**

RESEARCH ON GEOHYDROLOGY OF THE EASTERN SLOPE OF WEST MAUI ...Aquifers-general, Hawaii, Mountains-alpine, Patterns, Projections and Estimations, Water Yield, ...**6.0170**

SEDIMENTATION IN LAKES AND RESERVOIRS ...Conservation-general, Land Use, Rate of Deposition, Reservoirs and Impoundments, Soil Types-other, ...**2.0422**

STUDY OF ENGINEERING PRACTICES OF IRRIGATION IN KANSAS ...Irrigation Engineering, Irrigation-general, Kansas, Terrace-bench, Tillage, Cropping Systems, Yield, ...**8.0201**

CONSERVATION AND UTILIZATION OF RAINFALL AND IRRIGATION WATER ...Conservation & Management Eng, Irrigation, Runoff, Tillage, Cropping Systems, Water Harvesting, ...**3.0451**

THE RELATION OF DRAINAGE NETWORKS AND BASIN DEVELOPMENT TO ROCK TYPE AND CLIMATE ...Climate, Drainage Density-texture, Relief, River Basins, Rock Type, ...**2.0179**

BASIC PRINCIPLES AND MECHANICS OF RAINFALL, RUNOFF, SOIL MOVEMENT AND LOSS IN THE CORN BELT ...Engineering Properties-general, Erosion-general, Runoff, Sediment Transport-general, Structure-size, Surface Flow, ...**2.0475**

EVALUATION OF CLIMATIC, TOPOGRAPHIC, SOIL AND CROP MANAGEMENT FACTORS IN RELATION TO WATER MANAGEMENT AND EROSION CONTROL IN THE CORN BELT ...Climate, Corn Belt, Erosion-general, Runoff, Wind Erosion, ...**2.0476**

Small Watersheds

HYDROLOGICAL STUDY ...Discharge-general, Drainage, Gaging, Peak Flow, Rhode Island, ...**2.0943**

STUDY OF RUNOFF FROM SMALL DRAINAGE AREAS ...Drainage, Runoff, ...**2.0520**

DRAINAGE AREA FLOW RESEARCH ...Discharge-general, Drainage, Montana, ...**2.0270**

INVESTIGATION AND ANALYSIS OF FLOODS FROM SMALL WATERSHEDS IN OKLAHOMA ...Floods, Flow Characteristics -water, Gaging, Oklahoma, Peak Flow, ...**2.0278**

INFLOW HYDROGRAPH STUDY ...Floods, Hydrographs, Inflow, Shape, Wyoming, ...**2.0302**

FLOOD FREQUENCY SYNTHESIS FOR SMALL STREAMS IN ALABAMA ...Alabama, Drainage, Forecasting-prediction, Gaging, Peak Flow, Runoff, ...**3.0172**

SMALL DRAINAGE AREA STUDY ...Arizona, Drainage, Floods, Gaging, Peak Flow, ...**2.0289**

RUNOFF STUDIES ON SMALL DRAINAGE AREAS ...Data Acquisition-general, Discharge-general, Drainage, Peak Flow, West Virginia, ...**2.0290**

ANALYSIS OF RUN-OFF FROM SMALL DRAINAGE AREAS ...Design Flow-flood, Drainage, Floods, Massachusetts, Runoff, ...**2.0612**

FLOOD FREQUENCY FOR SMALL DRAINAGE AREAS ...Discharge-general, Drainage, Floods, Mississippi, ...**2.0291**

HYDROLOGY STUDY ...Bridges & Culverts, Culvert, Engineering Structures-general, Floods, Flow Characteristics -water, ...**2.0292**

INVESTIGATION AND ANALYSIS OF FLOODS FROM SMALL DRAINAGE AREAS IN OHIO ...Drainage Systems, Floods, Ohio, ...**2.0275**

HYDROLOGY RESEARCH PROJECT ...Data Acquisition-general, Data Analysis - General, Drainage, Hydrology-general, Structural, ...**2.0281**

INVESTIGATION AND ANALYSIS OF FLOODS FROM SMALL DRAINAGE AREAS IN SOUTH CAROLINA ...Culvert, Design Flow-flood, Drainage, Floods, South Carolina, ...**2.0301**

COLLECTION OF HYDROLOGIC DATA OF SMALL DRAINAGE AREAS ...Data Acquisition-general, Drainage, Maryland, Runoff, Storm Water, ...**2.0560**

INVESTIGATION AND ANALYSIS OF FLOOD HYDROGRAPHS FROM SMALL DRAINAGE BASINS IN SOUTH DAKOTA ...Bridges & Culverts, Culvert, Drainage, Floods, Hydrographs, Rain-general, ...**2.0294**

PROGRAM FOR INVESTIGATION AND ANALYSIS OF FLOODS FROM SMALL DRAINAGE AREAS IN DELAWARE ...Drainage, Floods, Flow Characteristics -water, Forecasting-prediction, Open Channel, ...**2.0295**

PROGRAM FOR HYDROLOGIC INVESTIGATION OF SMALL DRAINAGE AREAS IN TEXAS ...Design Flow-flood, Drainage, Floods, Hydraulic Structures, Texas, ...**2.0296**

SMALL WATERSHED STUDY ...Design-other, Drainage, Drainage Systems, Hydraulic Structures, ...**2.0297**

ESTIMATING RUNOFF RATES FROM SMALL RURAL WATERSHEDS ...Culvert, Drainage, Forecasting-prediction, Runoff, ...**2.0240**

INVESTIGATION OF WATER RESOURCES. FLOODS IN SMALL STREAMS IN TENNESSEE ...Drainage, Floods, Tennessee, ...**2.0298**

HYDROLOGIC STUDIES ...Data Acquisition-general, Floods, Virginia, ...**2.0299**

HYDROLOGIC-MINERAL CYCLE INTERACTION IN SMALL UNDISTRUBED AND MANMANIPULATED ECOSYSTEMS ...Chemical Reactions, Environment, Mineral Associations, New Hampshire, Water Cycle, ...**2.0745**

SOURCES, MOVEMENT, AND DISTRIBUTION OF SEDIMENT IN A SMALL WATERSHED ...Energy-dynamics, Erosion, Sediment Transport-general, Slopes, ...**2.0567**

SAN LUIS WATERSHED STUDY ...Conservation-general, Management, New Mexico, Sediment Yield, Water Yield, ...**2.0234**

CORRELATION OF SOIL SURFACE AND RAINFALL-RUNOFF-MOISTURE RELATIONSHIPS ON AGRICULTURAL WATERSHEDS ON COASTAL PLAINS SOILS (ABBREV) ...Antecedent Moisture, Recharge -general, Runoff, Soil Environment, Water Yield, ...**2.0002**

RUNOFF STUDIES ON SMALL WATERSHEDS ...Hydrographs, Runoff, Subsurface Flow, Surface Water, Water Yield, ...**2.1138**

FACTORS AFFECTING WATER YIELD FROM SMALL WATERSHEDS IN TENNESSEE ...Correlation, Cover Crops, General Synoptic Observations, Tennessee, Water Yield, ...**4.0224**

CHARACTERISTICS OF STREAM FLOW OF SMALL WATERSHEDS IN PENNSYLVANIA AND INFLUENCING FACTORS ...Climate, Flow Characteristics -water, Land Use, Model Studies, Morphology-general, Water Yield, ...**2.0929**

FLOODS FROM SMALL WATERSHEDS ...Amount, Floods, Rural Areas, Synthetic Hydrology-general, Systems Analysis, ...**2.0231**

HYDROLOGIC INVESTIGATION OF WATERSHEDS IN OHIO ...Discharge-general, Hydrology-general, Ohio, Simulation, ...**2.0861**

GENERALIZED ANALYSIS OF SMALL WATERSHED RESPONSES ...Discharge-general, Forecasting-prediction, Hydrology-general, Inflow, ...**2.0084**

THE EFFECT OF URBANIZATION ON RUNOFF IN SMALL WATERSHEDS ...Indiana, Land Use, Model Studies, Runoff, Urban Environments, ...**2.0458**

STUDY OF FACTORS AFFECTING THE CHANNEL PHASE OF RUNOFF FROM SMALL WATERSHEDS BY MATHEMATICAL MODELING ...Development of Models, Finite Differences, Flow Characteristics -water, Runoff, Streams, ...**2.0665**

HYDROLOGY OF SMALL DRAINAGE BASINS FOR DEVELOPING HYDRAULIC DESIGN ...Amount, Flow Characteristics -water, Hydrographs, Runoff, South Dakota, ...**2.0972**

A METHOD OF DETERMINING AND MAPPING THE HYDROLOGIC RESPONSE OF UNGAGED WATERSHEDS IN THE SOUTHEAST ...Atlases-maps, Hydrology-general, Land Use, Morphology-general, Southeast, ...**7.0025**

EVALUATION OF HYDROLOGIC EFFECTS OF URBANIZATION ...Hydrology-general, Land Use, Regression Analysis, Runoff, Storm Water, Urban Environments, ...**4.0231**

PARAMETERIZATION OF THE OBSERVED HYDROGRAPH AS A MEANS OF UNDERSTANDING RUNOFF PHENOMENA FROM SMALL WATERSHEDS ...Forecasting-prediction, Hydrographs, Model Studies, Runoff, Vermont, ...**2.1085**

INVESTIGATION OF A LINEAR MODEL TO DESCRIBE THE HYDROLOGIC PHENOMENON OF DRAINAGE BASINS ...Amount, Hydrographs, Model Studies, Runoff, Testing of Models, ...**2.1041**

PHASE TWO - EXPERIMENTAL INVESTIGATION OF SMALL WATERSHED FLOODS ...Floods, Mathematical Analysis, Model Studies, Rain-general, Runoff, ...**2.0233**

HYDROGEOCHEMICAL INVESTIGATION OF SELECTED WATERSHEDS IN SOUTHWESTERN MONTANA ...Chemical-general, Environmental Effects-geologic, Hydrogeochemical Properties, Montana, Rocks - Bedrock, ...**5.0698**

GEOCHEMISTRY AND HYDROLOGY OF A SMALL BASIN IN THE UPPER BUFFALO RIVER WATERSHED, TENNESSEE ...Hydrology-general, Tennessee, Water Cycle, Water Properties-general, Weathering Products, ...**2.0999**

EUTROPHIC EVALUATION OF A SMALL MULTI-LAND USE WATERSHED ...Eutrophication, Nitrogen, Phosphorus, Urban Environments, Wisconsin, ...**5.1319**

A HYDROMETEOROLOGICAL STUDY RELATED TO THE DISTRIBUTION OF PRECIPITATION AND RUNOFF OVER SMALL DRAINAGE BASINS - URBAN VERSUS RURAL AREAS ...Amount, Patterns, Runoff, Texas, Urban Environments, ...**2.1024**

ASSEMBLY AND ANALYSIS OF HYDROLOGIC AND GEOMORPHOLOGIC DATA FOR SMALL WATERSHEDS IN INDIANA ...Data Analysis - General, Geomorphology-general, Hydrographs, Indiana, Streams, ...**2.0459**

COMPUTER ANALYSIS OF WATERSHED CHARACTERISTICS AFFECTING FLOOD HYDROLOGY ...Data Analysis - General, Economic Efficiency, Floods, Research - Development, Water Loss Control, ...**2.0523**

ROLE OF ANIMAL WASTES IN AGRICULTURAL LAND RUNOFF ...Agricultural Watersheds, Animal Wastes - Feed Lots, Runoff, ...**5.0822**

MANAGEMENT ALTERNATIVES ON OZARK FOREST ...Arkansas, Erosion-general, Policy - Business Methods, Sediment Yield, Soils and Fertilizer, ...**2.0073**

FACTORS AFFECTING WATER YIELDS FROM SMALL WATERSHEDS IN GEORGIA ...Baseflow, Georgia, Runoff, Statistics-general, Water Yield, ...**4.0083**

HYDROLOGIC CHARACTERIZATION OF SMALL WATERSHEDS ...Aerial, Area, Illinois, Mathematical Analysis, Slopes, ...**6.0206**

HYDROLOGIC CHARACTERIZATION OF SMALL WATERSHEDS ...Drainage, Gravitational Movement -water, Internal Water Movement, Moisture Content, Slopes, ...**2.0434**

HYDROLOGIC CHARACTERIZATION OF SMALL WATERSHEDS ...Flow Characteristics -water, Gaging, Mathematical Analysis, Model Studies, Topographic, ...**4.0104**

HYDROLOGIC CHARACTERIZATION OF SMALL WATERSHEDS ...Cold - Climates, Mathematical Analysis, Model Studies, Peak Flow, Runoff, ...**4.0143**

SMALL WATERSHED YIELDS ...Amount, Aquifers-general, Land Use, Runoff, Water Yield, ...**4.0149**

HYDROLOGY OF SMALL AGRICULTURAL WATERSHEDS ...Hydrology-general, Missouri, Reservoirs and Impoundments, Runoff, Water Loss-general, ...**4.0151**

BASE FLOW ANALYSIS OF SELECTED DRAINAGE BASINS. ...Baseflow, Mathematical Analysis, New Hampshire, Seasonal, ...**2.0742**

HYDROLOGIC CHARACTERIZATION OF SMALL WATERSHEDS ...Hydrology-general, Mathematical Analysis, Model Studies, Runoff, Stochastic Models, ...**4.0197**

FACTORS AFFECTING WATER YIELDS FROM SMALL WATERSHEDS IN TENNESSEE ...Conservation & Management Eng, Instrumentation-general, Runoff, Soil Conditions, Water Harvesting, Water Yield, ...**4.0225**

DEVELOPING COMPUTER PROGRAMS FOR SOLUTION OF HYDROLOGIC PROBLEMS RELATED TO SMALL WATERSHEDS ...Climate-general, Forecasting-prediction, Hydrographs, Physiography-general, Water Yield, ...**7.0102**

ECONOMIC ANALYSIS OF SMALL WATERSHED DEVELOPMENT IN TEXAS. ...Alternative Planning, Benefit-cost Analysis, Economic Impact, Texas, Water Resources Development, ...**4.0241**

DATA REDUCTION METHODS FOR STREAMFLOW FROM SMALL, WILDLAND WATERSHEDS ...Computers-general, Data Analysis - General, Discharge-general, Gaging, Integration, Quadrature, Utah, ...**2.1068**

WATER YIELDS FROM SMALL WATERSHEDS ...Climate, Runoff, Shape, Virginia, Water Yield, ...**4.0265**

HYDROLOGY OF WATERSHEDS ON SHALE SOILS ...Fine-grained Clastics, Hydrology-general, Moisture Content, Moisture Tension, Runoff, Soil Properties - Other, ...**4.0273**

FACTORS AFFECTING WATER YIELDS FROM SMALL WATERSHEDS AND SHALLOW GROUND AQUIFERS ...Amount, Applied Climatology, Aquifers-general, Runoff, Soil Types-general, Water Yield, ...**4.0207**

GENERALIZED ANALYSIS OF SMALL WATERSHED RESPONSES ...Mathematical Analysis, Rain-general, Sequences - Series, Water Yield, ...**2.0085**

FLOODS FROM SMALL DRAINAGE AREAS ...California, Floods, Gaging, Hydrographs, ...**4.0039**

MATHEMATICAL MODELING OF SMALL WATERSHED FLOODS ...Floods, Mathematical Analysis, Model Studies, Rain-general, Runoff, ...**4.0073**

EXPERIMENTAL INVESTIGATION OF SMALL WATERSHED FLOODS ...Amount, Floods, Runoff, Synthetic Hydrology-general, ...**2.0232**

PILOT-STUDY OF SMALL WATERSHED HYDROLOGY ...Data Analysis - General, Floods, Instrumentation-general, Mathematical Analysis, Rain-general, Runoff, ...**2.0379**

NITRATE IN SURFACE WATERS IN ILLINOIS ...Fertilizers, Nitrate, Nitrite, Soil Types-other, Surface Water, ...**8.0179**

DRAINAGE CORRELATION RESEARCH PROJECT ...Climatography, Drainage, Floods, Peak Flow, Precipitation-general, ...**2.0710**

DETAILED CHARACTERIZATION OF SOILS AND VEGETATION AT SELECTED SITES TO SERVE AS BASIS FOR FUTURE EVALUATION OF RADIOACTIVE CONTAMINATION ...Absorption, Fixation, Exchange, Radioactive Pollution -ns, Radioactivity-general, Soil and Rock Leaching, Strontium, ...**5.0902**

FLOOD PREDICTION METHODS FOR PENNSYLVANIA HIGHWAY CROSSINGS ...Engineering Properties, Floods, Forecasting-prediction, Highway Sites, Systems Analysis, ...**2.0928**

RUNOFF PRODUCTION FROM UNIT SOURCE WATERSHEDS IN THE EDWARDS PLATEAU ...Amount, Forecasting-prediction, Rocks - Bedrock, Runoff, Texas, ...**2.1028**

RELATION OF CLIMATIC AND WATERSHED CHARACTERISTICS TO STORM RUNOFF IN THE EDWARDS PLATEAU ...Amount, Runoff, Storm Water, Storms-general, Texas, ...**2.1030**

SEDIMENT PRODUCTION YIELD AND DELIVERY RATE IN RELATIONS TO CLIMATIC AND WATERSHED CHARACTERISTICS ...Conservation, Land Use, Sediment Yield, Texas, ...**2.1018**

FLOOD HYDROGRAPH SYNTHESIS - UNGAGED WATERSHEDS ...Floods, Hydrographs, Tennessee, ...**2.0981**

UPPER BEAR CREEK EXPERIMENTAL PROJECT ...Alabama, Cover Crops, Discharge-general, Forecasting-prediction, Technique Development, ...**2.0987**

FROZEN GROUND INVESTIGATIONS, BARROW, ALASKA ...Alaska, Frost and Permafrost, Hydrology-general, Ice Content, Permafrost-frozen, Runoff, ...**2.0748**

HYDROLOGIC STUDY OF A SMALL ALASKAN WATERSHED ...Alaska, General, General Synoptic Observations, Hydrology-general, Water Sampling, ...**2.0749**

SOURCES, MOVEMENT, AND DISTRIBUTION OF SEDIMENT IN A SMALL WATER SHED ...Floodplains, Reservoirs and Impoundments, Sediment Yield, Supply Rate, Transport Distance, ...**2.0568**

FLUVIAL SEDIMENTATION IN STONY BROOK WATERSHED ...Gaging, Peak Flow, Runoff, Sedimentology-general, Total Volume, ...**2.0766**

EFFECT OF CONSERVATION PRACTICES ON HYDROLOGY AND SEDIMENTATION RATES ...Conservation, Land Use, Pennsylvania, Rate of Deposition, ...**4.0204**

FLOOD-FREQUENCY AND BASIN PARAMETER RELATIONSHIPS IN SMALL DRAINAGE AREAS ...Amount, Discharge-general, Floods, Morphology-general, Peak Flow, ...**2.0280**

Watersheds-general

ANALYSIS OF DRAINAGE BASINS AND LANDSCAPES ...Landscape, River Basins, ...**2.0633**

A STUDY OF THE HYDROLOGIC EFFECTS OF RAINFALL AUGMENTATION ...Amount, Augmentation-general, Clouds-precipitation, Digital Computers, Model Studies, ...**3.0076**

WATERSHED IMPROVEMENT--SOIL AND MOISTURE CONSERVATION PROGRAM ...Gaging, Modified Water Use, Moisture Content, Snowmelt, Water Yield, ...**8.0143**

REYNOLDS CREEK WATERSHED STUDY ...Idaho, Management and Fertility, Runoff, Sediment Yield, Water Yield, ...**2.0571**

CHEMICAL CONTROL OF CREOSOTEBUSH AND MESQUITE ...Evaluation, Legumes -other..mesquite... , Management Effects, Phreatophytes, Range, Zygophyllaceae, ...**4.0177**

WATERSHED EVALUATION ...Chemical Analysis (water), Population Dynamics, Stream Rehabilitation, Streams, Temperature, ...**4.0226**

EFFECTS OF WATERSHED MANIPULATION ON DEER AND ELK USE ...Cover Crops, Habitat Studies, Management, Population Dynamics, Water Yield, ...**4.0003**

THE ECONOMICS AND ADMINISTRATION OF WATER RESOURCES ...Administrative Structures, Alternative Planning, Colorado, Water - Alternative Uses, Water Costs, ...**6.0107**

REVIEW AND ANALYSIS OF PRECIPITATION AND RUNOFF DATA FOR SELECTED WATERSHEDS IN MINNESOTA ...Floods, Hydrographs, Infiltration, Precipitation-general, Runoff, ...**4.0140**

MATHEMATICAL SIMULATION OF HYDROLOGIC EVENTS ON UNGAGED WATERSHEDS ...Digital Computers, Hydrographs, Runoff, Sensitivity Problems, Testing of Models, ...**2.0461**

EFFECTS OF AREAL AND TIME DISTRIBUTION OF RUNOFF SUPPLY ON WATERSHED HYDROGRAPHS ...Hydrographs, Mathematical Analysis, Model Studies, Other Model Modif, Runoff, ...**2.0666**

SEDIMENTATION AND CONTAMINANT CRITERIA FOR WATER RESOURCES PLANNING AND MANAGEMENT ...Dispersion -water, Management, Planning, Pollutants - Path of , Sediment Yield, Sedimentology-general, ...**4.0066**

THE DETERMINATION OF ZONES OF INTENSE CONTRIBUTION TO STREAM FLOW AS RELATED TO THE CONCEPT OF PARTIAL AREA CONTRIBUTIONS ...Development of Models, Digital Computers, Model Studies, Runoff, Synthetic Hydrology-general, ...**2.0580**

DEVELOPMENT AND EVALUATION OF HYDROLOGIC SIMULATION MODELS ...Model Studies, Runoff, South Carolina, Synthetic Hydrology-general, Technique Development, ...**2.0954**

WATER RESOURCES IN SOURDOUGH AND MIDDLE CREEK WATERSHEDS - A COMPARATIVE STUDY OF QUALITY AND HYDROLOGY ...Conservation-general, Hydrology-general, Land Use, Montana, Water Quality Control-general, ...**5.0695**

RUNOFF GENERATION AS A FUNCTION OF PRECIPITATION AND WATERSHED CHARACTERISTICS ...Amount, Hydrographs, Runoff, Washington, ...**2.1120**

PARTIAL AREA CONTRIBUTION TO STREAM FLOW ...Digital Computers, Flow Characteristics -water, Model Studies, Runoff, Water Yield, ...**2.0581**

COMMUNITY INVOLVEMENT OF PARTICIPANTS IN WATERSHED PLANNING ...Citizen's Participation, Mississippi, Planning, Social Aspects, Water Resources Development, ...**6.0318**

MICROBIOLOGICAL STUDIES IN AN OPEN AND A CLOSED WATERSHED ...Bacterial Pollutant Sources, Coliforms (non-specific), Montana, Recreation Sites, Streptococcus Fecalis, ...**5.0696**

ECOLOGICAL STUDIES OF THE SURFACE WATERS OF THE WHITEWATER CREEK WATERSHED, WALWORTH, ROCK, AND JEFFERSON COUNTIES, WISCONSIN ...Bioindicators, Range Or Territorial Distr. , Water Quality-general, Wisconsin, ...**5.1323**

LIMNOLOGICAL EFFECTS OF ORGANIC WATERSHED LITTER ...Flash Floods, Forest Debris, Lakes, Southwest, ...**5.0048**

MASSACHUSETTS PESTICIDE MONITORING STUDY ...Massachusetts, Monitoring Systems, Pesticides -non-specific, Sampling, ...**5.0539**

A DEMONSTRATION OF JOINT-MUNICIPAL-INDUSTRIAL WASTE TREATMENT IN THE ONONDAGA LAKE WATERSHED ...Chemical Treatment, Combined Sewer, Industrial-general, Local Government, Waste Water Treatment-general, ...**5.0792**

PHYSICAL AND ECONOMIC ANALYSIS OF WATERSHEDS AS RELATED TO SOIL AND WATER CONSERVATION ...Benefit-cost Analysis, Conservation-general, Land, Land Use, Linear & Non-linear Program, ...**6.0222**

INFILTRATION CAPACITIES UNDER VARIOUS VEGETATION TYPES AS INFLUENCED BY WATERSHED MANAGEMENT PRACTICES ...Cover Crops, Environment, Infiltration, Management, Water Yield, ...4.0013

MATHEMATICAL SIMULATION OF HYDROLOGIC EVENTS ON UNGAGED WATERSHEDS ...Hydrographs, Hydrology-general, Mathematical Analysis, Model Studies, Research - Development, Runoff, ...2.0462

HYDROLOGIC BEHAVIOR OF SELECTED WATERSHEDS IN THE NORTHERN APPALACHIAN REGION ...Clouds-precipitation, Forecasting-prediction, Mathematical Analysis, Model Studies, Runoff, Valley and Ridge Province, ...2.0922

SEDIMENT YIELD IN RELATION TO CLIMATIC AND WATERSHED CHARACTERISTICS IN THE EDWARDS PLATEAU ...Floods, Reservoirs and Impoundments, Runoff, Sediment Yield, Texas, ...2.1020

THE ROLE OF VEGETATION AND SOIL IN WATERSHED YIELD ...Cover Crops, Dendroclimatology, Soil Properties - General, Soil-water-plant Relationships, Water Balance-budget, Water Yield, ...4.0256

VEGETATION MANIPULATION EFFECTS ON RUNOFF - SYCAMORE CREEK, ARIZ ...Conservation-general, Cover Crops, Runoff, Sediment Yield, Water Yield, ...3.0008

HYDROLOGIC BEHAVIOR OF SELECTED WATERSHEDS IN THE NORTHERN APPALACHIAN REGION ...Appalachian Highlands-other, Clouds-precipitation, Flow Characteristics - water, Model Studies, Modification, ...2.0184

WATERSHED REHABILITATION TO CONTROL EROSION AND SEDIMENTATION IN THE SOUTHWEST ...Erosion-general, General Deposition, Sediment Yield, Stabilization-general, ...4.0175

WATER YIELD IMPROVEMENT FROM SOIL TREATMENTS AND PLANT-COVER ALTERATIONS (ABBREV) ...Cover Crops, Precipitation -non-specific, Soil Management -other, Soil-water-plant Relationships, Water Yield, ...4.0249

A THEORETICAL STUDY OF INFILTRATION INTO RANGE AND FOREST SOILS ...Amount, Infiltration, Runoff, ...2.1066

STORM RUNOFF AND FLOOD FLOWS IN RELATION TO CLIMATIC AND WATERSHED CHARACTERISTICS ...Channels, Hydrographs, Water Yield, ...4.0206

RUNOFF AND SEDIMENT MOVEMENT ON UNIT SOURCE WATERSHEDS OF THE PACIFIC INFLUENCED BY CLIMATE, SOILS, VEGETATION AND TOPOGRAPHY ...Idaho, Physiography-general, Runoff, Sediment Yield, Water Yield, ...2.0387

WATER ACCUMULATION, FLOOD-WAVE MOVEMENT AND WATER YIELD FROM COMPLEX WATERSHEDS OF THE PACIFIC NORTHWEST ...Channels, Floods, Forecasting-prediction, Hydrographs, Idaho, Peak Flow, Storage of Water, Water Yield, ...3.0202

PRECIPITATION PATTERNS ON UPSTREAM WATERSHEDS IN CENTRAL AND SOUTHERN CALIFORNIA ...California, Climatography, Patterns, Runoff, Sediment Yield, ...2.0103

Watersheds-other

COMPUTER SIMULATION OF THE HYDROLOGIC SYSTEM OF A MOUNTAIN WATERSHED ...Digital Computers, Groundwater, Hydrology-general, Model Studies, Mountains-alpine, Surface Water, ...2.0707

COMPUTER SIMULATION OF URBAN HYDROLOGIC SYSTEMS ...Analog Computers, Hydrographs, Runoff, Texas, Urban Environments, ...4.0258

INCREASING CHAPARRAL WATERSHED YIELD THROUGH IMPROVED USE OF PHENOXY-TYPE HERBICIDES ...Environmental Effects, Herbicides -non-specific, Moisture Tension, Temperature, Translocation, Water Yield, ...3.0089

STUDIES OF SOCKEYE SALMON, ONCORHYNCHUS NERKA, IN THE KVICHAK RIVER SYSTEM, ALASKA ...Alaska, Commercial Fishing, Productivity - Food Chain, Salmon -coho,chinook,sockeye.., ...6.0627

DEVELOPMENT OF A MODEL RESOURCE ANALYSIS FOR RANGE WATERSHEDS ...Mapping, Model Studies, Quality and Utilization, Species and Species Evaluation, ...6.0460

GLACIOLOGICAL RESEARCH ...Advance, Regimen, Runoff, Thickness - Area, ...2.1136

Waves

LAKE ERIE DIKE ...Dike, Disposal-other, Lake Erie, Models, Wave Action, ...8.0219

WAVE FORCES ON SUBMERGED STRUCTURES ...Drag, Hydraulic Structures, Lift, Shoreline Structures, Wave Action, ...2.0629

EXPERIMENTAL STUDIES OF AIR AND WATER INTERFACIAL INTERACTION ...Pollutants - Path of , Turbulence-general, Wind Tunnels, Wind-water Interaction, ...2.0246

GREAT LAKES RESEARCH - LAKE WAVES ...Great Lakes-general, ...2.0641

CORRELATION OF BEACH PROPERTIES AND INCIDENT WAVES ...Beach, Development, Engineering Structures-general, ...2.0260

HYDRAULICS AND DYNAMICS OF ESTUARIES ...Erosion-general, Estuaries, Flow Characteristics -water, Sedimentology-general, Water Level Fluctuation, ...2.0261

DESIGN OF RUBBLE WAVE ABSORBERS ...Breakwaters, Energy Dissipators, Wave Action, ...7.0066

NUMERICAL SIMULATION OF HYDRODYNAMIC PHENOMENA BY DIGITAL COMPUTER ...Groundwater, Model Studies, Open Channel Flow, Porous Media - Flow Through, Subsurface Flow, ...2.1096

A STUDY OF NATURAL EVAPORATION FROM FREE WATER SURFACES ...Boundary Layer Studies, Evaporation, Oklahoma, Patterns, Water Loss Control, ...3.0129

MECHANICS OF SEDIMENT ENTRAINMENT, TRANSPORTATION AND DEPOSITION IN CHANNELS OF THE SOUTHERN BRANCH AND AT THE USDA SEDIMENTATION LABORATO ...Channels, Flume Studies, Sediment Transport-general, Sedimentation, Velocity -water, ...2.0677

FLOOD WAVE MOVEMENT IN NATURAL EPHEMERAL STREAM CHANNELS ...Channels, Ephemeral, Floods, Runoff, Thunderstorms, ...4.0008

Wax, Paraffin

MECHANISM OF FROST HEAVING ...Frost Heaving, Hydrated Acid and Norm, Liquid - Solid Interactions, Particle Surface, Permafrost-frozen, Silicones, ...2.0802

Weather - Physical Properties

Electricity

Charge on Droplets

EFFECT OF CHARGE UPON COLLISIONS IN WASHOUT ...Charged Particles, Collision Effects, Droplet Formation, Dust - Particulate Matter, Washout, ...2.0155

SCAVENGING STUDY OF SNOW AND ICE CRYSTALS ...Nucleation Physics, Structure, Structure-size, Washout, ...2.0406

Field Properties

ELECTRIC FIELDS IN THE CONDENSATION AND COALESCENCE OF WATER ...Formation, Ionization, Laboratory Analysis, Nucleation Physics, ...3.0299

Energy-radiation

Energy-general

COMBINED INFLUENCE OF ATMOSPHERIC DESICCATION AND SOIL WATER POTENTIAL ON THE IRRIGATION NEED AND WATER POTENTIAL OF PLANTS ...Evapotranspiration, Irrigation-general, Moisture Tension, Osmotic and Turgor Pressure, ...2.1078

RESEARCH ON THE METEROGENEITY OF CLOUD STRUCTURE ...Cloud Physics, Cloud Structure, Convection, In-cloud, ...2.1017

SNOW ACCUMULATION AND MELT ON STUDY AREAS ...Idaho, Mountains-alpine, Patterns, Photogrammetry, Snowmelt, ...2.0388

FACTORS GOVERNING EVAPOTRANSPIRATION OF WATER IN COASTAL REGIONS ...Climate, Evapotranspiration, Lysimeters, Moisture Tension, Soil Environment, ...8.0012

Heat Budget

DETERMINATION OF EVAPOTRANSPIRATION FOR SHORT INTERVALS ON A BENCHMARK BASIN ...Evapotranspiration, Israel, Karst Topography, Moisture Content, Water Balance-budget, ...2.0493

MICROMETEOROLOGICAL INVESTIGATIONS OF THE ENERGY BUDGET - EFFECT OF SUMMER WINDS ...Evapotranspiration, Heat Flow, Micrometeorology, Semi - Arid, Wind-general, ...2.0516

DAILY HEAT BUDGETS IN ENVIRONMENTAL FLUIDS ...Heat Flow, Illinois, Ohio, Temperature Or Heat Budgets, ...**2.0405**

GREAT LAKES RESEARCH - LAKE EVAPORATION ...Evaporation, Great Lakes-general, Humidity, Precipitation-general, Velocity, ...**2.0637**

EVAPORATION FROM LAKES AND RESERVOIRS ...Evaporation, Evapotranspiration, Lakes, Reservoirs and Impoundments, Water Balance-budget, ...**2.0187**

RADIO METHODS FOR DETERMINING WATER VAPOR CONTENT OF AIR ...Evaporation, Humidity, Humidity Instruments, Oklahoma, Reservoirs and Impoundments, Transmission Characteristics, Velocity, Water Loss Control, ...**3.0114**

FLOOD RUNOFF & WATER YIELD FROM GLACIATED MOUNTAINS ...Floods, Forest Watersheds, Glacial Environment, Runoff, Water Balance-budget, Water Yield, ...**3.0372**

QUANTITY, QUALITY, AND TIMING OF WATER YIELDS IN THE SOUTHERN APPALACHIANS-PIEDMONT ...Appalachia, Evapotranspiration, Forest Watersheds, Piedmont Province, Water Yield, ...**3.0374**

Heat Exchange

EVAPORATION OF WATER AS RELATED TO WIND BARRIERS ...Evaporation, Modified Water Use, Moisture Tension, Water Loss Control, Wind-general, ...**3.0138**

AN ATMOSPHERIC ENERGY BUDGET STUDY ...Great Basin, Storms-general, Water Balance-budget, ...**2.0738**

A THREE-DIMENSIONAL APPROACH TO THE EXCHANGE OF HEAT AND WATER VAPOR BETWEEN A LARGE WATER BODY AND THE ATMOSPHERE ...Boundary Layer Studies, Diffusion, Electric Power Plants, Evaporation, ...**2.0793**

TECHNIQUES OF MODELING THERMAL STRATIFICATION IN LAKES ...Evaporation, Lakes, Stratification, Temperature, ...**2.0617**

NUMERICAL MODELING OF GENERAL CIRCULATION OF EARTHS ATMOSPHERE ...Air Motion-general, Computers-general, Humidity, Latent Heats, Weather Modification-general, ...**7.0014**

COOPERATIVE EVAPOTRANSPIRATION RESEARCH ...Climate, Deserts, Evapotranspiration, Radiation-general, ...**2.0136**

GENERAL CIRCULATION - NUMERICAL MODELING OF PRECIPITATION ...Air Motion-general, Forecasting, Humidity, Model Studies, Weather Modification-general, ...**2.0265**

BASIC INVESTIGATION OF HEAT AND MOISTURE TRANSFER ACROSS THE AIR-WATER INTERFACE ...Boundary Layer Studies, Evaporation, Interface, Water Balance-budget, Water Loss Control, ...**3.0124**

CLIMATIC INFLUENCE ON WATER USE AND CROP PERFORMANCE IN THE CORN BELT REGION ...Climate, Corn Belt, Energy Budgets, Evapotranspiration, Humidity, Soil-water-plant Relationships, ...**2.0439**

THE ENERGY BUDGET AT THE EARTHS SURFACE ...Energy Budgets, Humidity, Moisture Content, Transpiration and Evap, Water Balance-budget, Wind Tunnels, ...**2.0808**

Latent Heats

NUMERICAL MODELING OF GENERAL CIRCULATION OF EARTHS ATMOSPHERE ...Air Motion-general, Computers-general, Heat Exchange, Humidity, Weather Modification-general, ...**7.0014**

CLOUD AND PRECIPITATION FORECAST MODEL ...Cloud Cover, Condensation-general, Forecasting, Model Studies, Weather Forecasting, ...**2.0267**

Radiation-general

ENERGY SOURCES FOR EVAPOTRANSPIRATION IN THE PLAINS REGION ...Antitranspirants, Evapotranspiration, Lysimeters, Nebraska, Water Loss Control, ...**2.0721**

WATER TRANSFER FROM SOIL TO THE ATMOSPHERE AS RELATED TO CLIMATE AND SOIL PROPERTIES ...Evaporation, Humidity, Moisture Content, Physical Climatology, Water Balance-budget, Water Transfer, ...**2.1046**

HETEROGENEOUS NUCLEATION OF ICE ...Growth and Preparation, Nucleation Physics, Photolysis, Temperature, ...**2.0785**

COOPERATIVE EVAPOTRANSPIRATION RESEARCH ...Climate, Deserts, Evapotranspiration, Heat Exchange, ...**2.0136**

EVAPORATION ...Atmosphere Radiation, Evaporation, Forecasting-prediction, Lakes, Water Yield, ...**2.0603**

USE OF WATER ON FEDERAL IRRIGATION PROJECTS ...Consumptive Use, Engineering Structures-general, Irrigation Engineering, Irrigation-general, Systems Analysis, ...**6.0094**

WATER YIELD IMPROVEMENT IN THE SNOWPACK TIMBER ZONE, RUNOFF FROM RANGELANDS ...Erosion-general, Gully Or Channel Erosion, Mountains-alpine, Snowmelt, Water Yield, ...**3.0143**

EFFECTS OF DIFFERENT FOREST TYPES AND CONDITIONS ON STREAM REGIMEN AND WATER YIELDS ...Climatic Effects, Environment, Flow Characteristics -water, Forest Watersheds, Land Use, Water Yield, ...**5.0794**

IMPROVEMENT OF WATER YIELDS BY MODIFICATION OF RADIANT ENERGY OVER LAND SURFACES (ABBREV) ...Energy Budgets, Evapotranspiration, Interception, Snowmelt, Water Yield, ...**2.0235**

Radiation-terrestrial

STUDY OF THE ENERGY BUDGET ON THE HAWAIIAN ISLANDS ...Evapotranspiration, Hawaii, Radiation Emission, Reflectance, ...**2.0370**

GREAT LAKES RESEARCH - ICE CHARACTERISTICS ...Aerial, Lake Superior, Micrometeorology, Origin, Petrofabrics, Sea Ice, ...**2.0644**

Sunshine

SOLAR HEATING OF WATER TO VERY HIGH TEMPERATURES ...Conductivity, Desalination, Mathematical Analysis, Medium Temperature - 300-1000k, Water, ...**3.0331**

PHOTOLYSIS MECHANISMS FOR POLLUTION ABATEMENT ...Chemical Treatment, Organics, Oxidants, Photolysis, Pollution Abatement, ...**5.0335**

CLIMATE RELATED TO PLANT RESPONSE IN THE MATANUSKA VALLEY ...Alaska, Direction, Evaporation, General Synoptic Observations, Transpiration and Evap, Velocity, ...**2.0029**

CLIMATOLOGICAL MEASUREMENTS RELATED TO AGRICULTURE ...Amount, Fog-haze-mist, Land Use, Physical Climatology, Temperature, Water Utilization -general, ...**2.0741**

SOLAR REFLECTANCE OF MONOLAYER-COVERED WATER SURFACES AS RELATED TO EVAPORATION SUPPRESSION ...Antitranspirants, Dyes and Coloring, Evaporation, Monolayers, Polymer-other, ...**3.0110**

Temperature

ICE FORMATION BY CONTACT NUCLEATION ...Formation, Growth and Preparation, Model Studies, Nucleation, Nucleation Physics, ...**3.0339**

CLIMATIC PATTERNS AND THEIR EFFECT ON CALIFORNIA AGRICULTURE ...Agriculture, Applied Climatology, California, Data Analysis - General, Phenology, Production & Processing, Weather, ...**2.0095**

CLIMATE AND PHENOLOGICAL PATTERNS FOR AGRICULTURE IN THE WESTERN REGION ...Nevada, Patterns, ...**2.0730**

ROLE OF LIGHT QUALITY, ETC, ON TRANSPIRATION OF WATER LOSSES BY PLANTS ...Humidity, Low Temp. - But Above 32f, Transpiration, ...**2.1038**

STATISTICAL ANALYSES OF THE VARIATIONS OF PRECIPITATION-TEMPERATURE AND EVAPORATION IN TEXAS ...Data Analysis Applications, Evaporation, Patterns, Texas, ...**2.1027**

DEVELOPMENT OF IMPROVED SNOW SURVEYING AND STREAM-FLOW FORECASTING TECHNIQUES ...Amount, Antecedent Moisture, Flow Characteristics -water, Forecasting-prediction, Moisture Content, ...**2.1072**

CALCULATION OF TEMPERATURE AND PRECIPITATION VALUES ...Air Temperature -non-specific, Distributions, Forecasting, Patterns, Utah, ...**2.1058**

HETEROGENEOUS NUCLEATION OF ICE ...Growth and Preparation, Nucleation Physics, Photolysis, Radiation-general, ...**2.0785**

AN EVALUATION OF THE SUGAR-INVERSION METHOD OF MEASURING MEAN TEMPERATURE IN A CLIMATOLOGICAL NETWORK ...Aldose and Ketose, Inversion, Microclimate-general, Physical Climatology, ...**2.0925**

SOIL-MOISTURE-PLANT RELATIONS OF AVOCADO TREES ...Irrigation-general, Lauraceae - Sassafras... , Moisture Content, Soil-water-plant Relationships, Trees, ...**2.0148**

CLIMATOLOGICAL MEASUREMENTS RELATED TO AGRICULTURE ...Amount, Fog-haze-mist, Land Use, Physical Climatology, Sunshine, Water Utilization -general, ...**2.0741**

SUBSYNOPTIC WEATHER SPECIFICATION ...Cloud Cover, Data Analysis Applications, Dew, Micrometeorology, Model Studies, Weather Forecasting, ...**2.0592**

REMOTE SENSING OF WATER VAPOR ...Electronics - Applied, Humidity, Optics, Radio, Turbulence-general, ...**7.0015**

Thermodynamics

NUMERICAL SIMULATION OF THE MACROPHYSICAL AND MICROPHYSICAL PROCESSES OF MOIST CONVECTION ...Cloud Formation and Evolution, Clouds-precipitation, Convection, Formation, Model Studies, ...**2.0239**

General Synoptic Observations

CONTINUATION OF GLACIOLOGICAL INVESTIGATIONS ON THE CASEMENT GLACIER, ALASKA ...Alaska, Floor Properties, Rate, Rheology - Flowage, ...**2.0858**

RESEARCH AND BASIC DATA ON THERMAL POLLUTION ...Diffusion, Dissipation, Eddies, Mixed Modes, Streams, Thermal Pollution, ...**4.0058**

DOCTORAL DISSERTATION RESEARCH IN GEOGRAPHY ...Data Analysis - General, Geography-physical, Humidity, Ohio River, Water Balance-budget, ...**3.0392**

FACTORS AFFECTING WATER YIELD FROM SMALL WATERSHEDS IN TENNESSEE ...Correlation, Cover Crops, Small Watersheds, Tennessee, Water Yield, ...**4.0224**

CLIMATE OF THE NORTHEAST - ANALYSES & RELATIONSHIP TO PLANT RESPONSE (NE-35 ...Aerial, Beans (garden), Climate-general, Delaware, Envir. responses (non-specific, ...**2.0251**

ESTIMATING SOIL MOISTURE FROM METEOROLOGICAL MEASUREMENTS ...Cover Crops, Evapotranspiration, Indiana, Moisture-other, Soil Types, ...**2.0474**

WEATHER INFORMATION FOR AGRICULTURE ...Applied Climatology, Iowa, Moisture Content, Oats, Soil Environment, ...**2.0484**

RUNOFF OF SMALL WATERSHEDS ...Agricultural Watersheds, Gaging, Moisture Retention, Runoff, Soil Types-general, ...**2.0531**

WEATHER INFORMATION FOR AGRICULTURE ...Climate-general, Data Analysis - General, Evapotranspiration, Soil Physical Properties, ...**4.0190**

HYDROLOGY OF PIEDMONT AGRICULTURAL WATERSHEDS ...Agricultural Watersheds, Cover Crops, Groundwater, Management, Piedmont Province, Soil-water-plant Relationships, Water Yield, ...**2.0958**

CLIMATE RELATED TO PLANT RESPONSE IN THE MATANUSKA VALLEY ...Alaska, Direction, Evaporation, Sunshine, Transpiration and Evap, Velocity, ...**2.0029**

PROCEDURES FOR ESTIMATING CROP WATER REQUIREMENTS FOR USE IN WATER ALLOCATIONS AND FOR IMPROVEMENT OF IRRIGATION EFFICIENCY ...Evapotranspiration, Irrigation-general, Lysimeters, Requirements for Water, Water Allocation, ...**3.0047**

LAKE EFFECT SNOW SITUATIONS, EASTERN LAKE ONTARIO AREA ...Atmospheric Pressure, Data Acquisition, Lake Ontario, Topographic Influences, ...**7.0084**

OPTIMUM ESCAPEMENT STUDIES OF CHIGNIK SOCKEYE SALMON ...Alaska, Aquatic Ecology, Lakes, Salmon -coho,chinook,sockeye.., Water Properties-general, ...**6.0623**

RADIOACTIVITY IN RAINFALL ...Illinois, Radioactivity, Rain-general, ...**2.0415**

RAINFALL EVALUATION STUDIES ...Data Analysis Applications, Gages, Modification, Patterns, Storms-general, ...**2.0416**

WEATHER RECORDS ...Moisture Content, Temperature, ...**2.0942**

NATIONWIDE PRECIPITATION - NMC FORECAST TECHNIQUES ...Clouds-general, Computers-general, Forecasting, Forecasting-prediction, Regression Analysis, ...**2.0589**

AUTOMATIC VHF RADIO HYDROLOGIC DATA REPORTING SYSTEM ...Automatic Data Aquisition, Data Transmission Systems, Hydrology-general, Radio, Very High Frequency, ...**7.0096**

HYDROLOGIC STUDY OF A SMALL ALASKAN WATERSHED ...Alaska, General, Hydrology-general, Small Watersheds, Water Sampling, ...**2.0749**

Humidity

DOCTORAL DISSERTATION RESEARCH IN GEOGRAPHY ...Data Analysis - General, General Synoptic Observations, Geography-physical, Ohio River, Water Balance-budget, ...**3.0392**

WATER TRANSFER FROM SOIL TO THE ATMOSPHERE AS RELATED TO CLIMATE AND SOIL PROPERTIES ...Evaporation, Moisture Content, Physical Climatology, Radiation-general, Water Balance-budget, Water Transfer, ...**2.1046**

ROLE OF LIGHT QUALITY, ETC. ON TRANSPIRATION OF WATER LOSSES BY PLANTS ...Low Temp. - But Above 32f, Temperature, Transpiration, ...**2.1038**

NUMERICAL MODELING OF GENERAL CIRCULATION OF EARTHS ATMOSPHERE ...Air Motion-general, Computers-general, Heat Exchange, Latent Heats, Weather Modification-general, ...**7.0014**

GENERAL CIRCULATION - NUMERICAL MODELING OF PRECIPITATION ...Air Motion-general, Forecasting, Heat Exchange, Model Studies, Weather Modification-general, ...**2.0265**

REMOTE SENSING OF WATER VAPOR ...Electronics - Applied, Optics, Radio, Temperature, Turbulence-general, ...**7.0015**

GREAT LAKES RESEARCH - LAKE EVAPORATION ...Evaporation, Great Lakes-general, Heat Budget, Precipitation-general, Velocity, ...**2.0637**

RADIO METHODS FOR DETERMINING WATER VAPOR CONTENT OF AIR ...Evaporation, Heat Budget, Humidity Instruments, Oklahoma, Reservoirs and Impoundments, Transmission Characteristics, Velocity, Water Loss Control, ...**3.0114**

DEVELOPMENT OF ATMOSPHERIC LASER RADAR ...Amplifiers, Lasers, Lasers and Masers, Radar, Ruby, ...**2.0194**

CLIMATIC INFLUENCE ON WATER USE AND CROP PERFORMANCE IN THE CORN BELT REGION ...Climate, Corn Belt, Energy Budgets, Evapotranspiration, Heat Exchange, Soil-water-plant Relationships, ...**2.0439**

THE ENERGY BUDGET AT THE EARTHS SURFACE ...Energy Budgets, Heat Exchange, Moisture Content, Transpiration and Evap, Water Balance-budget, Wind Tunnels, ...**2.0808**

Optics

REMOTE SENSING OF WATER VAPOR ...Electronics - Applied, Humidity, Radio, Temperature, Turbulence-general, ...**7.0015**

Pressure-density

TROPICAL STORM RAINFALL AND HURRICANE WIND FIELDS ...Forecasting, Gulf of Mexico, Tropical Cyclones, Velocity, ...**2.0595**

METEOROLOGICAL ANALYSIS OF PRECIPITATION EFFECTS OF SWISS HAIL SUPPRESSION EXPERIMENTS ...Clouds-precipitation, Modification, Patterns, Weather Charts-maps, ...**2.0108**

EFFECT OF EXTERNAL AIR PRESSURE ON LIQUID FLOW THROUGH A POROUS MEDIUM ...Canals, Model Studies, Permeability, Physical Properties -other, Seepage, ...**2.0392**

GREAT LAKES RESEARCH - HARBOR CURRENTS ...Currents - water, Great Lakes-general, Harbors, Model Studies, Water Level Fluctuation, Wind-general, ...**2.0642**

Weather Modification

Clouds-precipitation

RAIN SCAVENGING STUDIES - DATA ANALYSIS, SYNTHESIS AND INTERPRETATION ...Dust - Particulate Matter, Precipitation-general, Storms-general, Tracers, Washout, ...**7.0057**

ROCKY MOUNTAIN OROGRAPHIC CLOUD PRECIPITATION AND MODIFICATION ...Cloud Structure, Colorado, Formation, Patterns, Topographic Influences, ...**3.0140**

A STUDY OF THE HYDROLOGIC EFFECTS OF RAINFALL AUGMENTATION ...Amount, Augmentation-general, Digital Computers, Model Studies, Watersheds-general, ...**3.0076**

NUMERICAL SIMULATION OF THE MACROPHYSICAL AND MICROPHYSICAL PROCESSES OF MOIST CONVECTION ...Cloud Formation and Evolution, Convection, Formation, Model Studies, Thermodynamics, ...**2.0239**

METEOROLOGICAL ANALYSIS OF PRECIPITATION EFFECTS OF SWISS HAIL SUPPRESSION EXPERIMENTS ...Modification, Patterns, Pressure-density, Weather Charts-maps, ...**2.0108**

UTAH ATMOSPHERIC WATER RESOURCES (THE WASATCH WEATHER MODIFICATION PROJECT) ...Automatic Stations, Data Networks, Gages, Patterns, Utah, ...**2.1074**

WATER UTILIZATION ASPECTS OF WEATHER MODIFICATION AS APPLIED TO KANSAS ...Amount, Development of Models, Kansas, Model Studies, Water Harvesting, ...**2.0505**

WEATHER MODIFICATION IN NORTH DAKOTA ...Amount, Hail, Modification, North Dakota, Weather, ...**2.0831**

HYDROLOGIC BEHAVIOR OF SELECTED WATERSHEDS IN THE NORTHERN APPALACHIAN REGION ...Forecasting-prediction, Mathematical Analysis, Model Studies, Runoff, Valley and Ridge Province, Watersheds-general, ...**2.0922**

CASCADES ATMOSPHERIC WATER RESOURCES PROGRAM ...Augmentation-general, Cascade Mountains, Data Analysis - General, Formation, Washington, ...**2.1128**

SCALE OF PRECIPITATION ...Amount, Modification, Precipitation Instruments, ...2.0605

ATMOSPHERIC WATER RESOURCES PROGRAM ...Augmentation-general, Modification, Reservoirs and Impoundments, Technique Development, Water Quantity-general, ...2.0163

ATMOSPHERIC WATER RESOURCES RESEARCH IN THE STATE OF NEW MEXICO ...Clouds-general, New Mexico, Precipitation Instruments, Rio Grande, Storms-general, ...2.0175

PARK RANGE ATMOSPHERIC WATER RESOURCES PROGRAM ...Colorado, Nucleation Physics, Orographic Effects, Patterns, Technique Development, ...2.0164

LARGE SCALE DYNAMIC EFFECTS OF CLOUD SEEDING ...Patterns, Statistics-general, ...2.0171

A TEST OF CERTAIN EVALUATION DESIGNS FOR CLOUD-SEEDING EXPERIMENTS ...Forecasting, Mathematical Analysis, Model Studies, Oklahoma, Weather Charts-maps, ...2.0180

ARIZONA WEATHER MODIFICATION ENGINEERING RESEARCH, ATMOSPHERIC WATER RESOURCES ...Arizona, Cloud Formation and Evolution, Nucleation Physics, Other, Storms-general, ...2.0186

EFFECT OF THE WARM CLOUD BASE UPON CLOUDSEEDING FROM THE GROUND ...Iodine, Nucleation, Nucleation Physics, Silver, Vapor, ...2.0156

CONVECTIVE CLOUD SYSTEMS, NORTHERN GREAT PLAINS, ATMOSPHERIC WATER RESOURCES ...Cloud Structure, Convection, Cumulus, Great Plains Province, Model Studies, ...2.0193

STATE OF WASHINGTON DEPARTMENT OF WATER RESOURCES CASCADE ATMOSPHERIC WATER RESOURCES PROGRAM ...Augmentation-general, Cascade - Sierra Mountains, Nucleation Physics, Patterns, Washington, ...2.0195

SKYWATER ...Amount, Fronts, Montana, Storms-general, Topographic Influences, ...2.0200

ATMOSPHERIC WATER RESOURCES RESEARCH ...Augmentation-general, California, Modification, Technique Development, ...2.0206

LEGAL IMPLICATIONS OF WEATHER MODIFICATION ...Fog-mist Dissipation, Legal Review, Legal Studies-general, Weather Modification-general, ...2.0169

EVALUATION OF PRECIPITATION MANAGEMENT PROGRAMS BY PRECIPITATION RATE MEASUREMENTS ...Modification, Planning-support, ...2.0199

FEASIBILITY OF USING ATMOSPHERIC WATER RESOURCES IN THE NORTHEASTERN UNITED STATES ...Applied Climatology, Benefit-cost Analysis, Connecticut River, River Basins, Water Resources Development, ...2.0161

INVESTIGATION OF THE FEASIBILITY OF WARM-CLOUD MANAGEMENT ...Cloud Temperature, Model Studies, Modification, Other, ...2.0165

HYDROLOGIC BEHAVIOR OF SELECTED WATERSHEDS IN THE NORTHERN APPALACHIAN REGION ...Appalachian Highlands-other, Flow Characteristics -water, Model Studies, Modification, Watersheds-general, ...2.0184

Fog-mist Dissipation

LEGAL IMPLICATIONS OF WEATHER MODIFICATION ...Clouds-precipitation, Legal Review, Legal Studies-general, Weather Modification-general, ...2.0169

Nucleation Physics

SCAVENGING STUDY OF SNOW AND ICE CRYSTALS ...Charge on Droplets, Structure, Structure-size, Washout, ...2.0406

ICE FORMATION BY CONTACT NUCLEATION ...Formation, Growth and Preparation, Model Studies, Nucleation, Temperature, ...3.0339

ELECTRIC FIELDS IN THE CONDENSATION AND COALESCENCE OF WATER ...Field Properties, Formation, Ionization, Laboratory Analysis, ...3.0299

HETEROGENEOUS NUCLEATION OF ICE ...Growth and Preparation, Photolysis, Radiation-general, Temperature, ...2.0785

PRECIPITATION SCAVENGING ...Dispersion - Transporation, Nuclear Explosions - Fallout, Rain-other, Snow-other, Washout, ...5.1252

PARK RANGE ATMOSPHERIC WATER RESOURCES PROGRAM ...Clouds-precipitation, Colorado, Orographic Effects, Patterns, Technique Development, ...2.0164

ARIZONA WEATHER MODIFICATION ENGINEERING RESEARCH, ATMOSPHERIC WATER RESOURCES ...Arizona, Cloud Formation and Evolution, Clouds-precipitation, Other, Storms-general, ...2.0186

EFFECT OF THE WARM CLOUD BASE UPON CLOUDSEEDING FROM THE GROUND ...Clouds-precipitation, Iodine, Nucleation, Silver, Vapor, ...2.0156

STATE OF WASHINGTON DEPARTMENT OF WATER RESOURCES CASCADE ATMOSPHERIC WATER RESOURCES PROGRAM ...Augmentation-general, Cascade - Sierra Mountains, Clouds-precipitation, Patterns, Washington, ...2.0195

ENGINEERING DEVELOPMENT OF ICE NUCLEI DISPERSION SYSTEMS ...Flow of Dispersed Solids, Technique Development, ...2.0197

ATMOSPHERIC WATER RESOURCES RESEARCH UNIVERSITY OF WYOMING ...Cloud Formation and Evolution, Cloud Physics, Orographic Effects, Snowpack, Wyoming, ...2.0162

PRODUCTION AND DETECTION OF ARTIFICIAL ICE NUCLEI ...Cloud Physics, Formation, Model Studies, Modification, Precipitation Instruments, ...2.0173

RESEARCH IN ATMOSPHERIC SCIENCES AS RELATED TO INCREASING WATER SUPPLY ...Modification, Montana, Snowmelt, Topographic Influences, ...2.0904

Weather Modification-general

RAINFALL EVALUATION STUDIES ...Data Analysis - General, Gages, Modification, Patterns, Sampling-general, ...3.0219

WATER RESOURCE OPERATIONS STUDY ...Conjunctive Use, Operations Research, Planning, Water Cycle, Wyoming, ...6.0652

COMPUTER SIMULATION OF EFFECTS OF LAND MANAGEMENT AND WEATHER MODIFICATION ON WATERSHED ECOSYSTEMS ...Land Use, Multivariate Analysis, Plant Ecosystems(non-specific), Simulation Theory, Water Yield, ...6.0297

NUMERICAL MODELING OF GENERAL CIRCULATION OF EARTHS ATMOSPHERE ...Air Motion-general, Computers-general, Heat Exchange, Humidity, Latent Heats, ...7.0014

DENSE RAINGAGE NETWORK PROJECTS ...Climatography, Data Networks, Gages, Modification, Storms-general, ...2.0424

GENERAL CIRCULATION - NUMERICAL MODELING OF PRECIPITATION ...Air Motion-general, Forecasting, Heat Exchange, Humidity, Model Studies, ...2.0265

MISCELLANEOUS FIELD RESEARCH IN CLIMATOLOGY ...Amount, Physical Climatology, Precipitation-general, Water Resources Development, Water Yield, ...2.0606

SKYWATER--PARK RANGE FOREST HYDROLOGY ...Colorado, Forest Watersheds, Model Studies, Mountains-alpine, Topographic Influences, ...2.0172

MATHEMATICAL METHODS OF EVALUATION OF RESULTS OF ATMOSPHERIC WATER RESOURCES PROGRAMS ...Error Analysis, Intermontane Plateaus-other, Mountains-alpine, Physiography-general, Reliability Theory, ...2.0189

EXPERIMENTAL DESIGN & STATISTICAL EVALUATION OF WEATHER MODIFICATION EXPERIMENTS ...Computers-general, Data Analysis - General, Data Analysis Applications, Statistics-general, Technique Development, ...2.0198

LEGAL IMPLICATIONS OF WEATHER MODIFICATION ...Clouds-precipitation, Fog-mist Dissipation, Legal Review, Legal Studies-general, ...2.0169

ECOLOGICAL EFFECTS OF WEATHER MODIFICATION ...Climate-general, Management, Modification, Water Properties-general, ...2.0168

Weather Modification-other

A COHERENT-AREA STUDY OF SOUTHERN LAKE MICHIGAN ...Bioindicators, Chemical Identification, Eutrophication, Lake Michigan, Sedimentology-general, ...5.0547

AIRFLOW AND DIFFUSION PARAMETERS IN CONNECTION WITH ATMOSPHERIC WATER RESOURCES PROGRAM ...Diffusion, Model Studies, Orographic Effects, Topographic Influences, Wind Tunnels, ...2.0167

Weather Parameters Instruments

Aircraft

RESEARCH ON CHARACTERISTICS OF CONVECTIVE CLOUDS IN TEXAS ...Cloud Physics, Cumulus, Data Analysis - General, Model Studies, Texas, ...2.1023

Automatic Stations

UTAH ATMOSPHERIC WATER RESOURCES (THE WASATCH WEATHER MODIFICATION PROJECT) ...Clouds-precipitation, Data Networks, Gages, Patterns, Utah, ...**2.1074**

EFFECT OF THE CLIMATE AND MICROCLIMATE ON AGRICULTURE IN SOUTH DAKOTA ...Applied Climatology, Digital Computers, Microclimate-general, South Dakota, Statistics-general, ...**2.0973**

WEATHER RADAR - PRECIPITATION RELATIONSHIP ...Computers-general, Forecasting, Patterns, Radar, ...**2.0876**

IMPROVE PRECIPITATION MEASURING EQUIPMENT - PRESSURE TRANSDUCER ANALYSIS ...Gages, Instrumental Services, Transducers, ...**2.0590**

MOUNTAIN RESEARCH ...General, Mountains-alpine, ...**2.0753**

PROJECT SKYWATER - NEW MEXICO ...Gages, Instrumental Services, New Mexico, Other Telemetry, Snow-general, Technique Development, ...**2.0203**

PROJECT SKYWATER - COLORADO - STEAMBOAT SPRINGS ...Colorado, Gages, Instrumental Services, Other Telemetry, Snow-general, ...**2.0204**

Lasers

DEVELOPMENT OF ATMOSPHERIC LASER RADAR ...Amplifiers, Humidity, Lasers and Masers, Radar, Ruby, ...**2.0194**

Radar

(U) INSTABILITY PATTERNS IN THE TROPICS ...Tropic, Weather Forecasting, ...**2.0320**

HYDROMETEOROLOGICAL ANALYSIS OF SEVERE RAINSTORMS ...Illinois, Meteorological Extremes, Patterns, Storms-general, Weather Charts-maps, ...**2.0414**

CLIMATOLOGY OF HAIL ...Applied Climatology, Modification, Patterns, Storms-general, ...**4.0097**

USE OF RADAR FOR HYDROLOGICAL STUDIES ...Cloud Physics, Evaporation, Groundwater Movement, Patterns, Structure-size, ...**2.0776**

WEATHER RADAR - PRECIPITATION RELATIONSHIP ...Automatic Stations, Computers-general, Forecasting, Patterns, ...**2.0876**

DEVELOPMENT OF ATMOSPHERIC LASER RADAR ...Amplifiers, Humidity, Lasers, Lasers and Masers, Ruby, ...**2.0194**

Towers

GREAT LAKES RESEARCH - ENERGY TRANSFER AT THE AIR-WATER INTERFACE ...Data Analysis - General, Heat and Radiation Transfer, Heat-transfer-other, Lake Michigan, Mass Transfer, Wind-water Interaction, ...**2.0639**

Weathering - Geologic

Features

STUDIES OF SAPROLITE AND ITS RELATION TO THE MIGRATION AND OCCURRENCE OF GROUNDWATER IN CRYSTALLINE ROCKS ...Chemical Sediments, Infiltration, Microstructure, Permeability, Texture, ...**2.0350**

Processes

PHYSIOGRAPHIC STUDY OF PART OF THE HENRY MOUTAINS REGION, UTAH ...Erosion, Henry Mountains, Physical Features-general, Physiography-general, Utah, ...**2.0563**

PHYLLOSILICATE WEATHERING IN UNCONSOLIDATED MATERIAL OF WISCONSIN AGE IN A HUMID TEMPERATURE ENVIRONMENT ...Glacial, Infiltration, Other, Soil Genesis, Soil Morphology, Profiles, ...**2.0801**

MATHEMATICAL GEOMORPHOLOGY ...Erosion, Features, Geomorphology-quantitative, Model Studies, Terrain Analysis, ...**2.0425**

Weathering-general

INFLUENCE OF GEOHYDROLOGY ON LANDSCAPE AND SOIL FORMATION ...Hydrology-general, Morphology-general, Physiography-general, Soil Genesis, ...**5.0409**

West Virginia

RUNOFF STUDIES ON SMALL DRAINAGE AREAS ...Data Acquisition-general, Discharge-general, Drainage, Peak Flow, Small Watersheds, ...**2.0290**

GEOCHEMICAL BEHAVIOR OF IRON AND MANGANESE IN A RESERVOIR (LAKE LYNN, WEST VIRGINIA) FED BY STREAMS CONTAINING ACID MINE DRAINAGE ...Acidity, Geochemical Analysis, Iron, Manganese, Mine Drainage Control, ...**2.1139**

INFLUENCE OF TOPOGRAPHIC FEATURES ON RAINFALL IN WEST VIRGINIA ...Forecasting, Mathematical Analysis, Patterns, Topographic Influences, Weather Charts-maps, ...**2.1140**

PRECIPITATION INTENSITY-FREQUENCY RELATIONSHIPS FOR WEST VIRGINIA ...Amount, Digital Computers, Patterns, ...**2.1141**

PHYSIOLOGICAL EFFECTS OF SUBLETHAL LEVELS OF ACID WATER ON FISH ...Acidity, Metabolic Efficiency, Mining Activities, Ph, Acidity -water, Water Quality-general, ...**5.1281**

PIPELINE TRANSPORT OF SLUDGE ...Disposal, Mass Transfer, Mining Activities, Pump, Sewage Treatment Plant, ...**5.0869**

AN INTEGRATED RECREATION AND NATURAL AREA PRESERVATION PLAN FOR OHIO AND MARSHALL COUNTIES, WEST VIRGINIA ...Camping, Fishing, Hunting, Inventories, Planning, Recreation Sites, ...**6.0634**

Wetlands

CHEMICAL STUDIES ON THE WATERS AND SOILS OF LAKES AND WETLANDS, WITH SPECIAL REFERENCE TO MINOR ELEMENTS ...Chemical, Chemical-general, Lakes, Minnesota, Trace Element Analysis, ...**2.0660**

EVALUATION OF FIVE METHODS FOR SAMPLING DESERT AND WETLAND VEGETATION ...Arid and Desert, Colorado, Deserts, Plant Ecology (non-specific), Utah, ...**3.0471**

PHYSICAL & CHEMICAL PROPERTIES OF WATER & SOILS OF MARSHES AS THESE PROPERTIES RELATE TO THE SUCCESS OF WATERFOWL FOODS & COVER. ...Biological-general, Food Supply, Soil (wildlife) Cover, ...**6.0371**

IMPORTANCE OF TYPE 1 WETLAND COMMUNITIES TO WATERFOWL PRODUCTION ...Censusing, Land Use, Spawn Or Nesting Sites, Water Fowl, N.s. , Water Utilization -animal, ...**4.0218**

THE EFFECT OF LIVESTOCK UTILIZATION ON WATERFOWL HABITAT AND PRODUCTION ...Cattle, Habitat Studies, Utah, Vasc. plant & Vert. -other, Water Fowl, N.s. , ...**6.0595**

A PRELIMINARY STUDY OF THE ECOLOGY, PRESENT AND ALTERNATIVE FUTURE LAND USE PATTERNS IN THE DISMAL SWAMP AREA OF NORTH CAROLINA ...Agricultural Land Use Effects, Economic Impact, Game Reserves & Preserves, Land Use, North Carolina, ...**6.0404**

THE INFLUENCE OF WETLANDS ON QUANTITY AND QUALITY OF STREAM FLOW ...Available Water, Evapotranspiration, Hydrology-general, Low Flow, Streams, ...**4.0170**

ENHANCEMENT OF ECOLOGIC AND AESTHETIC VALUES OF WETLANDS ASSOCIATED WITH INTERSTATE HIGHWAYS ...Administrative Structures, Beautification, Interstate, New England Province, Water Law-general, ...**6.0282**

DEVELOPMENT OF A MATHEMATICAL MODEL FOR THE SIMULATION OF FLAT-LAND WATERSHED HYDRAULICS ...Development of Models, Hydraulics-general, Mathematical Analysis, Model Studies, Technique Development, ...**4.0102**

SEASONAL VARIABLITY OF SOIL MOISTURE AND LEVELS OF GROUNDWATER TABLE ON LOWLAND AREAS ...Moisture Levels, Poland, Seasonal, Soils and Fertilizer, Water Table Fluctuation, ...**3.0422**

MARSH EVALUATION AND ACQUISITION - MARITIMES ...Habitat Studies, Management, Management -other, ...**4.0052**

MARSH EVALUATION AND ACQUISITION, QUEBEC ...Canada, Habitat Studies, ...**4.0049**

WETLANDS EVALUATION AND DEVELOPMENT - MARITIMES ...Canada, Habitat Studies, Species Evaluation, ...**6.0085**

MARSH EVALUATION AND ACQUISTION - ONTARIO ...Canada, Habitat Studies, Management, Management -other, Water Fowl, N.s. , ...**4.0046**

LITERATURE REVIEW ON FLOODED GREEN TIMBER AREAS ...Canada, Management, Site Index and Site Quality, Survey Studies, Water Fowl, N.s. , ...**4.0045**

DRAINAGE STUDIES OF NEW YORK SOILS ...Drainage, Land, Land Use, Production & Processing, ...**4.0182**

WETLANDS ECOLOGY LITERATURE REVIEW ...Bibliography, Planning, Wisconsin, ...**7.0113**

HYDROLOGY OF A WETLAND AREA IN THE YELLOW RIVER BASIN, WISCONSIN ...Aquifers-general, Flow Characteristics -water, Water Quality-general, Wisconsin, ...**2.1150**

WATERFOWL MANAGEMENT THROUGH WATER-LEVEL CONTROL ...Depth,water Level, Fluctuation, Drawdown, Management, Management -other, Water Fowl, N.s. , ...4.0133

FIELD TECHNIQUES FOR CHEMICAL ANALYSIS OF WETLAND CRITERIA ...Chemical Analysis (water), Chromatography-other, Colorimetric, Translation Grants, ...1.0091

CHEMICAL CHARACTERIZATION OF WATERS OF PRAIRIE AND FOREST WETLANDS ...Chemical-general, Habitat Studies, ...1.0092

DISTRIBUTION AND DENSITY OF BREEDING WATERFOWL POPULATIONS AS RELATED TO QUANTITY AND QUALITY OF WETLAND HABITAT IN NORTH DAKOTA ...Geography-physical, North Dakota, Number Or Density, Spawn Or Nesting Sites, Water Fowl, N.s. , ...6.0420

HYDROLOGY AND MANAGEMENT OF WETLAND FORESTS ...Forests, Soils and Fertilizer, ...3.0431

SILVICULTURE OF COASTAL PLAIN TIMBER TYPES ...Environment, Forest Watersheds, Pines, Taxodioideae, Timber Stand Improvement, ...4.0212

White River

EFFECT OF HEATED WATER DISCHARGE FROM IPALCO'S PETERSBURG PLANT ON THE WATERS OF WHITE RIVER, INDIANA ...Biological-general, Chemical-general, Electric Power Plants, Physical-general, Pollution - Effects of , Thermal Pollution, ...5.0383

Whole Body Culture & Rearing

REARING AND SENSITIVITY STUDIES OF VARIOUS LIFE STAGES OF MARINE MACROINVERTEBRATES ...Bioindicators, Crabs, All, Shrimps - Common, ...5.1079

Wild Rivers

EVALUATION OF NATURAL RIVER ENVIRONMENTS ...Productivity - Food Chain, Regimen, Streams, Succession, Water Quality-general, ...6.0441

DEVELOPMENT OF METHODS FOR VALUING WILD RIVERS ...Benefit-cost Analysis, Economics-general, River Basins, ...6.0083

WILD RIVERS ECOLOGY STUDIES ...Acidity, Fish -non-specific, Invertebrates -non-specific, Population Dynamics, Wisconsin, ...6.0638

HYDROLOGIC PARAMETERS CONTROLLING RECREATIONAL USE OF MINNESOTA RIVERS ...Minnesota, Morphology-general, Projections and Estimations, Recreation Sites, Water Quality-general, ...6.0307

SCENIC RIVERS STUDY ...Federal Government, Intergovern Relations, Recreation Sites, ...3.0170

Willamette River

EFFECTS OF CHEMICAL AND BIOLOGICALLY MODIFIED PULPING EFFLUENTS ON THE PRODUCTION OF FISH ...Effluents-waste Water, Fish -non-specific, Industrial Wastes, Pulp, Paper , and Logging, Self-purification, Tox & Allergenic Effects, ...5.0936

Wisconsin

THE APPLICATION OF RADIOISOTOPES TO STUDIES OF AQUATIC ECOSYSTEMS ...Aquatic Ecology, Benthic Organisms (non-specif), Freshwater Ecology, Productivity - Food Chain, Water Properties-general, ...6.0643

BIOPOTENTIAL OF NATURAL WATERS ...Acidity, Atomic Absorption, Lakes, Phytoplankton, Primary Productivity, Visible, ...7.0114

INSECTICIDE ADSORPTION BY LAKE SEDIMENTS AS A FACTOR CONTROLLING INSECTICIDE ACCUMULATION IN LAKES ...Adsorption Capacity, Degradation, Deposits-other, Insecticides -non-specific, Lakes, ...5.1300

EUTROPHIC EVALUATION OF A SMALL MULTI-LAND USE WATERSHED ...Eutrophication, Nitrogen, Phosphorus, Small Watersheds, Urban Environments, ...5.1319

NUTRITIONAL ECOLOGY AND COMMUNITY STRUCTURE OF THE PHYTOPLANKTON OF GREEN BAY ...Bays, Mineral Composition, Nutrition Studies, Physiological Ecology, Phytoplankton, ...5.1290

SHALLOW GROUND-WATER FLOW SYSTEMS IN RELATION TO INDUSTRIAL AND MUNICIPAL WATER SUPPLY AND WASTE DISPOSAL REQUIREMENTS ...Disposal Wastes, Groundwater Movement, Industrial Wastes, Sanitary Landfills, ...5.1316

EXPERIMENTAL REVERSAL OF THE LAKE EUTROPHICATION PROCESS ...Biological-general, Circulation -water, Eutrophication, Nutrients, Temperature, ...5.1308

SEDIMENTARY FACIES IN LAKE BUTTE DES MORTS, WISCONSIN ...Eutrophication, General, Lakes, Organic, Size, ...2.1169

ECOLOGICAL STUDIES OF THE SURFACE WATERS OF THE WHITEWATER CREEK WATERSHED, WALWORTH, ROCK, AND JEFFERSON COUNTIES, WISCONSIN ...Bioindicators, Range Or Territorial Distr. , Water Quality-general, Watersheds-general, ...5.1323

HUMBOLDT AVENUE POLLUTION ABATEMENT PROJECT ...Combined Sewer, Economic Efficiency, Runoff, Urban Environments, Waste Treatment-economics, ...4.0280

OPERATION AND EVALUATION OF A DEMONSTRATION ROTATING BIOLOGICAL CONTACTOR ...Aeration, Biological, Biological Treatment-other, Combined Sewer, Microbial-bacterial, ...5.1317

EFFECT OF PESTICIDES ON WILDLIFE,(SONGBIRDS, HERRING GULLS AND FISH) ...DDT , Pollution Effects, Wildlife, Wildlife -non-specific, ...5.1309

BIOLOGICAL FACTORS IN THE MANAGEMENT OF LAKE FLIES ...Lakes, Midges, Piscicides -non-specific, Pollution - Effects of , Predation, Predators and Parasite, ...6.0644

SURVEY OF DDT AND DIELDRIN RESIDUES IN FISHES IN WISCONSIN WATERS ...DDT , Dieldrin, Survey Studies, Wildlife, ...5.1291

MILWAUKEE RIVER WATERSHED LAKE VEGETATION SURVEY ...Aquatic Plants (non-specific), Lakes, Mapping, Range Or Territorial Distr. , Survey Studies, ...2.1144

WETLANDS ECOLOGY LITERATURE REVIEW ...Bibliography, Planning, Wetlands, ...7.0113

WILD RIVERS ECOLOGY STUDIES ...Acidity, Fish -non-specific, Invertebrates -non-specific, Population Dynamics, Wild Rivers, ...6.0638

DDT RESIDUE ACCUMULATION IN WISCONSIN FISH AND THE EFFECT ON REPRODUCTION ...DDT , Maturity & Growth Stages, Reproduction Studies (general), Walleyes, Wildlife, ...5.1292

SIMULATION MODEL FOR THE STUDY OF THE HYDROLOGY OF THE WISCONSIN RIVER ...Flow Characteristics -water, Hydrology-general, Reservoirs and Impoundments, River Basins, Simulation, ...2.1155

STUDY OF THE APPLICABILITY OF EFFLUENT CHARGES TO WATER QUALITY MANAGEMENT IN THE STATE OF WISCONSIN ...Economic Impact, Effluents-waste Water, Survey Studies, Water Costs, Water Quality Control-general, ...5.1307

FLOOD PLAIN DELINEATION - DRD - USGS, COOPERATIVE STUDY ...Floodplains, Floodproofing, ...6.0641

BASIC RESEARCH IN GEOMORPHOLOGY AND HYDROLOGY ...Control Factors-general, Discharge-general, Eastern, Meanders, Outwash Plains, ...2.0272

WATER RESOURCES OF CENTRAL WISCONSIN, A WATER-POOR AREA ...Artificial Recharge, Augmentation-general, Deposits, Geophysical Analysis, Valley, Buried, ...2.1146

WATER RESOURCES OF SOUTHEASTERN WISCONSIN - FOX RIVER BASIN ...Available Water, Groundwater Movement, Mans Activities, Projections and Estimations, Surface Water, ...4.0277

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U.S. Dept. of Commerce Bus. Def. Serv.
5.0239.

U.S. Dept. of Commerce E.S.S.A.
2.0205, 2.0265, 2.0266, 2.0267, 2.0311, 2.0321, 2.0370, 2.0450, 2.0482, 2.0492, 2.0493, 2.0496, 2.0510, 2.0511, 2.0587, 2.0588, 2.0589, 2.0590, 2.0591, 2.0592, 2.0593, 2.0594, 2.0595, 2.0596, 2.0597, 2.0598, 2.0599, 2.0600, 2.0601, 2.0602, 2.0603, 2.0604, 2.0605, 2.0606, 2.0611, 2.0692, 2.0725, 2.0761, 2.0876, 2.0925, 2.1113, 2.1163, 4.0283, 7.0015, 7.0048, 7.0049, 7.0050, 7.0051, 7.0052, 7.0053, 7.0084, 7.0110, 8.0214.

U.S. Dept. of Commerce Econ. Dev. Adm.
2.0256.

U.S. Dept. of Commerce Maritime Admin.
5.0209, 5.0336, 5.0747, 6.0183, 8.0171.

U.S. Dept. of Defense Army
1.0067, 1.0071, 1.0072, 1.0076, 2.0102, 2.0133, 2.0151, 2.0255, 2.0258, 2.0259, 2.0260, 2.0261, 2.0262, 2.0263, 2.0264, 2.0320, 2.0347, 2.0365, 2.0366, 2.0423, 2.0549, 2.0595, 2.0596, 2.0597, 2.0621, 2.0636, 2.0637, 2.0638, 2.0639, 2.0640, 2.0641, 2.0642, 2.0643, 2.0644, 2.0645, 2.0646, 2.0647, 2.0648, 2.0649, 2.0650, 2.0651, 2.0686, 2.0687, 2.0688, 2.0689, 2.0690, 2.0747, 2.0748, 2.0749, 2.0750, 2.0751, 2.0752, 2.0753, 2.0754, 2.0755, 2.0756, 2.0757, 2.0769, 2.0802, 2.0900, 3.0250, 3.0251, 3.0252, 5.0059, 5.0174, 5.0237, 5.0241, 5.0309, 5.0372, 5.0374, 5.0444, 5.0512, 5.0534, 5.0535, 5.0561, 5.0625, 5.0808, 5.1214, 5.1215, 5.1216, 5.1217, 5.1218, 5.1219, 6.0073, 6.0074, 6.0075, 6.0076, 6.0077, 6.0078, 6.0079, 6.0128, 6.0129, 6.0190, 6.0248, 7.0058, 7.0062, 7.0063, 7.0064, 7.0065, 7.0066, 7.0067, 7.0068, 8.0006, 8.0014, 8.0015, 8.0016, 8.0148, 8.0149, 8.0150, 8.0151, 8.0152, 8.0153, 8.0154, 8.0155, 8.0156, 8.0157, 8.0162, 8.0168, 8.0172, 8.0173, 8.0208, 8.0209, 8.0210, 8.0211, 8.0212, 8.0215, 8.0223, 8.0224, 8.0225, 8.0226, 8.0227, 8.0228, 8.0229, 8.0230, 8.0231, 8.0232, 8.0233, 8.0234, 8.0235, 8.0236, 8.0237, 8.0238, 8.0239, 8.0240, 8.0241, 8.0242, 8.0243, 8.0244, 8.0245, 8.0246, 8.0247, 8.0248, 8.0249, 8.0250, 8.0251, 8.0252, 8.0253, 8.0254, 8.0255, 8.0256, 8.0257, 8.0258, 8.0259, 8.0260, 8.0261, 8.0262, 8.0264, 8.0265, 8.0266, 8.0267, 8.0273, 8.0278, 8.0280, 8.0281, 8.0282, 8.0296, 8.0297, 8.0299, 8.0300, 8.0301, 8.0302, 8.0310, 8.0311, 8.0312, 9.0001.

U.S. Dept. of Defense Navy
3.0078, 5.0134.

U.S. Dept. of Hlth. Ed. Wel. F.D.A.
5.0957, 5.1310.

U.S. Dept. of Hlth. Ed. Wel. P.H.S.
1.0058, 1.0062, 1.0066, 1.0070, 1.0077, 1.0089, 1.0121, 1.0126, 2.0024, 2.0309, 2.0624, 2.0990, 2.1115, 2.1162, 3.0004, 4.0263, 5.0016, 5.0017, 5.0018, 5.0019, 5.0020, 5.0021, 5.0032, 5.0066, 5.0085, 5.0122, 5.0127, 5.0150, 5.0212, 5.0226, 5.0233, 5.0262, 5.0289, 5.0315, 5.0339, 5.0347, 5.0360, 5.0398, 5.0403, 5.0462, 5.0518, 5.0522, 5.0551, 5.0567, 5.0568, 5.0569, 5.0624, 5.0677, 5.0716, 5.0719, 5.0729, 5.0741, 5.0786, 5.0800, 5.0811, 5.0825, 5.0933, 5.0945, 5.1009, 5.1013, 5.1019, 5.1052, 5.1067, 5.1068, 5.1069, 5.1070, 5.1071, 5.1072, 5.1073, 5.1074, 5.1075, 5.1076, 5.1152, 5.1161, 5.1171, 5.1191, 5.1223, 5.1224, 5.1225, 5.1226, 5.1227, 5.1228, 5.1229, 5.1320, 6.0039, 6.0058, 6.0082, 6.0172, 6.0631, 7.0070, 7.0088, 7.0111, 7.0112.

U.S. Dept. of Housing Urban Development
6.0254, 6.0409, 6.0409.

U.S. Dept. of Interior Alaska Power Adm.juneau Alaska
2.0028.

U.S. Dept. of Interior Bonnvl. Pwr. Adm.
2.0124, 2.0904, 2.0904, 7.0011, 7.0071.

U.S. Dept. of Interior Bu. Comm. Fish.
1.0034, 2.0015, 2.0016, 2.0017, 2.0026, 2.0323, 2.0324, 2.0325, 2.0542, 2.0543, 2.0544, 2.0545, 2.0546, 2.0547, 2.0557, 2.0558, 2.0559, 2.0586, 2.0625, 2.0626, 2.0627, 2.0628, 2.0670, 2.0671, 2.0672, 2.0817, 2.0818, 2.0819, 2.1047, 2.1048, 2.1131, 4.0002, 4.0075, 4.0271, 5.0039, 5.0268, 5.0269, 5.0270, 5.0271, 5.0506, 5.0507, 5.0540, 5.0541, 5.0542, 5.0543, 5.0544, 5.0545, 5.0546, 5.0576, 5.0577, 5.0578, 5.0580, 5.0619, 5.0803, 5.0804, 5.0806, 5.0827, 5.0829, 5.0900, 5.0924, 5.0947, 5.0985, 5.1101, 5.1230, 6.0003, 6.0005, 6.0006, 6.0009, 6.0032, 6.0111, 6.0113, 6.0114, 6.0154, 6.0155, 6.0156, 6.0249, 6.0251, 6.0264, 6.0265, 6.0266, 6.0267, 6.0268, 6.0269, 6.0290, 6.0291, 6.0292, 6.0293, 6.0294, 6.0295, 6.0400, 6.0401, 6.0424, 6.0438, 6.0439, 6.0440, 6.0464, 6.0497, 6.0543, 6.0544, 6.0565, 6.0614, 6.0615, 6.0616, 6.0617, 6.0618, 6.0619, 6.0622, 6.0623, 6.0627, 6.0628, 6.0630, 6.0635, 6.0636, 7.0060, 7.0061, 8.0280, 8.0290, 8.0304, 8.0305, 8.0306, 8.0307, 8.0308, 8.0309.

U.S. Dept. of Interior Bu. Land Mgmt.
2.0176, 2.0177, 2.0221, 2.0234, 2.0571, 2.0740, 2.1067, 4.0011, 4.0012, 4.0160, 4.0161, 4.0166, 4.0168, 4.0177, 4.0255, 4.0281, 5.0030, 6.0364.

U.S. Dept. of Interior Bu. Outdoor Rec.
2.0160, 3.0168, 3.0170, 3.0171, 6.0160, 6.0324, 6.0350.

U.S. Dept. of Interior Bu. Reclamation
2.0043, 2.0108, 2.0114, 2.0156, 2.0161, 2.0162, 2.0163, 2.0164, 2.0165, 2.0166, 2.0167, 2.0168, 2.0169, 2.0171, 2.0172, 2.0173, 2.0175, 2.0176, 2.0180, 2.0184, 2.0186, 2.0189, 2.0190, 2.0191, 2.0193, 2.0194, 2.0195, 2.0197, 2.0198, 2.0199, 2.0200, 2.0203, 2.0204, 2.0205, 2.0206, 2.0731, 2.0922, 2.0974, 2.1074, 3.0042, 3.0093, 3.0094, 3.0106, 3.0107, 3.0108, 3.0109, 3.0110, 3.0111, 3.0113, 3.0114, 3.0118, 3.0119, 3.0121, 3.0124, 3.0125, 3.0126, 3.0127, 3.0128, 3.0129, 3.0130, 3.0131, 3.0132, 3.0133, 3.0308, 3.0317, 3.0335, 3.0494, 4.0023, 4.0032, 4.0059, 4.0159, 5.0045, 5.0087, 5.0143, 5.0180, 5.0181, 5.0182, 5.0183 , 5.0184, 5.0185, 5.0186, 5.0187, 5.0188, 5.0189, 5.0191, 5.0317, 6.0089, 6.0090, 6.0091, 6.0092, 6.0093, 6.0094, 6.0095, 6.0096, 6.0097, 6.0098, 6.0099, 6.0175, 6.0331, 6.0538, 7.0017, 7.0019, 7.0026, 8.0007, 8.0018, 8.0019, 8.0020, 8.0021, 8.0022, 8.0023, 8.0024, 8.0025, 8.0026, 8.0027, 8.0028, 8.0029, 8.0030, 8.0031, 8.0032, 8.0033, 8.0034, 8.0035, 8.0036, 8.0037, 8.0038, 8.0039, 8.0040, 8.0041, 8.0042, 8.0043, 8.0044, 8.0045, 8.0046, 8.0047, 8.0048, 8.0049, 8.0050, 8.0051, 8.0052, 8.0053, 8.0054, 8.0055, 8.0056, 8.0057, 8.0058, 8.0059, 8.0060, 8.0061, 8.0063, 8.0064, 8.0065, 8.0066, 8.0067, 8.0068, 8.0069, 8.0070, 8.0071, 8.0072, 8.0073, 8.0074, 8.0075, 8.0076, 8.0077, 8.0078, 8.0079, 8.0080, 8.0081, 8.0082, 8.0083, 8.0084, 8.0085, 8.0087, 8.0088, 8.0089, 8.0090, 8.0091, 8.0092, 8.0093, 8.0094, 8.0095, 8.0096, 8.0097, 8.0098, 8.0099, 8.0100, 8.0101, 8.0102, 8.0103, 8.0104, 8.0105, 8.0106, 8.0107, 8.0108, 8.0109, 8.0110, 8.0111, 8.0112, 8.0114, 8.0115, 8.0116, 8.0117, 8.0118, 8.0119, 8.0120, 8.0121, 8.0122, 8.0123, 8.0124, 8.0125, 8.0126, 8.0127, 8.0128, 8.0129, 8.0130, 8.0131, 8.0132, 8.0133, 8.0134, 8.0135, 8.0136, 8.0137, 8.0138, 8.0139, 8.0140, 8.0141, 8.0143, 8.0169, 8.0271, 8.0298.

U.S. Dept. of Interior Bu. Sport Fish.
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U.S. Dept. of Interior Bureau of Mines
1.0096, 1.0097, 2.0873, 2.0874, 3.0478, 5.0154, 5.0616, 5.1017, 5.1018, 5.1324, 7.0091.

U.S. Dept. of Interior F. Water Pol. Ctl
1.0005, 2.0616, 2.0632, 2.0769, 3.0005, 4.0032, 4.0044, 4.0069, 4.0091, 4.0203, 4.0205, 4.0274, 4.0280, 5.0003, 5.0015, 5.0026, 5.0027, 5.0028, 5.0029, 5.0030, 5.0031, 5.0033, 5.0034, 5.0035, 5.0038, 5.0042, 5.0043, 5.0048, 5.0050, 5.0055, 5.0056, 5.0060, 5.0061, 5.0064, 5.0065, 5.0067, 5.0069, 5.0072, 5.0073, 5.0074, 5.0075, 5.0076, 5.0077, 5.0078, 5.0088, 5.0089, 5.0090, 5.0091, 5.0092, 5.0094, 5.0095, 5.0096, 5.0097, 5.0100, 5.0104, 5.0105, 5.0106, 5.0107, 5.0108, 5.0109, 5.0110, 5.0111, 5.0112, 5.0113, 5.0114, 5.0123, 5.0124, 5.0125, 5.0126, 5.0128, 5.0129, 5.0130, 5.0131, 5.0132, 5.0133, 5.0144, 5.0148, 5.0149, 5.0152, 5.0153, 5.0155, 5.0156, 5.0157, 5.0158, 5.0159, 5.0160, 5.0161, 5.0163, 5.0167, 5.0192, 5.0193, 5.0203, 5.0205, 5.0213, 5.0222, 5.0227, 5.0228, 5.0229, 5.0230, 5.0231, 5.0232, 5.0234, 5.0235, 5.0242, 5.0243, 5.0244, 5.0245, 5.0246, 5.0248, 5.0249, 5.0250, 5.0254, 5.0257, 5.0258, 5.0259, 5.0260, 5.0261, 5.0263, 5.0265, 5.0266, 5.0267, 5.0272, 5.0274, 5.0277, 5.0278, 5.0279, 5.0280, 5.0281, 5.0282, 5.0283, 5.0284, 5.0285, 5.0286, 5.0291, 5.0299, 5.0303, 5.0307, 5.0308, 5.0311, 5.0320, 5.0329, 5.0333, 5.0335, 5.0337, 5.0338, 5.0340, 5.0341, 5.0342, 5.0343, 5.0344, 5.0345, 5.0346, 5.0357, 5.0358, 5.0361, 5.0365, 5.0368, 5.0373, 5.0380, 5.0387, 5.0388, 5.0394, 5.0395, 5.0399, 5.0400, 5.0406, 5.0414, 5.0418, 5.0419, 5.0422, 5.0424, 5.0431, 5.0436, 5.0445, 5.0455, 5.0458, 5.0461, 5.0464, 5.0465, 5.0475, 5.0477, 5.0479, 5.0480, 5.0496, 5.0500, 5.0503, 5.0504, 5.0508, 5.0509, 5.0516, 5.0517, 5.0519, 5.0520, 5.0523, 5.0524, 5.0525, 5.0526, 5.0527, 5.0528, 5.0529, 5.0530, 5.0531, 5.0532, 5.0536, 5.0537, 5.0538, 5.0539, 5.0547, 5.0549, 5.0550, 5.0552, 5.0553, 5.0554, 5.0555, 5.0557, 5.0558, 5.0559, 5.0560, 5.0562, 5.0565, 5.0579, 5.0581, 5.0582, 5.0583, 5.0584, 5.0585, 5.0586, 5.0587, 5.0588, 5.0589, 5.0590, 5.0591, 5.0592, 5.0593, 5.0594, 5.0595, 5.0596, 5.0598, 5.0599, 5.0601, 5.0603, 5.0604, 5.0608, 5.0609, 5.0610, 5.0611, 5.0614, 5.0618, 5.0620, 5.0669, 5.0679, 5.0682, 5.0683, 5.0684, 5.0685, 5.0686, 5.0692, 5.0694, 5.0697, 5.0699, 5.0700, 5.0705, 5.0706, 5.0710, 5.0718, 5.0722, 5.0723, 5.0724, 5.0725, 5.0737, 5.0740, 5.0744, 5.0745, 5.0748, 5.0749, 5.0754, 5.0756, 5.0758, 5.0759, 5.0760, 5.0761, 5.0762, 5.0764, 5.0766, 5.0770, 5.0777, 5.0778, 5.0779, 5.0780, 5.0781, 5.0782, 5.0783, 5.0784, 5.0785, 5.0787, 5.0788, 5.0791, 5.0792, 5.0793, 5.0795, 5.0796, 5.0797, 5.0798, 5.0799, 5.0801, 5.0802, 5.0807, 5.0809, 5.0814, 5.0821, 5.0822, 5.0824, 5.0838, 5.0839, 5.0840, 5.0841, 5.0842, 5.0843, 5.0844, 5.0845, 5.0846, 5.0847 , 5.0848, 5.0849, 5.0850, 5.0851, 5.0852, 5.0853, 5.0854, 5.0855, 5.0856, 5.0857, 5.0858, 5.0859, 5.0860, 5.0861, 5.0862, 5.0863, 5.0864, 5.0865, 5.0866, 5.0867, 5.0868, 5.0869, 5.0871, 5.0872, 5.0873, 5.0880, 5.0881, 5.0891, 5.0892, 5.0896, 5.0897, 5.0898, 5.0899, 5.0901, 5.0904, 5.0905, 5.0906, 5.0907, 5.0908, 5.0909, 5.0910, 5.0911, 5.0912, 5.0913, 5.0914, 5.0915, 5.0916, 5.0917, 5.0920, 5.0921, 5.0922, 5.0923, 5.0925, 5.0927, 5.0931, 5.0932, 5.0934, 5.0940, 5.0941, 5.0946, 5.0948, 5.0951, 5.0952, 5.0953, 5.0955, 5.0958, 5.0962, 5.0963, 5.0969, 5.0970, 5.0971, 5.0972, 5.0973, 5.0974, 5.0975, 5.0976, 5.0977, 5.0978, 5.0979, 5.0980, 5.0981, 5.0982, 5.0983, 5.0984, 5.0987, 5.0988, 5.0989, 5.0994, 5.0995, 5.0996, 5.0997, 5.0998, 5.0999, 5.1000, 5.1001, 5.1002, 5.1003, 5.1004, 5.1005, 5.1006, 5.1007, 5.1008, 5.1010, 5.1014, 5.1016, 5.1020, 5.1021, 5.1056, 5.1059, 5.1063, 5.1078, 5.1079, 5.1080, 5.1081, 5.1082, 5.1083, 5.1084, 5.1085, 5.1086, 5.1087, 5.1088, 5.1089, 5.1090, 5.1091, 5.1092, 5.1093, 5.1094, 5.1095, 5.1096, 5.1097, 5.1103, 5.1116, 5.1127, 5.1135, 5.1136, 5.1137, 5.1138, 5.1139, 5.1140, 5.1143, 5.1145, 5.1149, 5.1151, 5.1153, 5.1155, 5.1156, 5.1159, 5.1164, 5.1165, 5.1167, 5.1168, 5.1169, 5.1170, 5.1172, 5.1173, 5.1181, 5.1182, 5.1184, 5.1185, 5.1186, 5.1187, 5.1189, 5.1190, 5.1196, 5.1197, 5.1199, 5.1211, 5.1220, 5.1221, 5.1222, 5.1237, 5.1238, 5.1241, 5.1242, 5.1243, 5.1247, 5.1254, 5.1256, 5.1258, 5.1259, 5.1260, 5.1262, 5.1263, 5.1265, 5.1266, 5.1269, 5.1270, 5.1272, 5.1280, 5.1288, 5.1289, 5.1302, 5.1303, 5.1304, 5.1313, 5.1314, 5.1317, 5.1321, 5.1322, 5.1325, 6.0046, 6.0103, 6.0124, 6.0152, 6.0158, 6.0159, 6.0191, 6.0215, 6.0220, 6.0286, 6.0312, 6.0353, 6.0382, 6.0394, 6.0421, 6.0465, 6.0545, 6.0606, 6.0620, 7.0006, 7.0024, 7.0039, 7.0055, 7.0078. 7.0105, 8.0182, 8.0197, 8.0202, 9.0006, 9.0010.

U.S. Dept. of Interior Geological Survey
1.0032, 1.0120, 2.0011, 2.0012, 2.0013, 2.0014, 2.0036, 2.0037, 2.0042, 2.0043, 2.0044, 2.0045, 2.0066, 2.0115, 2.0116, 2.0117, 2.0118, 2.0119, 2.0120, 2.0121, 2.0122, 2.0123, 2.0125, 2.0126, 2.0127, 2.0128, 2.0129, 2.0152, 2.0153, 2.0170, 2.0174, 2.0176, 2.0177, 2.0178, 2.0179, 2.0181, 2.0182, 2.0183, 2.0185, 2.0187, 2.0188, 2.0192, 2.0196, 2.0201, 2.0202, 2.0224, 2.0236, 2.0237, 2.0268, 2.0271, 2.0272, 2.0274, 2.0276, 2.0279, 2.0280, 2.0282, 2.0283, 2.0284, 2.0286, 2.0287, 2.0300, 2.0303, 2.0317, 2.0318, 2.0319, 2.0327, 2.0328, 2.0329, 2.0330, 2.0331, 2.0362, 2.0368, 2.0425, 2.0452, 2.0453, 2.0454, 2.0455, 2.0456, 2.0488, 2.0489, 2.0490, 2.0491, 2.0502, 2.0527, 2.0528, 2.0535, 2.0536, 2.0537, 2.0538, 2.0539, 2.0540, 2.0561, 2.0562, 2.0564, 2.0565, 2.0566, 2.0568, 2.0569, 2.0613, 2.0614, 2.0623, 2.0701, 2.0705, 2.0766, 2.0767, 2.0768, 2.0769, 2.0770, 2.0771, 2.0781, 2.0809, 2.0824, 2.0825, 2.0826, 2.0837, 2.0838, 2.0839, 2.0840, 2.0841, 2.0842, 2.0843, 2.0844, 2.0845, 2.0846, 2.0847, 2.0901, 2.0902, 2.0903, 2.0905, 2.0908, 2.0909, 2.0910, 2.0963, 2.0964, 2.0975, 2.0976, 2.0994, 2.0995, 2.09962.0997, 2.0998, 2.1003, 2.1004, 2.1005, 2.1052, 2.1081, 2.1091, 2.1092, 2.1093, 2.1094, 2.1095, 2.1096, 2.1097, 2.1098, 2.1099, 2.1100, 2.1101, 2.1102, 2.1134, 2.1135, 2.1136, 2.1137, 2.1146, 2.1147, 2.1148, 2.1149, 2.1150, 2.1151, 2.1152, 3.0008, 3.0009, 3.0067, 3.0134, 4.0001, 4.0037, 4.0038, 4.0039, 4.0056, 4.0078, 4.0085, 4.0086, 4.0093, 4.0130, 4.0148, 4.0157, 4.0158, 4.0183, 4.0195, 4.0196, 4.0204, 4.0216, 4.0232, 4.0233, 4.0234, 4.0277, 4.0278, 4.0279, 5.0118, 5.0119, 5.0120, 5.0190, 5.0305, 5.0306, 5.0319, 5.0481, 5.0521, 5.0890, 5.1108, 5.1271, 6.0304, 6.0307, 6.0603, 6.0641, 7.0003, 7.0013, 7.0016, 7.0018, 7.0020, 7.0021, 7.0022, 7.0023, 7.0046, 7.0059, 7.0089, 7.0099, 7.0108, 7.0109.

U.S. Dept. of Interior O. Water Res. Rch
1.0001, 1.0002, 1.0003, 1.0006, 1.0017, 1.0019, 1.0020, 1.0021, 1.0027, 1.0028, 1.0037, 1.0039, 1.0040, 1.0060, 1.0069, 1.0073, 1.0074, 1.0099, 1.0108, 1.0110, 1.0111, 1.0112, 1.0122, 2.0002, 2.0005, 2.0006, 2.0008, 2.0009, 2.0010, 2.0018, 2.0020, 2.0021, 2.0022, 2.0051, 2.0061, 2.0062, 2.0068, 2.0083, 2.0084, 2.0092, 2.0097, 2.0104, 2.0106, 2.0111, 2.0140, 2.0145, 2.0216, 2.0219, 2.0222, 2.0223, 2.0229, 2.0231, 2.0233, 2.0243, 2.0244, 2.0246, 2.0247, 2.0248, 2.0250, 2.0253, 2.0254, 2.0326, 2.0339, 2.0340, 2.0346, 2.0349, 2.0350, 2.0352, 2.0353, 2.0359, 2.0360, 2.0369, 2.0371, 2.0375, 2.0378, 2.0381, 2.0390, 2.0391, 2.0398, 2.0399, 2.0400, 2.0411, 2.0426, 2.0432, 2.0437, 2.0444, 2.0447, 2.0448, 2.0458, 2.0459, 2.0461, 2.0463, 2.0465, 2.0467, 2.0468, 2.0469, 2.0473, 2.0478, 2.0479, 2.0481, 2.0483, 2.0486, 2.0503, 2.0504, 2.0505, 2.0506, 2.0507, 2.0509, 2.0514, 2.0516, 2.0518, 2.0521, 2.0522, 2.0523, 2.0525, 2.0530, 2.0552, 2.0554, 2.0580, 2.0581, 2.0584, 2.0607, 2.0608, 2.0609, 2.0610, 2.0653, 2.0655, 2.0656, 2.0659, 2.0663, 2.0664, 2.0665, 2.0666, 2.0667, 2.0668, 2.0679, 2.0682, 2.0685, 2.0696, 2.0699, 2.0700, 2.0702, 2.0703, 2.0704, 2.0707, 2.0709, 2.0711, 2.0712, 2.0713, 2.0714, 2.0715, 2.0716, 2.0717, 2.0718, 2.0719, 2.0721, 2.0722, 2.0726, 2.0732, 2.0734, 2.0735, 2.0736, 2.0737, 2.0738, 2.0739, 2.0744, 2.0746, 2.0759, 2.0773, 2.0774, 2.0779, 2.0780, 2.0792, 2.0793, 2.0794, 2.0795, 2.0803, 2.0807, 2.0816, 2.0821, 2.0822, 2.0823, 2.0828, 2.0832, 2.0833, 2.0848, 2.0851, 2.0854, 2.0859, 2.0861, 2.0862, 2.0879, 2.0881, 2.0889, 2.0891, 2.0892, 2.0915, 2.0918, 2.0920, 2.0924, 2.0927, 2.0929, 2.0934, 2.0935, 2.0937, 2.0950, 2.0951, 2.0954, 2.0955, 2.0957, 2.0961, 2.0966, 2.0968, 2.0970, 2.0972, 2.0979, 2.0992, 2.0993, 2.0999, 2.1009, 2.1012, 2.1013, 2.1015, 2.1024, 2.1039, 2.1041, 2.1046, 2.1069, 2.1084, 2.1085, 2.1086, 2.1087, 2.1088, 2.1089, 2.1103, 2.1105, 2.1108, 2.1109, 2.1110, 2.1112, 2.1114, 2.1117, 2.1120, 2.1121, 2.1132, 2.1138, 2.1139, 2.1140, 2.1141, 2.1153, 2.1159, 2.1161, 2.1166, 2.1169, 3.0012, 3.0019, 3.0025, 3.0045, 3.0138, 3.0139, 3.0160, 3.0177, 3.0180, 3.0198, 3.0207, 3.0244, 3.0253, 3.0312, 3.0331, 3.0336, 3.0337, 3.0375, 3.0376, 3.0377, 3.0382, 3.0397, 3.0398, 3.0399, 3.0400, 3.0424, 3.0429, 3.0433, 3.0434, 3.0460, 3.0464, 3.0484, 4.0010, 4.0018, 4.0020, 4.0025, 4.0031, 4.0043, 4.0060, 4.0061, 4.0066, 4.0082, 4.0102, 4.0115, 4.0118, 4.0122, 4.0134, 4.0135, 4.0137, 4.0139, 4.0140, 4.0141, 4.0144, 4.0152, 4.0155, 4.0162, 4.0170, 4.0172, 4.0173, 4.0189, 4.0224, 4.0230, 4.0231, 4.0242, 4.0243, 4.0245, 4.0246, 4.0247, 4.0258, 4.0260, 4.0261, 4.0272, 5.0001, 5.0002, 5.0005, 5.0006, 5.0007, 5.0008, 5.0010, 5.0011, 5.0013, 5.0024, 5.0025, 5.0036, 5.0037, 5.0046, 5.0051, 5.0053, 5.0068, 5.0071, 5.0083, 5.0137, 5.0199, 5.0200, 5.0211, 5.0214, 5.0215, 5.0216, 5.0217, 5.0218, 5.0220, 5.0221, 5.0223, 5.0225, 5.0252, 5.0253, 5.0256, 5.0293, 5.0295, 5.0296, 5.0297, 5.0298, 5.0310, 5.0313, 5.0314, 5.0323, 5.0326, 5.0330, 5.0332, 5.0364, 5.0370, 5.0379, 5.0381, 5.0396, 5.0401, 5.0402, 5.0405, 5.0408, 5.0409, 5.0410, 5.0412, 5.0413, 5.0415, 5.0416, 5.0417, 5.0420, 5.0421, 5.0423, 5.0426, 5.0428, 5.0430, 5.0432, 5.0433, 5.0434, 5.0438, 5.0439, 5.0441, 5.0442, 5.0443, 5.0446, 5.0450, 5.0457, 5.0463, 5.0466, 5.0468, 5.0471, 5.0474, 5.0476, 5.0478, 5.0494, 5.0495, 5.0497, 5.0498, 5.0499, 5.0501, 5.0502, 5.0513, 5.0514, 5.0515, 5.0548, 5.0556, 5.0571, 5.0572, 5.0600, 5.0602, 5.0605, 5.0606, 5.0607, 5.0612, 5.0617, 5.0623, 5.0668, 5.0671, 5.0672, 5.0673, 5.0674, 5.0675, 5.0676, 5.0681, 5.0688, 5.0689, 5.0690, 5.0691, 5.0693, 5.0695, 5.0696, 5.0698, 5.0701, 5.0704, 5.0711, 5.0712, 5.0713, 5.0714, 5.0717, 5.0726, 5.0727, 5.0728, 5.0732, 5.0733, 5.0734, 5.0739, 5.0742, 5.0750, 5.0751, 5.0753, 5.0755, 5.0768, 5.0769, 5.0772, 5.0810, 5.0812, 5.0813, 5.0815, 5.0819, 5.0820, 5.0823, 5.0830, 5.0832, 5.0833, 5.0834, 5.0837, 5.0874, 5.0875, 5.0877, 5.0878, 5.0879, 5.0882, 5.0883, 5.0887, 5.0888, 5.0918, 5.0919, 5.0926, 5.0928, 5.0929, 5.0942, 5.0961, 5.1036, 5.1040, 5.1041, 5.1045, 5.1046, 5.1048, 5.1050, 5.1053, 5.1054, 5.1055, 5.1057, 5.1060, 5.1062, 5.1064, 5.1065, 5.1102, 5.1105, 5.1106, 5.1107, 5.1109, 5.1113, 5.1114, 5.1117, 5.1126, 5.1128, 5.1129, 5.1130, 5.1132, 5.1133, 5.1134, 5.1148, 5.1150, 5.1157, 5.1158, 5.1180, 5.1188, 5.1195, 5.1207, 5.1209, 5.1210, 5.1212, 5.1213, 5.1232, 5.1235, 5.1236, 5.1245, 5.1255, 5.1257, 5.1261, 5.1264, 5.1267, 5.1276, 5.1277, 5.1278, 5.1279, 5.1281, 5.1282, 5.1283, 5.1284,

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U.S. Dept. of Interior Off. of Coal Rch.
3.0325, 5.0870.

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DEFINITIONS OF WATER RESOURCES RESEARCH

These definitions, developed by the Committee on Water Resources Research of the Federal Council for Science and Technology, February 1966, were used in the preparation of Volume 4 of the Water Resources Research Catalog.

I. Nature of Water
Properties of Water; Aqueous Solutions.

II. Water Cycle
General Studies; Precipitations; Snow, Ice and Frost; Evaporation and Transpiration; Streamflow; Groundwater; Water in Soils; Lakes; Water and Plants; Erosion and Sedimentation; Chemical processes; Estuarine Problems.

III. Water Supply Augmentation and Conservation
Saline Water Conversion; Water Yield Improvement; Use of Water of Impaired Quality; Conservation in Domestic Use; Conservation in Industry; Conservation in Agriculture.

IV. Water Quantity Management and Control
Control of Water on the Land; Groundwater Management; Effects of Man's Related Activities on water; Watershed Protection.

V. Water Quality Management and Protection
Identification of Pollutants; Sources and Fate of Pollution; Effects of Pollution; Waste Treatment Processes; Ultimate Disposal of Wastes; Water Treatment; Water Quality Control.

VI. Water Resources Planning
Techniques of Planning; Evaluation Process; Cost Allocation, Cost Sharing, Pricing and Repayment; Water Demand; Water Law; Institutional Problems; Non-structural Alternatives; Ecologic Impact of Water Development.

VII. Resource Data
Network Design; Instrumentation; Data Acquisition; Evaluation, Processing and Publication.

VIII. Engineering Works
Design; Materials; Construction and Operation.

IX. Manpower, Grants and Facilities
Education-extramural; Education-In House; Research Facilities; Grants, Contracts and Research Act Allotments.

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